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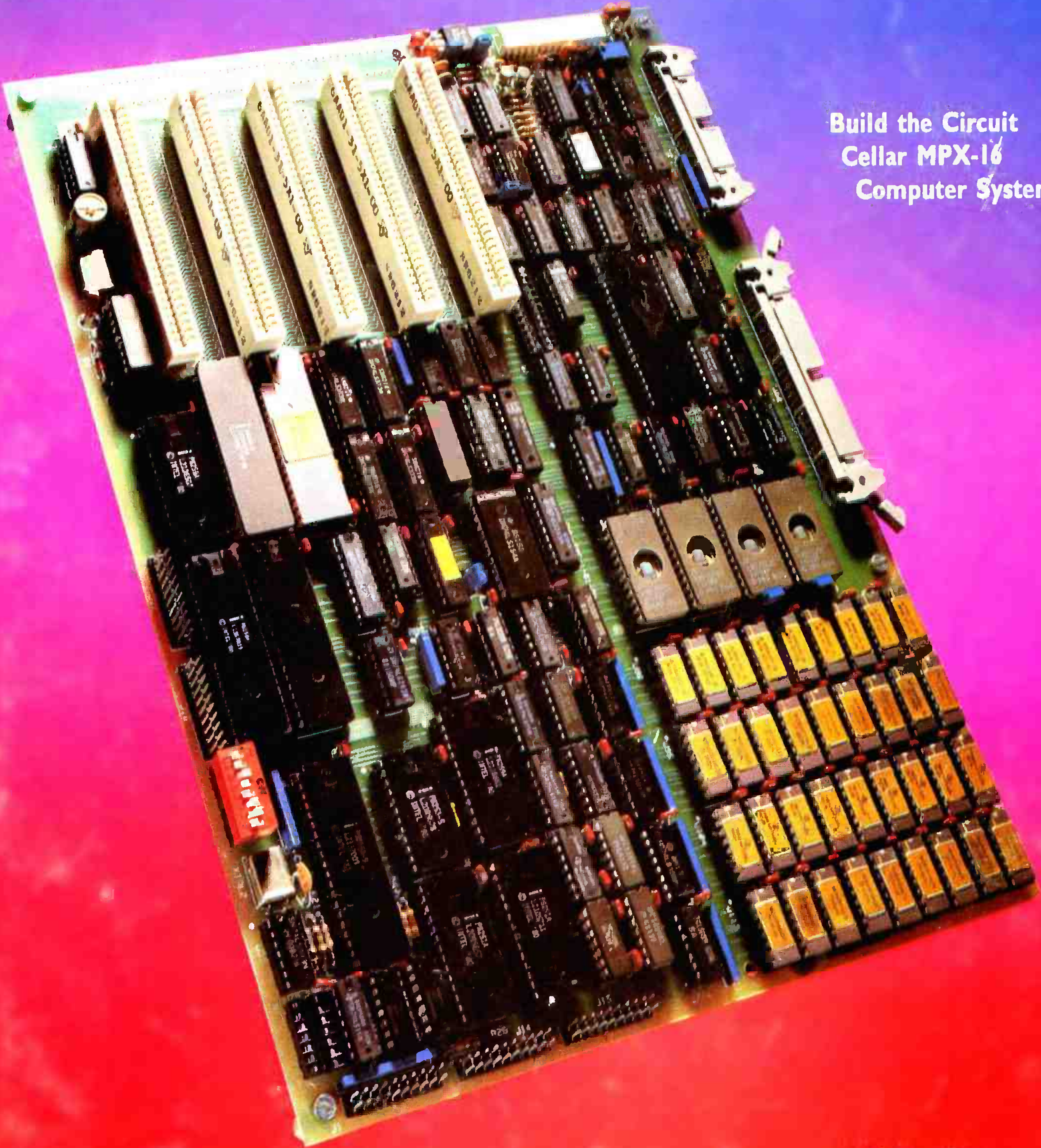
the small systems journal



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Cellar MPX-16
Computer System

GRAPHICS

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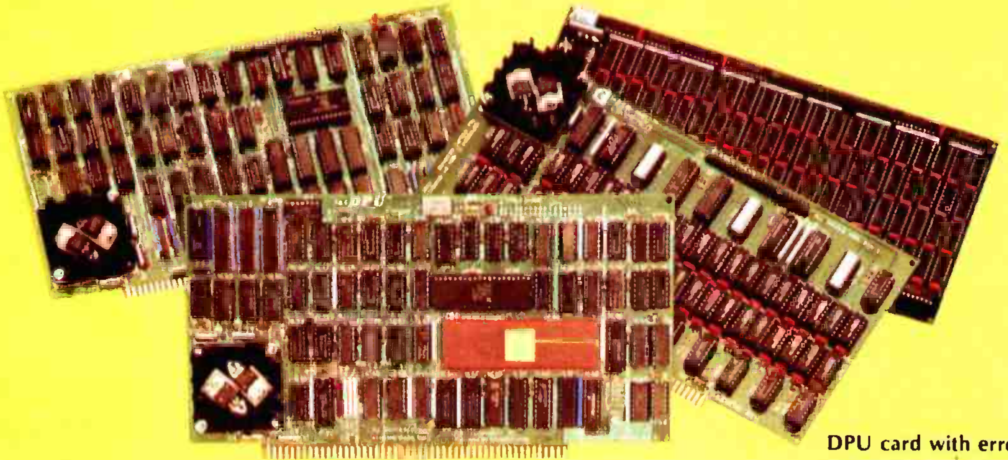

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The dual part of the DPU refers to its on-board Z-80A processor. With this you have access to existing CP/M* software.

But besides being compatible with this wealth of existing 8-bit software, the System One/DPU has available a whole family of new 68000 system software. This includes a wide range of high-level software such as our 68000 Assembler, FORTRAN 77, Pascal, BASIC, COBOL, and C.

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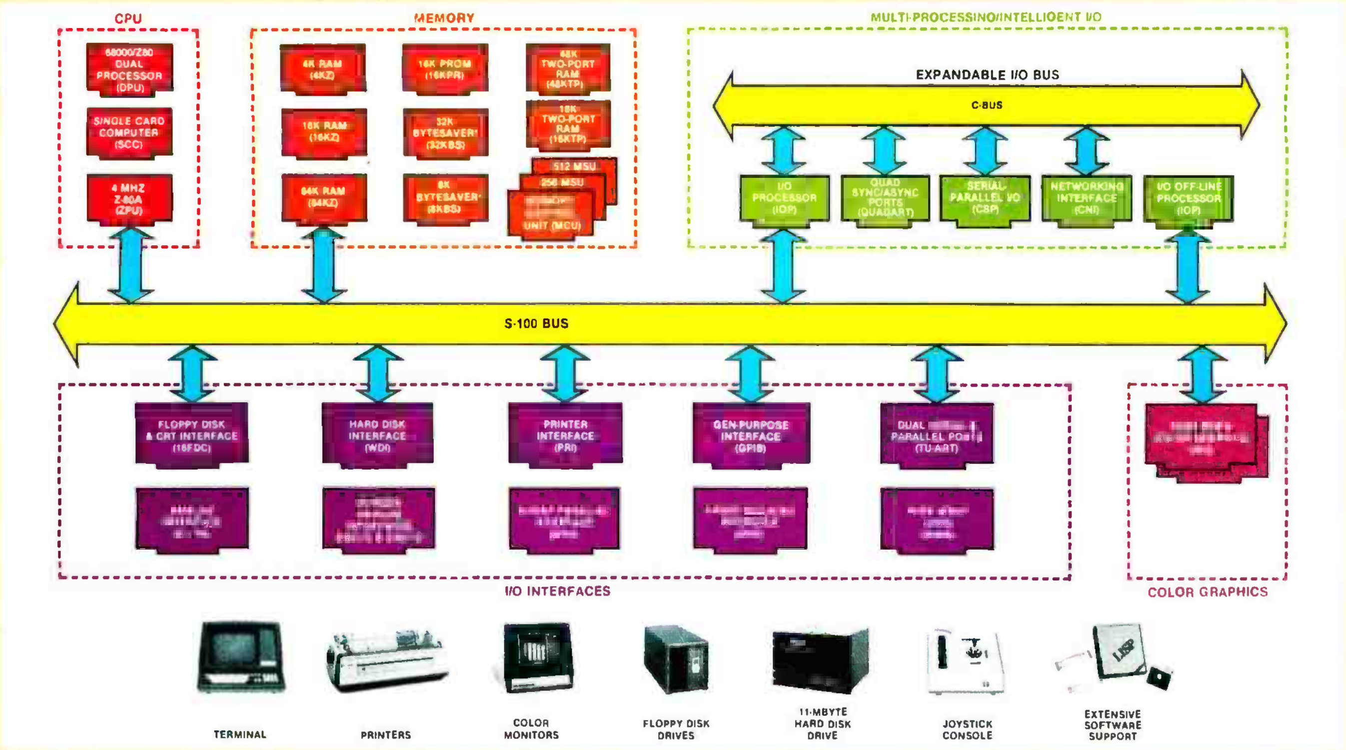

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In The Queue

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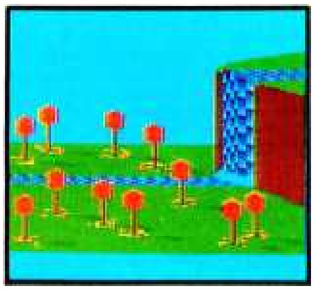
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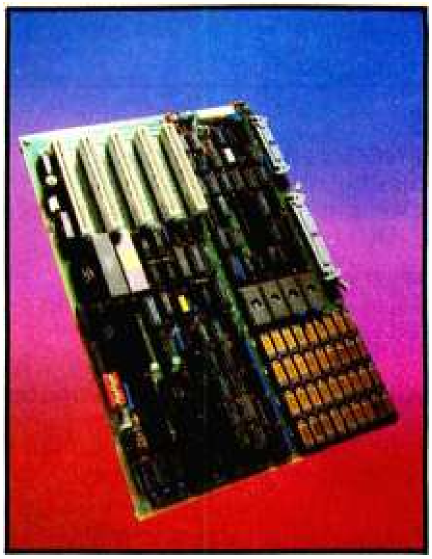

In This Issue

This month we're proud to present the Circuit Cellar MPX-16 computer system, designed and developed by Steve Ciarcia. In this exclusive three-part article, Steve will discuss all the design aspects of his IBM-compatible computer based on the Intel 8088 microprocessor. Our cover photograph (© 1982 by Jonathan Goell) shows the MPX-16 as a single-board computer composed of the processor, the memory, parallel and serial interfaces, a disk controller, and expansion slots. We hope you'll enjoy Steve's most extensive technical project to date. Our theme this month is graphics, and we have some interesting features. "Tronic Imagery" is a behind-the-scenes look at the development of the computer-generated graphics in Disney Studio's epic film **Tron**. Gregg Williams provides an introduction to computer graphics in "A Graphics Primer," and Alexander Pournelle takes us on a tour of "The Third NCGA and the Future of Computer Graphics." In "Build a Video Digitizer" Michael Keryan shows you how to construct a video "frame grabber," and in "Microvec: The Other Type of Video Display" Billy Garrett describes how to construct an inexpensive vector graphics display. Andrew Pickholtz discusses "Interactive 3-D Graphics for the Apple II." And we have reviews of the Victor 9000, Cambridge Development Labs graphics board, The Graphics Magician, and the Executive Briefing System. Plus more Game Contest winners, the User's Column, and our regular features.

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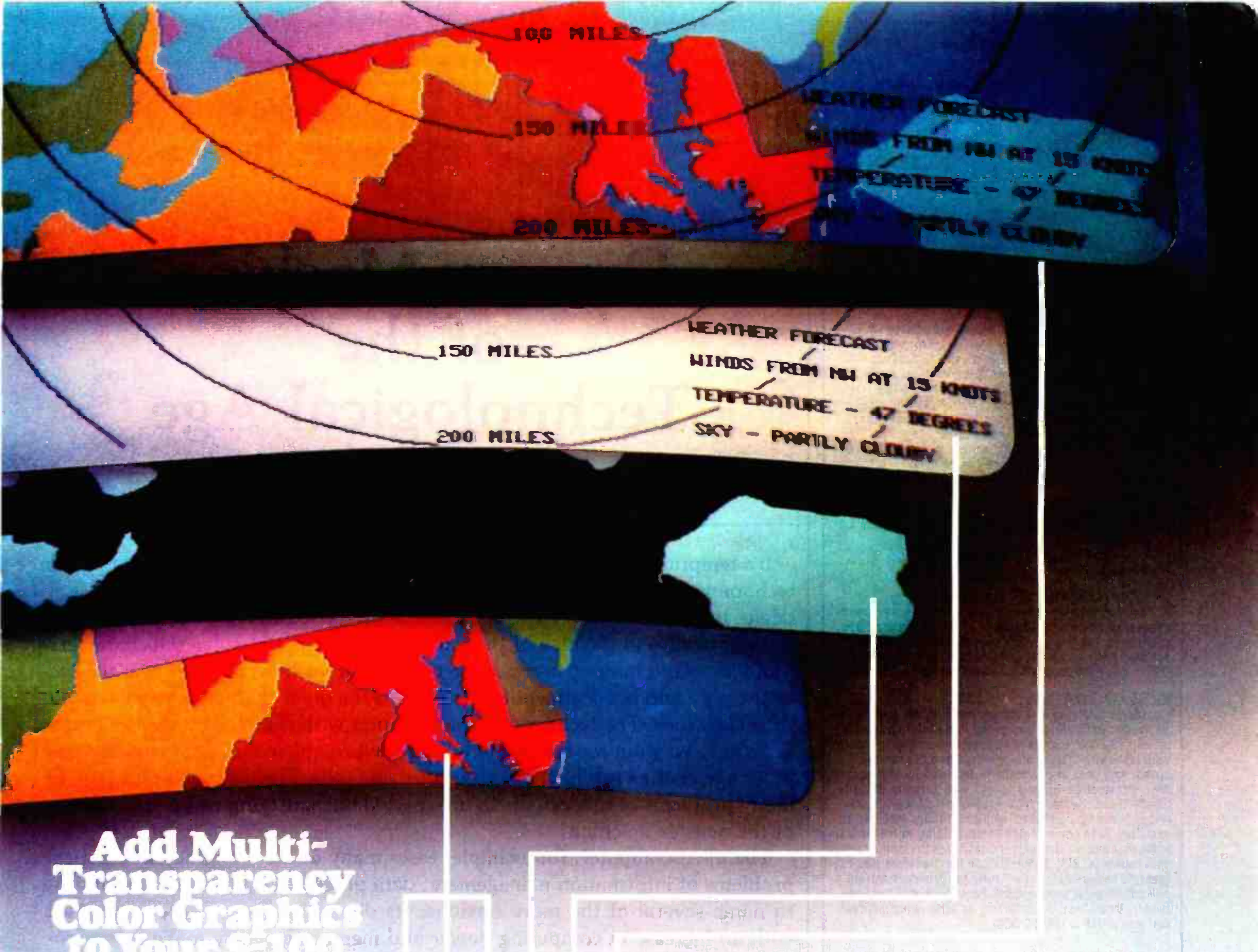

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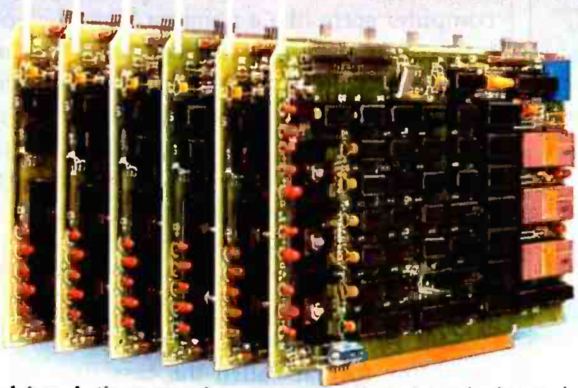

The system builder's best choice for color graphics is a CS5000 color system from SCION. Its basic component is MicroAngelo®, the single board graphics display computer that has revolutionized monochrome display capability with low cost 512x480 pixel graphics resolution and 40 line by 85 character text capacity. When MicroAngelo boards are combined, they create high resolution color graphics that have a unique advantage. The displayed image is a combination of transparencies. So you can add, modify or delete images by transparency rather than as an entire image.

SCION's Series CS5000 builds an image with up to 8 bit planes, each generated by a MicroAngelo board. You select the assignment of those bit planes to transparencies. Each transparency can display 2^n-1 colors where n is the number of bit planes it uses... 2 bit planes would make a three color transparency, 8 bit planes would make a 255 color transparency. Once each transparency has been defined, your host can work with it independently, generating and modifying its graphics and text without interacting with the others. The independent transparencies are combined by the Color Mixer board which also assigns one of 16.8 million possible colors to each color of each transparency.

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System shown is a Model CS5050S.
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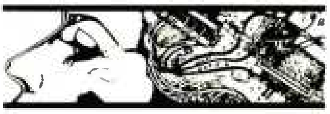

Editorial

Deus ex Machina of the Technological Age

by Chris Morgan, Editor in Chief

It's tempting to think of the microcomputer as the deus ex machina of the technological age. The term, literally "god from a machine," is a theatrical device first used by Greek tragedians to tie up the loose ends of a plot by introducing, always in the nick of time, an external means to solve the characters' problems. For example, in a modern plot, a rich relative might die near the end of the play and bequeath enough money to the main characters to solve their financial woes. The technique is looked upon with disfavor by theater critics as an easy way out for the playwright. Yet when applied to today's microcomputer age deus ex machina has a positive ring to it. The microcomputer solves many problems of modern life in unexpected but satisfying ways—the essence of the deus ex machina.

The microcomputer, for example, eases many of the monumental logistical problems of information management, data processing, and communications, to name several of the more obvious. Its diminishing size and cost coupled with an increase in computing power and memory capacity make the microcomputer seem like a panacea from the gods. Going one step further than the microcomputer in convenience and transportability is the expanding class of computers referred to as portable computers.

A fast-growing and attractive subset of microcomputers, portable computers are enjoying a new-found popularity. The early ones had about them the air of the underdog. When the first portable models appeared several years ago, they seemed incredibly limited; their capabilities were few and primitive. But in the intervening time their price/performance ratio has increased dramatically. It reminds me of a similar situation that took place in the audio world in the early 1960s.

At that time North American Philips quietly introduced a new tape-recording format called the cassette, designed to be used in small, portable tape recorders solely for "low-fi" applications such as dictation and noncritical music recording. No one had great expectations for the format. Its saving graces were its portability and convenience. Since then, as you know, technology has catapulted the quality of the lowly cassette to the point where it offers serious competition to long-playing records and open-reel tape.

The saga of the portable computer is simply a more spectacular manifestation of the same trend. To illustrate, I'd like to discuss Hewlett-Packard's new HP-75C portable computer, the first of a series of portable computers to come from that company. Consider its features for a moment: 10 by 5 by 1¼ inches; 26 ounces; battery operable for several weeks on a single charge; a fast BASIC with 147 commands built into the operating system; CMOS circuitry that stays on constantly to retain data and programs between sessions; full QWERTY-style touch-typing keyboard with all keys user-definable (à la the

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Photo 1: *The Hewlett-Packard HP-75C portable computer.*

HP-41C); a 32-character, liquid-crystal display (LCD) that serves as a window on a 96-character line, with character descenders; a hand-pulled magnetic-card reader that reads or writes up to 1.3K bytes per card; built-in 16K bytes of RAM (random-access read/write memory) that can be increased to 24K bytes; three software-module plug-in ports in the computer that accept 8K- or 16K-byte ROM (read-only memory) modules (With three 16K-byte plug-in modules, the 48K-byte built-in operating system, and 24K bytes of RAM, the HP-75C's maximum memory is 120K bytes!); the ability to store program files, data files, and appointment files in RAM—all such files can interact with one another; a built-in real-time clock; built-in HPIL interface loop (HP's new two-wire serial interface loop for battery-operated controllers); built-in appointment modes with alarm; limited production of musical tones; and a range of off-the-shelf software for engineering applications, mathematics and statistics, electronic spreadsheets, and graphics presentations. The base price for the 16K-byte RAM unit is $995. (The C in HP-75C stands for "continuous memory.")

Think about these features for a moment. They weren't even available in a portable computer five years ago at any price! As the first of a series of portable computers from Hewlett-Packard, the HP-75C is only the beginning. No official details are available yet about future models in the 70 series.

Hewlett-Packard makes a distinction between "hand-held" and "portable" computers, the former referring to the HP-41C and its future kin (rumor has it that an HP-42C is in the works), the latter to the 70 series. In HP parlance, a hand-held computer is one you can literally hold in one hand. Portable, on the other hand (no pun intended), refers to a small, transportable computer on which you can touch-type. The design goal of the HP-75C was to make a computer as small as possible on which touch-typing is still feasible.

After browsing through the thorough instruction manual for the HP-75C (it's up to the company's usual high standards for documentation), I auditioned the machine and was impressed. The keyboard is indeed suited for touch-typing—although marginally so for extended sessions. I wouldn't want to use the HP-75C for serious word processing. But then, it wasn't designed for that purpose. Its strong points are its portability and built-in BASIC (which is 10 times faster than the HP-41C's RPN), both features that will make the machine popular with engineers and technicians who work away from the office. This machine would have made the perfect "electronic slide rule plus" for me in my engineering school days. My guess is that future machines in the 70 series will have much larger LCDs and more "typable" keyboards.

The company, incidentally, is encouraging outside software vendors to develop software for the HP-75C. As well, several peripherals have been announced for the machine, including a digital cassette drive, a video/TV interface to let you display up to twenty 32-character lines on a TV screen, two printers, a digital multimeter, and two video monitors. To come in early 1983 are a plotter, a modem, an HPIL to RS-232C converter, and an HPIL to HPIB converter.

With the reputation of the fastest 8 bit microcomputer on any race course, IBC has designed its 16 bit computer entry for world class competition. The all new ENSIGN™ multi-slave processor architecture has performance that rivals the largest and most expensive 16 bit mini-computers and small 32 bit mainframes at a fraction of their cost. The ENSIGN supports up to 32 users using the OASIS-16™ or UNIX™ operating systems. Eight bit IBC Cadet owners can easily upgrade their system to an ENSIGN configuration as both systems share a common cabinet, disk drives and power supply.

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Microprocessor Type	68000	Z-8000	8086
Microprocessor Speed	8MHz	4MHz	5MHz
OASIS-16 Operating System (Max Users)	32	***	8
UNIX Operating System (Max Users)	32	8	8
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Seek (Milli Sec.)	35	50	65
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I took the machine with me to a recent meeting of the New York Audio Society, where I knew I'd find several HP-41C users, to get their first impressions of the HP-75C. (I'm a confirmed audiophile, and I'm wondering how many BYTE readers are similarly addicted to audio.) First impressions from the HP-41C users were positive. I was somewhat surprised because 41C users tend to be fanatical in their devotion to their machines, generally look askance at algebraic notation versus reverse Polish notation, and prefer the powerful assembly language of the 41C. Nonetheless, they were taken by the machine. I look upon this as a good omen.

Speaking of HP-41C fanaticism, probably the best-organized and most active special-interest group in personal computing is PPC, which spelled out reads "The Personal Programming Center is for People Programming Calculators." Interested readers can contact the group at 2545 West Camden Place, Santa Ana, CA 92704. PPC has done some remarkable work over the years, including designing a custom ROM for the 41C that does more things than I have space to list here. I applaud the group's efforts and hope interested readers will contact it to find out more about PPC.

The HP-75C is not for everyone, but it does a *lot* for the money. I'm curious to see future products in Hewlett-Packard's 70 series.

* * *

1982 SIGGRAPH

This month's theme is computer graphics, in preparation for which several BYTE staff members and I attended SIGGRAPH, the ACM's annual conference sponsored by its special-interest group for computer graphics. Nearly 19,000 people attended this year's conference held this past July in Boston.

The conference has rapidly become one of my favorite annual computer gatherings. SIGGRAPH attracts many interesting people, and the organizers work to keep the conference from becoming overly commercialized. The tone remains that of a true symposium, with dozens of technical papers presented and day-long classroom sessions held. The emphasis is decidedly on education. SIGGRAPH evenings, on the other hand, are reserved for the pure enjoyment of computer graphics. We attended the evening sessions on films and video and enjoyed them immensely. I urge all those BYTE readers with an interest in computer graphics to attend next year's SIGGRAPH conference. For information, contact SIGGRAPH '83 Conference Office, 111 East Wacker Drive, Chicago, IL 60601, (312) 644-6610. ■

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Digital Shifts Royalty Policy

In his May 1982 BYTE User's Column, Jerry Pournelle criticized Digital Research Inc. for charging run-time library licensing royalties for programs written in that company's compiler languages (see "Supercalc, Spelling Programs, BASIC Compilers, and Home-Grown Accounting," page 226). The article was apparently written prior to February 16, 1982, when Digital Research announced it had dropped these licensing requirements.

Independent software vendors (ISVs) no longer have to pay royalties to Digital Research for selling programs written in the company's compilers. In addition, ISVs who have already paid royalties may credit these amounts to future purchases.

The languages affected by this liberalized policy are PL/I-80, Pascal/MT+, the CBASIC Compiler called CB-80, and these languages' 16-bit counterparts. In addition, this policy applies to other run-time library products from Digital Research, including its programmer productivity tools, Access Manager and Display Manager.

The three languages originated from three different companies: PL/I-80 from Digital Research, Pascal/MT+ from MT Microsystems, and the CB-80 CBASIC Compiler from Compiler Systems. Each had its own licensing policy, so dropping the licensing requirements allows Digital Research to deal more fairly and consistently with its customers.

Dan Fineberg, Account Manager/Digital Research Inc.
Franson & Associates
800 Charcot Ave. #110
San Jose, CA 95131

Enhancements to AIDS

George Wolfe's review of the AIDS (Assisted Instructional Development System) that appeared in the August 1982 BYTE (page 408) was a well-written and accurate assessment of the program's capabilities. As a result of the review, we have initiated two major changes in the program.

First, high-resolution graphics can now be used with the program. The graphic displays are easily accessed through an embedded control command that can appear anywhere in a lesson. Also, the displays themselves can be created through any means at the user's disposal.

Second, the time necessary to load questions has been reduced considerably so that students can spend more time on the lessons themselves. We feel this improvement is of great importance to educators, as it increases actual student time-on-task when using the computer.

One other development will be of interest to BYTE readers: AIDS is now marketed nationally by Zweig Associates, a division of Skillcorp Publishers. We are supporting the program through a network of independent dealers and are initiating an innovative user-exchange service.

Michael N. Milone Jr., Editor
Skillcorp Publishers Inc.
203 Eighth St.
Honesdale, PA 18431

Association Promotes Computers and the Humanities

As the president of ACH (Association for Computers and the Humanities), I want to praise BYTE for the July 1982 issue on Computers in the Arts and Sciences. Over the years, considerable work has been done in the arts and humanities without receiving much publicity. I want to inform the readers of BYTE about an organization in this area.

ACH was founded to promote computing in the humanities, which includes the arts as described in the phrase "Arts and Sciences," as well as the humanistic areas of the social sciences and the fine and performing arts: dance, sculpture, music, art history, etc. ACH sponsors a major biennial conference, the ICCH (International Conference on Computers and the Humanities). The next one, ICCH/83, will be held from June 6 to 8, 1983, in Raleigh, North Carolina. In addition to paper sessions and exhibits of equipment and software, we plan to hold juried exhibits in computer-assisted art and music. Anyone interested in attending or contributing to ICCH/83 should contact Sarah K. Burton, ICCH/83, POB 5308, North Carolina State University, Raleigh, NC 27650.

Anyone who would like further information about joining ACH should contact me at the address below or send $15 (U. S.) to Harry Lincoln, Treasurer, Department of Music, State University of New York, Binghamton, NY 13901. ACH members receive a discount subscription rate of $15 (U. S.) for the journal *Computers and the Humanities.*

Mary Dee Harris Fosberg,
Associate Professor, Computer Science
Department of Mathematical Sciences
Box 35
Loyola University
New Orleans, LA 70118

Never Say Enough

I read with great interest and enjoyment Professor Don Karl Rowney's article "The Historian and the Microcomputer." (See the July 1982 BYTE, page 166.) The efforts and advances in using computers for the social sciences are praiseworthy, and Professor Rowney is entirely correct when he says that there is much to be done, particularly in the areas of documentation and product information.

However, he misses the fundamental aspect of the microcomputer revolution. Not only does the microcomputer decentralize the means for solving problems, but it decentralizes the means for *arriving at* those means. Professor Rowney states that he has no plans to learn a computer language: "Having already studied Russian, French, German, Latin, Hebrew, and Greek, I think enough is enough!"

This is the first time in my life I have ever heard an academician state that he believes that there is such a thing as enough knowledge. But beyond that, by refusing to take the few hours that it would require for such an obviously intelligent person to learn a computer language, Professor Rowney misses a golden opportunity to gain insight into the workings of the computer. If he would, he could possibly come up with new methods of solving problems that might not occur to trained programmers, and he would unquestionably be able to communicate with programmers efficiently.

I urge Professor Rowney and others in similar positions to learn something of programming, not to leave it to professional programmers.

Lee Amon, Corporate Data Analyst
The Center for Professional Advancement
POB H
East Brunswick, NJ 08816

SEE US AT COMDEX

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Archaeologists Dig Microcomputers

Ned and Lou Heite's article in the July 1982 BYTE presents some useful programs based on a sound set of ground rules (see "Breaking the Jargon Barrier," page 76). Nevertheless, they present a misleading representation of the status of computers and microcomputers in archaeology. What is not mentioned anywhere in the article is that the Heites are obviously trying to reach and, perhaps, even characterize *historical* archaeologists, particularly those who work in colonial archaeology on the Atlantic seaboard of the United States, where pipestem dating and mean ceramic-formula dating are most applicable. The nonarchaeologist reader of their article could be led to believe that most archaeologists are put off by computers and rely exclusively on mainframes, if they go near a computer at all. This is far from the case for *prehistoric* archaeologists, at least.

Some form of quantification (usually frequencies and trait lists) has been around archaeology for many years. Use of statistics, including complex multivariate statistics, increased rapidly in the 1960s (presumably as computer time became more available) and exploded in the 1970s (simply check the pages of the major archaeology journals for the last 15 years or so). Archaeologists are just beginning to turn to the use of microcomputers, but their use is bound to increase as university computer dollars become scarcer and as more and more archaeologists are employed outside universities.

Legislation enacted since 1974 mandates consideration of the impact of construction projects (reservoirs, pipelines, transmission lines, power plants, etc.) upon the archaeological resources of the construction site. This legislation has spawned a whole new breed of contract archaeologists, often employed in the private sector, to provide clients with archaeological services that will place them in compliance with the regulations. This breed of archaeologist is doing archaeology and is often heavily reliant on microcomputers for word processing (report turnaround after field work is sometimes almost unrealistically short), database management, data analysis, and, in smaller firms, for accounting, bookkeeping, etc.

Unquestionably, many prehistoric archaeologists do not use statistics, minimally quantify their data, and are intimidated by both computers and the people who know how to use them. It is also the case that many archaeologists, particularly younger ones (and at age 35, I may well be in the transition generation), have become familiar with statistics and computers as part of their graduate education and routinely use both in their work. This group is buying microcomputers and even taking them into the field (I wrote this from a field camp using a word processor on an Apple), then returning to the office to store and analyze data and produce reports (or even do all this while still in the field).

I don't know what meeting it was where only 7 of 700 conference registrants attended the microcomputer session. I strongly doubt, however, that we can infer that only 1% of the archaeological profession is interested in computing.

As microcomputers become more popular, better understood, and less expensive, and as software becomes more readily available (frankly, archaeologists are more users than programmers), I predict that the next microcomputer session at a national meeting will be attended by a much larger percentage of the conferees.

Donna C. Roper
102 North Durand St.
Jackson, MI 49202

Praising the Write Tools

I enjoyed Wayne Holder's article "Software Tools for Writers" (see the July 1982 BYTE, page 138). His plans to create a computer program that uses the techniques outlined in Richard Lanham's *Revising Prose* especially caught my eye. Dr. Lanham, the executive director of the UCLA Writing Programs, realizes that computers can provide much needed assistance for overburdened writing instructors and, more importantly, can offer writers new ways of seeing their writing. BYTE readers might like to know that I have already written a *Revising Prose* computer program, which students at UCLA have used for several years.

The program, called Homer, does many of the things that Dr. Lanham's book suggests writers should do. It isolates prepositions and forms of the verb "to be," counts words and sentences, draws sentence-length graphs, and even scans text for abstract words (which Homer calls woolly words) and possibly nominalized verbs (e. g., action rather than act). It also displays the analyzed text in several interesting formats.

Though UCLA students and staff usually use Homer on our IBM 3033 or our IBM 4341, a microcomputer version also exists. It's written in UCSD Pascal and runs on an Apple II. Charles Scribner's Sons (publishers of *Revising Prose*) has made tentative plans to distribute the program. (A videotape version of *Revising Prose* is already distributed by Charles Scribner's Sons.)

Mr. Holder's interest in software tools for writers deserves praise. I hope to see more from him and others in the future.

Michael E. Cohen, Software Consultant
UCLA Writing Programs
371 Kinsey Hall
University of California
Los Angeles, CA 90024

No Key to Shifty QWERTY's Solution

In his letter to the editor in the July BYTE, C. W. Green observes that the traditional QWERTY typewriter keyboard is inefficient (see "Getting Rid of QWERTY," page 31). Its original efficiency was mechanical—if the keys for letters that are frequently used in combination in the English language were struck in fast sequence, there would have been a mechanical scramble. The layout was efficient for fast typing on a mechanical device. Letters frequently combined in English had to be separated on the keyboard by letters that seldom appeared together.

Unfortunately, generations of typists have gotten used to QWERTY. I doubt that their influence has anything to do with the retention of the keyboard design for computers. When computing started, the number of people trained in typing who used computers was probably minimal.

As personal computers penetrate offices and homes, they are still being used by people who have no typing skills, but because of the computer's proliferation, the opportunity to change the keyboard (to what?) has probably been lost already.

Touch-typing is a skill that is not particularly dependent upon the layout of the keyboard. However, the French have

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learned that a keyboard in ABC order is no more useful for nontypists than any other layout. It probably doesn't matter very much what the keyboard is, as long as people learn touch-typing on something standard.

Incidentally, the numeric organization of a push-button telephone and of a calculator are different, and that doesn't seem to bother too many people.

Ellen Moss Poler
78 East Second St.
New York, NY 10003

As C. W. Green pointed out in his letter in the July BYTE, the Sholes QWERTY keyboard is not the best—in fact, it was designed to be the worst. The blessed Dvorak keyboard speeds typing, reduces errors, and is easier to learn—so they keep telling me. How wonderful!

In a craze of improvement last spring, I yanked off all the keytops on my Ohio Scientific Challenger 1P and put them back on in Dvorak's arrangement. It's great! Too bad I'm too lazy to burn in a new monitor ROM (read-only memory)—but most new software I write can read this new keyboard.

For input systems using light pens or proximity switches, Edward B. Montgomery has found an even better arrangement that allows common sequences of letters such as "the," "and," "-ing," "-ion," "with," etc. to be entered in one smooth sweep of a pen, stylus, or finger. The full story is told in the March 1982 issue of *Computer* magazine.

The Dvorak keyboard was meant for use with touch-typing. Otherwise, it is no better than Sholes. But touch-typing uses both my hands! I like to use my left index finger to keep track of where I am in a listing or table. Until I grow a third arm, I type with one hand.

But if I type with one hand, I must look at the keytops. The keyboard has too many keys for one hand, so I must watch my fingers. Montgomery's system also requires looking. My eyes have better things to do.

So why not invent a completely new type of input device, not just rearrange the characters of a standard keyboard, but find a better mechanical system? One that can be operated easily with one hand and without looking. One that is comfortable to use. I cannot, however, imagine what such a device would be like.

Daren Wilson
POB 197
Union Lake, MI 48085

A number of devices are available that allow one-handed entry of ASCII (American Standard Code for Information Interchange) characters. They generally consist of six buttons; four operated by the fingers and two by the thumb. These buttons produce 64 ASCII characters directly. A new device has just been introduced in England called the Microwriter, from the London-based Microwriter Ltd. It, too, uses six keys, but follows a new coding based on a character's shape. The company is currently seeking a distributor in the U. S. . . M.H.

Call for Articles

I hereby enter a plea for BYTE to devote an issue to that most neglected of computer topics: maintenance and repair.

In the October 1981 BYTE, I described our computer at the Poricy Park Nature Center in Middletown, New Jersey (see "Bridging the 10-Percent Gap," page 264). We have a straightforward system for business, and we run North Star DOS (disk operating system) and BASIC. The system serves our purposes very well.

Our computer is essential, and it's used over 3 hours per day, 5 days a week for, say, at least 750 hours a year. Since we obtained the computer in the fall 1979, we've had one floppy-disk head crash, a new memory board fail after 6 months, and the original memory fail after 3 years. Three hardware failures in 3 years, not bad. Or is it? We don't know. In addition, every few months some disk block can't be read, requiring the use of the backup or some other technique to get it going again.

Our staff members are not computer experts, and they can't recover bad disk blocks, let alone fix the memory. We would gladly pay for a program to salvage a bad disk (e. g., copy all files that are okay), but I've not seen one advertised. North Star won't talk to customers anymore, not even to give advice; it insists we go through dealers. Our dealer moved to Arizona, but, thank heavens, he gives excellent mail and phone service.

Is our experience typical? Who repairs computers? Are service contracts avail-

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able? What are the mean times between failures for memory? disk drives? processors? And how about advice for purchasers, such as to forget the 64K-byte memory card and, instead, split memory on at least two boards so that one can diagnose the other.

There must be lots of people or businesses like ours who have established their system, and whose main interest is not in expansion or new software, but in *keeping the system running*. How about some articles for us?

Paul T. Brady
91 Marcshire
Middletown, NJ 07748

Praise and Advice

Many years ago, we received a complimentary subscription to a new magazine called BYTE. Not only was the name strange, but the publication dealt with a subject matter that was a little over our heads. The subscription lapsed, and the issues which we saved sat on a shelf gathering dust. We threw them out to make some room about three years ago.

Our business, which deals in the sales and service of professional land-mobile radio-communications equipment, was thriving, and we were reading about all the new affordable business computing systems that were becoming available. We decided to do some research into the feasibility of using a computer in our office. But where do we start?

At that time (about two years ago), I remembered the magazine with the funny name and recalled that it spoke about computers. One thing led to another, and we have been subscribers ever since. I can kick myself, however, for throwing out those original issues.

We continue to read BYTE each month, picking up more and more knowledge about the fascinating world of computers from both the articles (which still are a bit over our heads) and from information that we receive through the use of the Reader Service cards.

Finally, we bought a system comprised of an IMS 8000SX computer, an IBM 3101-10 display terminal, and an Okidata Microline 83 printer. These particular items were selected because we saw them work, and each seemed to do an excellent job of what it was designed to do.

Although we were extremely pleased with our new system, we learned that we would literally have to teach ourselves how to use it. For some reason, all of the hardware manufacturers assume that the people who buy their products are computer professionals, but this is far from the case.

Thank goodness we had learned enough from reading BYTE, and we were fortunate enough to have purchased the system from one of BYTE's advertisers (John D. Owens and Associates), who was patient enough with us to get us started on the right track. Otherwise, we might still be staring at the machine.

We were eager to start running some applications programs on our new equipment. While a software consultant was advising us about various accounting programs, we decided to get one of the electronic spreadsheets to play around with. But which one?

Once again, BYTE came to the rescue, this time in the form of Jerry Pournelle's excellent articles, which I thoroughly enjoy and look forward to. It seems that Jerry has the knack of writing a review that doesn't really sound like a review; it sounds more like a story that he is telling some friends. He makes for very enjoyable reading.

In any case, I recalled a recent article in which Jerry mentioned Supercalc from Sorcim, so we decided to give it a try. The first thing we found out was that our IBM 3101 terminal was not listed as one of the terminals supported by this program, but a quick call to the folks at Sorcim showed that they really knew their product well, and they were eager to help. The fellow we spoke to said "no problem," and he proceeded to tell me the few steps that allowed us to configure the software to run with our terminal. After a few moments, everything was working! The sense of frustration that we felt earlier was starting to evaporate, and we were following the well-written users manual that Sorcim provides with Supercalc.

That evening, we configured our first set of sheets with the program. We have been enjoying it ever since. I think I'm really going to like this program.

It's a shame that there aren't some clearly written users guides that can help a first-time user learn what to do after plugging the equipment into the wall. We are sure that the more popular microcomputing systems, such as Apple, Radio Shack, etc., provide such user guides, so

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why can't other companies do the same? It wouldn't have to be too technical, but merely some basic information about how to format disks, what the various operating system commands do and how to use them, how to copy and back up files, and so forth. It would also be a fine idea to mention some good practices to follow, such as making plenty of backups often enough and how to find out whether or not you are going to run out of disk space when you would least want to.

In short, we feel that the field of electronics, computers, and, in particular, information handling is a very dynamic one. The manufacturers should realize that there is tremendous potential in the form of first-time users, *if* they can come out with documentation that is both thorough and understandable.

Please keep up the good work and high quality of BYTE magazine. I look forward to receiving it every month for years to come.

Jules K. Neuringer, President
Portronix Communications Inc.
2106 Bath Ave.
Brooklyn, NY 11214

Maybe Smoke Got in His Eyes

I read BYTE avidly each month and enjoy it greatly. I cannot resist being one of the many (probably) who will write to say that the music pictured in photo 1 (page 447) of the July 1982 issue is *not* "Home on the Range," but a modification of the first phrase of "On Top of Old Smokey." (See "Tuning Up the 1802," page 442.) This, of course, does not detract from the interest and utility of Art Makosinski's excellent article!

John B. Schaefer
Department of Physics
Geneva College
Beaver Falls, PA 15010

Another Name to Drop

As Karim Alim expressed in his letter in the August 1982 BYTE, I, too, have enjoyed Jerry Pournelle's User's Column. (See "What's the Story, Jerry," page 30.) I do not, however, share Mr. Alim's concern about not being able to afford the equipment that Mr. Pournelle uses (if he wrote about the machines I can afford, BYTE readers would grow bored with reviews of 10-year-old portable typewriters).

With regard to Mr. Pournelle's name-dropping: I hope that someday Jerry will drop my name to his friend Adam because I covet owning one of Adam's computers, so I have no objection whatever to Jerry's name-dropping. I also realize that coveting is a bad thing for someone in my profession to do, but honest is honest!

Keep up the good work, Jerry! Mention my name the next time you see your old buddy Adam.

Roland M. Brown III, Pastor
Rodgers Forge United
Methodist Church
56 Stevenson Lane
Baltimore, MD 21212

Post-Warranty Service Applauded

I read BYTE magazine with what might be described as religious fervor, and I've noticed that the Letters section has recently carried several entries discussing many disturbing aspects of manufacturers' warranties. I would like to describe a very positive experience that I had with a manufacturer and service center.

About 7 months ago, I purchased an IDS (Integral Data Systems) 560. The printer performed well for about six months, when suddenly the quality of the print deteriorated. Naturally, I found this disturbing because I had only used the unit for, perhaps, the equivalent of 40 hours of continuous use and the standard 90-day warranty had long since expired. I called IDS on its toll-free customer assistance number and spoke with a technician who patiently walked me through several tests. Though we isolated the problem to some degree, we were unable to rectify it, so the technician suggested I take the unit to a factory-authorized service center for further diagnosis and repair.

I called the service center and set up an appointment to bring the unit by for "walk-in" service on a Sunday. The owner-serviceman quickly identified the problem as a faulty print head and he replaced it. He informed me that the list price for replacement was about $200, but he also noted the unit obviously had not been used very much and that, in his opinion, the failure was probably due to a manufacturer's defect. He volunteered to call IDS and request that the work be covered under warranty. IDS agreed with his assessment over the phone.

Needless to say, I am quite pleased. I think both IDS and the service center should be acknowledged for their exceptionally flexible and fair treatment. I am hopeful that they will set a standard for the personal computer industry.

Cortis Cooper
237 Burleigh
Bangor, ME 04401

Maintenance Concern Covers Canadian Computers

In reference to Lewis A. Whitaker's excellent article "Maintenance Alternatives for Personal Computers" (June 1982 BYTE, page 452), may I offer some information on a third-party maintenance alternative for BYTE's Canadian readers? Because the maintenance companies mentioned in the article (TRW, Dow Jones, and Sorbus) do not operate to any degree in Western Canada, BYTE readers may be interested in knowing that professional computer service is available from Datatech Systems in nine major cities across Canada. Datatech has been in the computer business since 1963 and offers both field and depot service on a wide variety of computer products.

Steve Glover, Field Engineering
Representative
Datatech Systems Ltd.
1095 McKenzie Ave.
Victoria, British Columbia V8P 2L5

No Sale—No Support

This is in response to the letter by Mr. William D. Maudlin of Broadcasting/Recording Productions regarding the decision by Apple Computer to discourage mail and phone discount sales of its products. (See "No Discount—No Sale," July 1982 BYTE, page 31.)

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CONSIDER THE FEATURES—Only PrintMate™ 150 offers so many ways to get your message across: graphics; display fonts; downline loadable character sets; high print speed; advanced logic seeking; 15 inch wide carriage; a variety of forms and paper capabilities and; friendly "SoftSwitch™" interaction. The PrintMate™ 150 is the responsive performer that perfectly mates with your microsystem or personal computer. With prices beginning at $995, it is evident that the PrintMate™ 150 is the superior performer in function and price.

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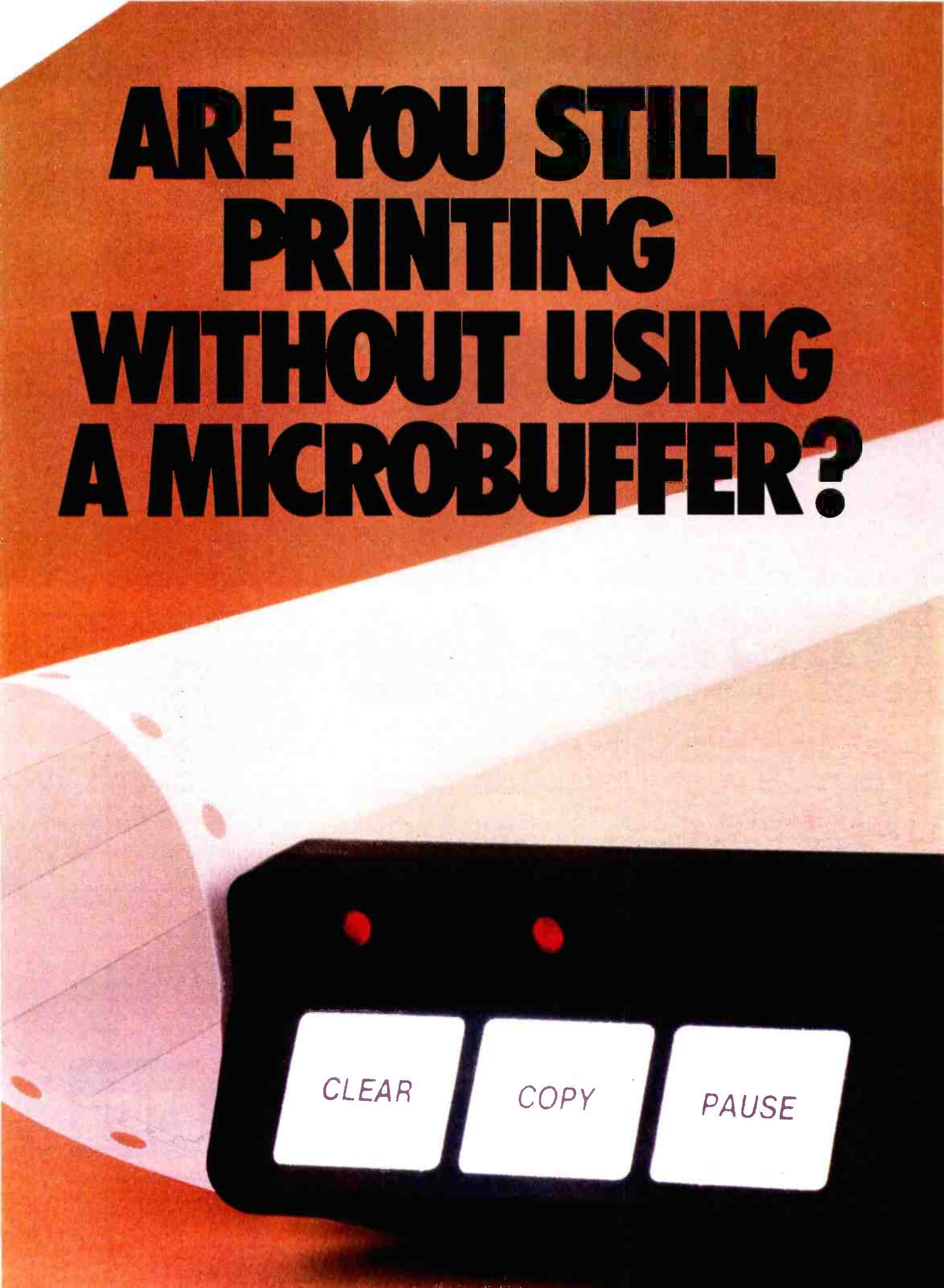
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WHY?

USING YOUR COMPUTER TO DRIVE YOUR PRINTER IS A WASTE OF TIME.

While your printer is running, your computer is tied up . All you can do is twiddle your thumbs until the program is finished.

MICROBUFFER ALLOWS YOU TO PRINT AND PROCESS SIMULTANEOUSLY.

You just dump your printing data directly to Microbuffer, whoosh!, and continue processing.

Microbuffer accepts data as fast as your computer can send it. It first stores the data in its own memory buffer, then takes control of your printer.

It's that easy.

THERE IS A MICROBUFFER FOR ANY COMPUTER/PRINTER COMBINATION.

Microbuffers are available in Centronics-compatible parallel or RS-232C serial versions.

FOR APPLE II COMPUTERS, Microbuffer II features on-board firmware for text formatting and advanced graphics dump routines. Both serial and parallel versions have very low power consumption. Special functions include Basic listing formatter, self-test, buffer zap, and transparent and maintain modes. The 16K model is priced at $259 and the 32K, at $299.

FOR EPSON PRINTERS, Microbuffer is $159 in either an 8K serial or a 16K parallel version. The serial buffer supports both hardware handshaking and XON-XOFF software handshaking at baud rates up to 19,200. Both interfaces are compatible with Epson commands including Graftrax-80 and Graftrax-80+. Both are user-expandable to 32K.

ALL OTHER COMPUTER/PRINTER COMBINATIONS are served by the in-line, stand-alone Microbuffers. (Pictured here, twice actual size.)

Both serial and parallel versions are expandable up to 256K.

The serial stand-alone will support different input and output baud rates and handshake protocol. The 32K model starts at $299, $349 for 64K, and 64K add-ons (for up to a total of 256K) are just $179.

SIMPLE TO INSTALL.

Microbuffer II is slot-independent. It will fit directly inside the Apple II in any slot except zero.

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Nov. 29-Dec. 2, 1982
Las Vegas Convention Center
Las Vegas, Nevada

I would like to applaud Apple for supporting its authorized, full-service dealers. On several occasions, I have lost a sale to a discounter only to have the customer come back to me when his or her discount dealer failed to provide any post-sale service. My customers do not seem to mind paying a fractionally higher price initially because they realize that in the long run, if anything goes wrong, I'm here to help.

I would also like to thank Mr. Maudlin for saving full-service Apple retailers the time which would have been wasted on a customer who seems to find getting a discount more important than getting good service.

Finally, I would like to say to the full-service retailers of the product that Mr. Maudlin did purchase that if he comes to you for service, tell him to go see the dealer who sold him the equipment.

Randy Piscione, Sales Representative
Light Computer Centre
1 Yorkdale Rd.
Toronto, Ontario, M6A 3A1
Canada

Letter Off Base

The July 1982 BYTE included a letter about the Base 2 Inc. printer from Victor Ung (see page 16). The letter implied that Base 2 Inc. could be contacted through Advanced Computer Products. This is to inform BYTE and its readers that Advanced Computer Products Inc. is not, and never has been, associated with Base 2 Inc.

Tom Freeman, Vice President
Advanced Computer Products Inc.
POB 17329
Irvine, CA 92713

Gimme That Old BASIC Language

You can keep your Pascal, keep your Ada, keep your C because if I can have the BASIC described by Thomas Kurtz, I'll be a happy man. (See "On the Way to Standard BASIC," June 1982 BYTE, page 182.)

That, however, brings up this question: how soon can we expect to see the new standard BASIC implemented? Obviously, Professor Kurtz's committee has no control over that, but I wonder if BYTE could poll IBM, Apple, Tandy, Commodore, etc. to find out when these manufacturers expect to release standard BASIC implementations for their computers.

Steve Switzer
108 Lequer Rd.
Port Washington, NY 11050

Stick by Ads

Dr. Alan Wilcox recently implored BYTE to carry only advertisements that are directly related to computers and computing. (See "Stick to Computers," August 1982 BYTE, page 34.)

Great. I can hardly wait to see the subscription price rise as BYTE tries to make up the lost revenue.

I don't care how many pages of advertising appear in each issue of BYTE, or what products the ads are pushing. If a reader doesn't like an ad, he can simply turn the page.

Michael Truffer, Publisher
Skydiving
POB 189
Deltona, FL 32725

Program Takes Up CPM's Slack

Steven Zimmerman and Leo M. Conrad's article describing CPM (Critical-Path Method) and introducing a BASIC program to solve scheduling problems was, for me, very timely. (See "Programming the Critical-Path Method in BASIC," July 1982 BYTE, page 378.) I have modified their program to run on the IBM Personal Computer and am presently adding an input/output section more suited to my applications. To test the program, I have used, as data, the sample CPM that appears in "The ABCs of the Critical Path Method," by Levy, Thompson, and Wiest (*Harvard Business*

Review, September 1963). I heartily recommend this article to those just learning CPM. The program ran flawlessly, but it lacks a feature that I have incorporated and present here for BYTE readers (see listing 1).

The Slack Time calculation performed by the BASIC program is the same variable as Total Slack cited in the *Harvard Business Review* article. This number is the total amount of time an activity may slide without forcing a delay of the overall project-completion date. Such a number is useful when tight control can be kept on those activities that follow the delayed activity.

However, in the real world, delaying the start of an activity often affects its cost and its duration (due to availability of manpower, for example). What the project manager needs is a figure that indicates how much an activity may slide without impacting the Early Start Time of subsequent activities. This number is described in the *Harvard Business Review* article and is known as Free Slack. By definition, it cannot exceed Total Slack and, most often, it will be less than the Total Slack.

By making just a few changes to the Zimmerman and Conrad BASIC program, Free Slack calculations can be added to the already powerful scheduling tool. The revisions are shown in listing 1.

When applied to Zimmerman and Conrad's test data, running a normal time analysis yields some interesting Free Slack times. For instance, activity F appears to have a Slack Time of 39.7 weeks. Yet the Free Slack figure reveals that a slide of only 23.7 weeks can be allowed without affecting the Early Start times of activities M and O. This is not an attempt to prove that either slack-time calculation is the more important. However, having both calculations available certainly increases the utility of the CPM program.

Listing 1

```
  60 DIM A$(D%,2),A(D%,14),SV(12)
1301 REM FREE-SLACK VARIABLE CALCULATONS
1302 FOR I=1 TO M%
1303 MIM=99999
1304 FOR J=1 TO M%
1305 IF A(I,2)=A(J,1) AND A(J,8)<MIM THEN MIM=A(J,8)
1306 NEXT J
1307 IF MIM>99998 THEN A(I,14)=0 ELSE A(I,14)=MIM-A(I,9)
1308 NEXT I
1320 PRINT"CODE DESCRIPTION USED     EARLY   EARLY    LAST     LAST
     TOTAL    FREE"
1330 PRINT"                     TIME     START   FIN      START    FIN
     SLACK    SLACK"
1385 PRINT USING C5$;A(I,14);
```

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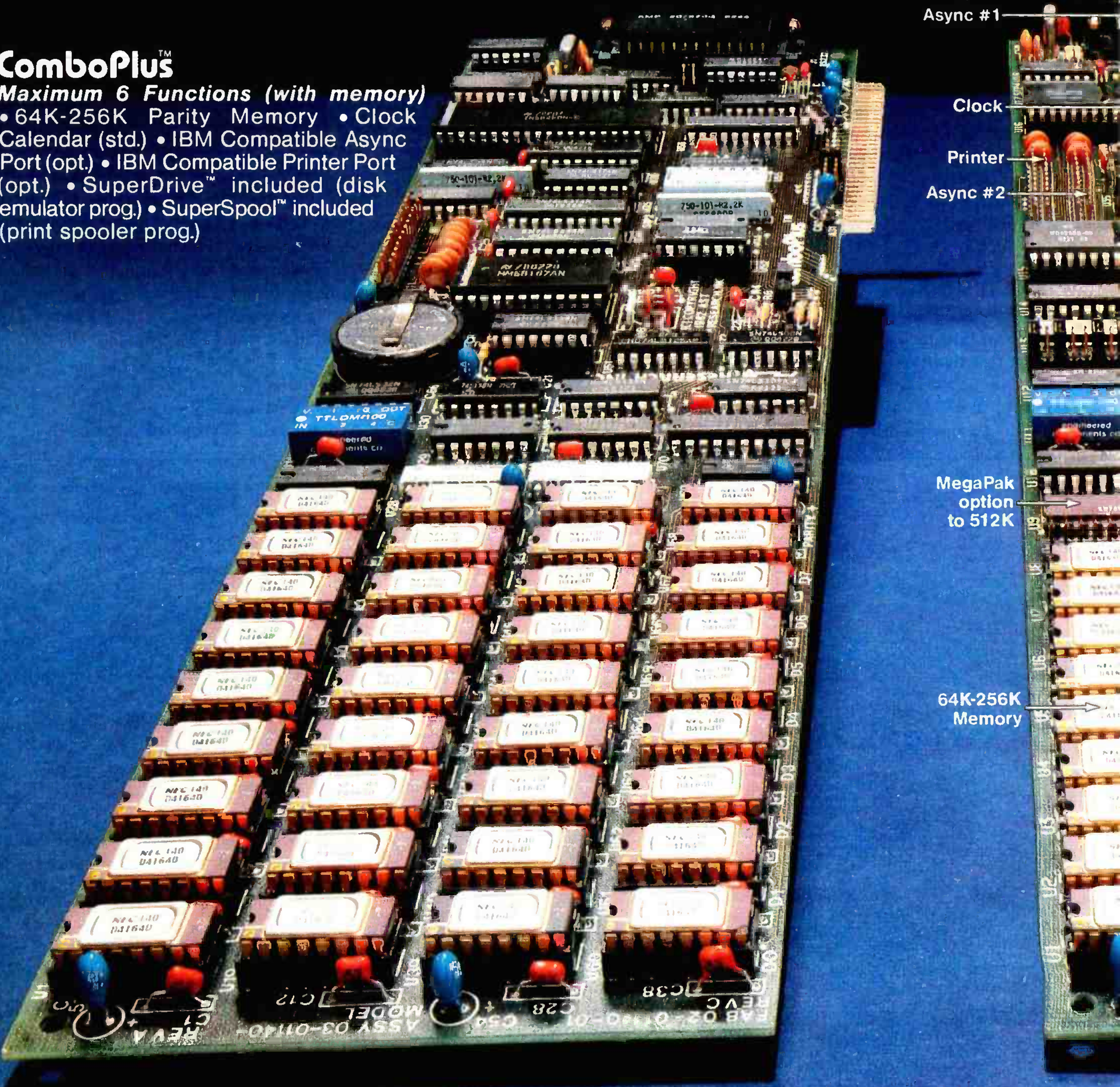

Other products available for IBM PC: 1) 2780/3780 Bisync Emulation Package; 2) Advance Communication Card (Async, Bisync, SDLC, HDLC); 3) Expansion Parity Memory (64K-256K); 4) Disk++ (memory, Async & disk host adaptor); 5) Original Memory Combo; 6) Async Communication Card (1 or 2 ports); 7) Wire Wrap Card 13.1" x 4"); 8) Extender Card; 9) 327X Emulation. AST products are now available from your local Computerland stores and selected dealers throughout the U.S.

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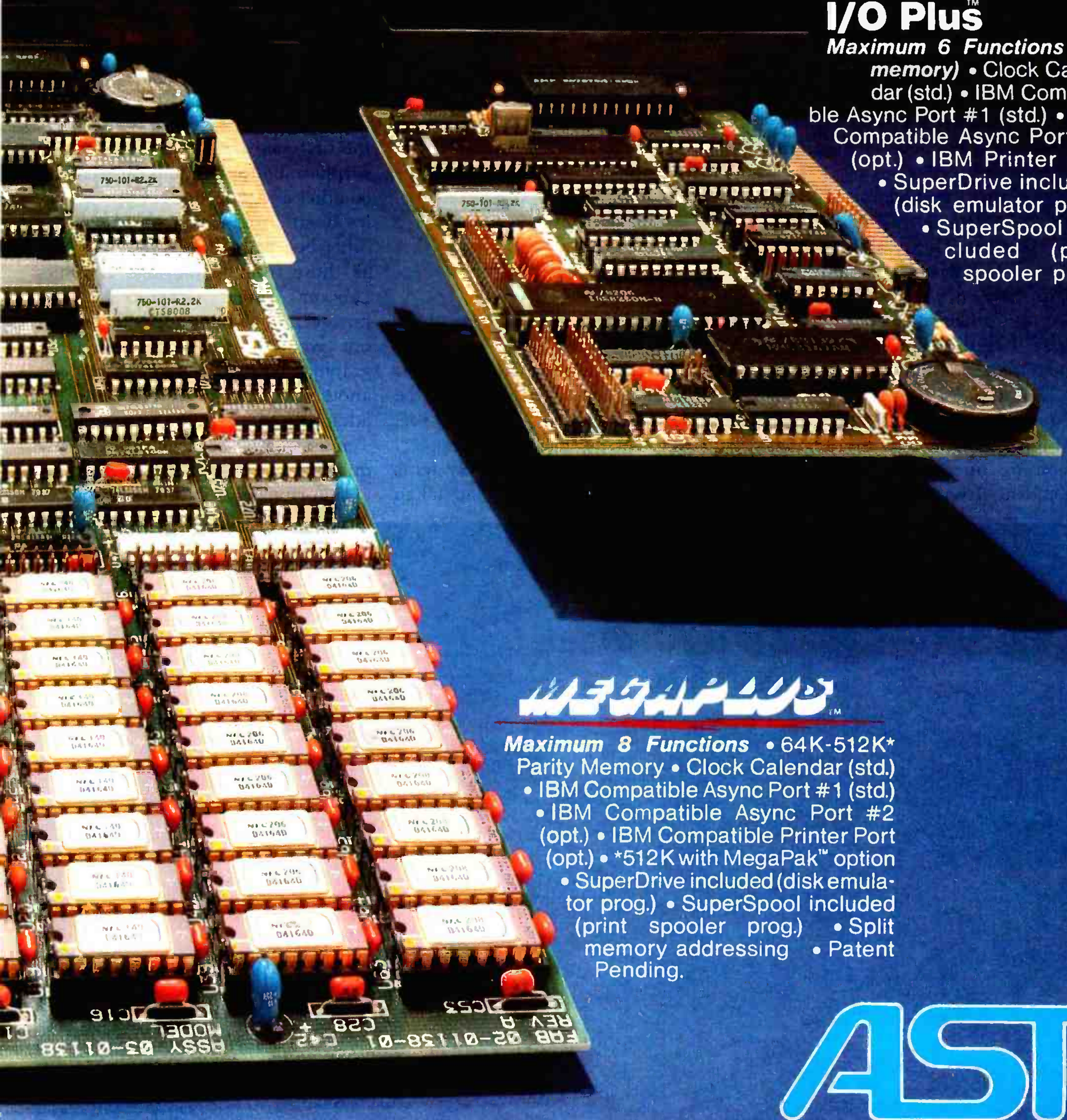

I/O Plus™

Maximum 6 Functions (no memory) • Clock Calendar (std.) • IBM Compatible Async Port #1 (std.) • IBM Compatible Async Port #2 (opt.) • IBM Printer Port • SuperDrive included (disk emulator prog.) • SuperSpool included (print spooler prog.)

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The Third NCGA and the Future of Computer Graphics

A survey of the current state of computer graphics.

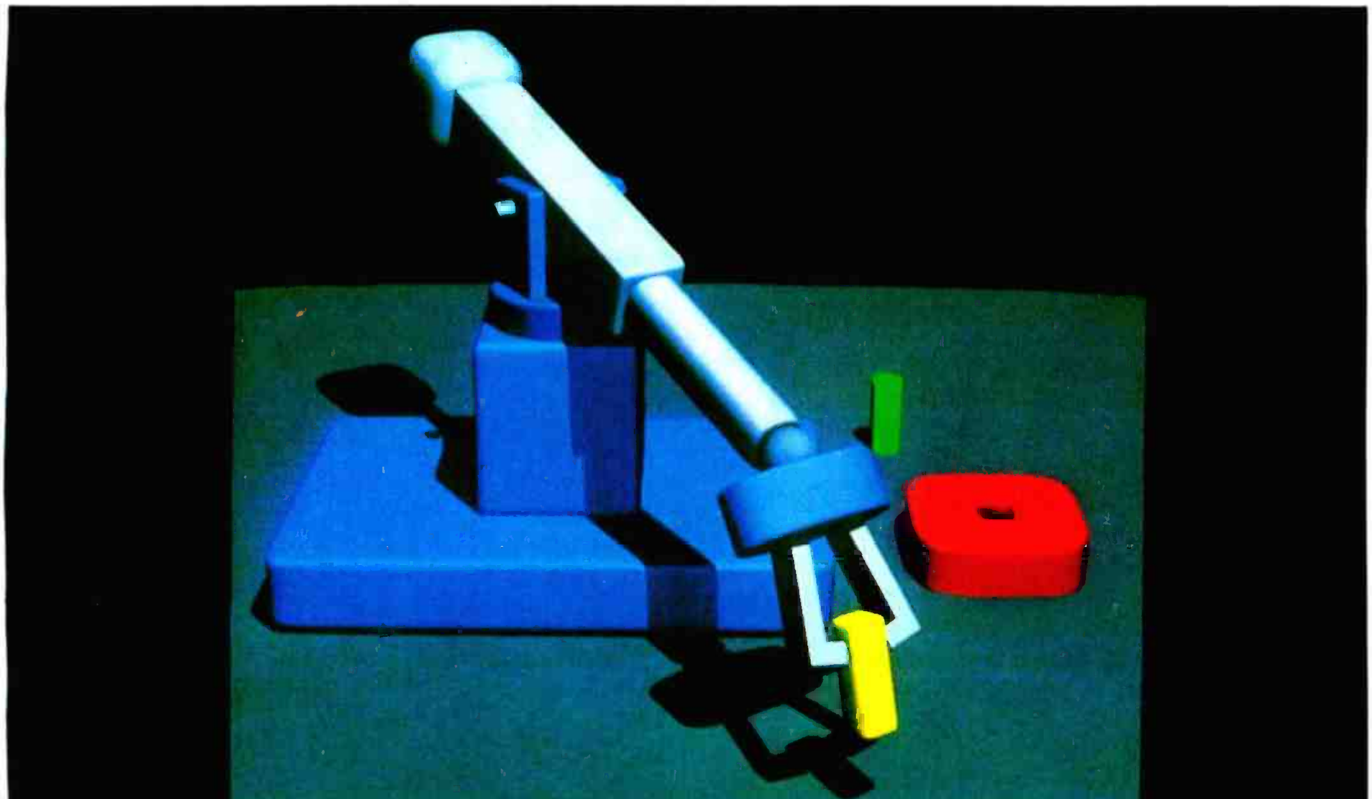
Alexander Pournelle
c/o Workman & Associates
112 Marion Ave.
Pasadena, CA 91106

Drafting Dan never materialized, but a lot of his relatives did.

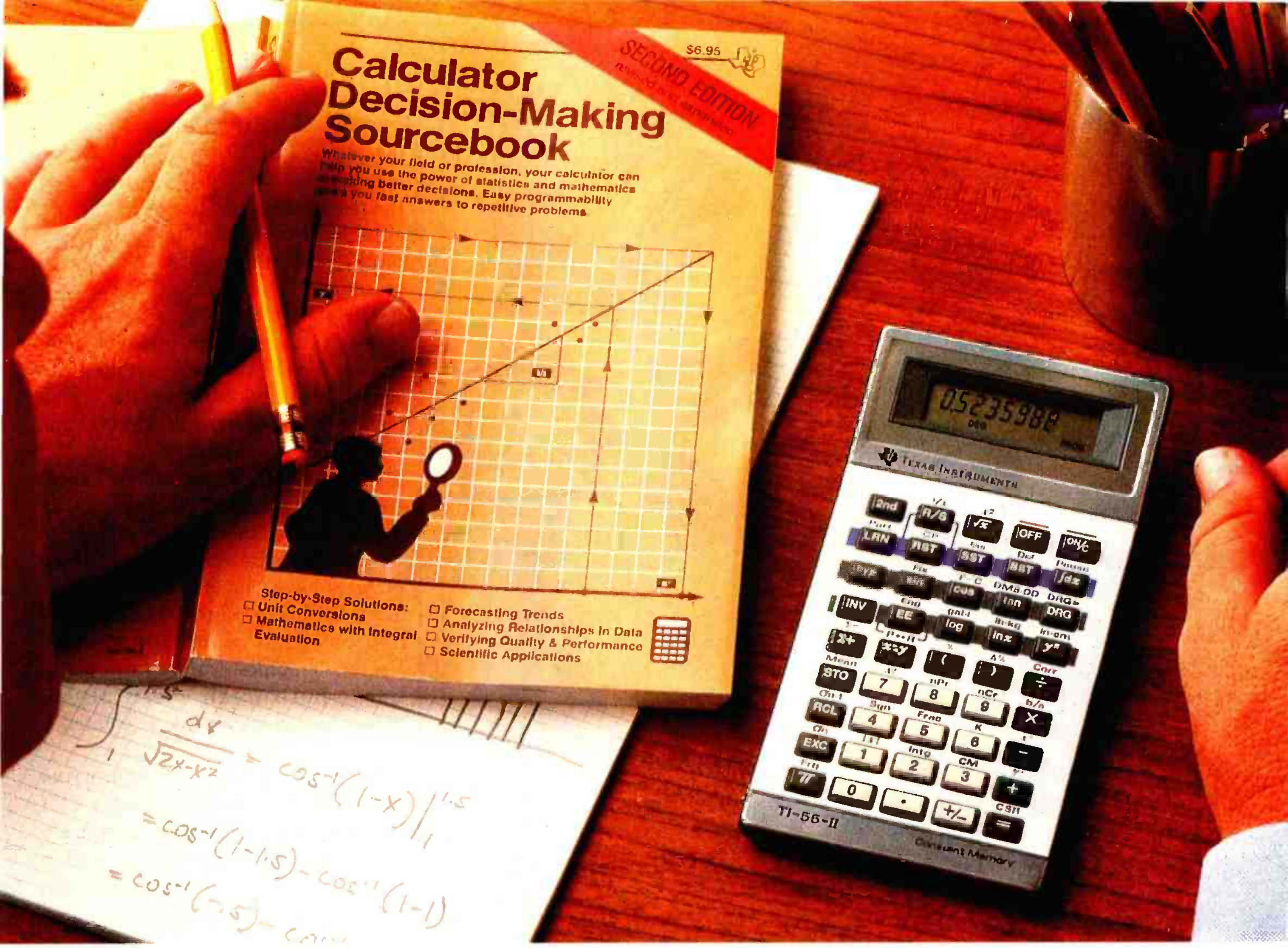
For those of you who haven't read Robert A. Heinlein's *Door into Summer*, Drafting Dan was a cross between a typewriter and a drafting board. And since I've never been very good at drawing except with a T square, I've always been interested in something that could do what Drafting Dan did. As a result of this, and because I'm also interested in film-making, another industry that's becoming increasingly computer-dependent, I was especially eager to attend the third annual meeting of the National Computer Graphics Association (NCGA) in Anaheim last June.

Basically, I went to see what the normal BYTE reader might go for: upgrades for my personal computer, a California Computer Systems machine named Helen. I had taken the first step when I'd bought a $99 surplus monitor a month earlier. But I couldn't afford a Microangelo graphics board from Scion or any of the other boards for the S-100 bus, such as those from Cambridge Graphics Lab or Digital Graphics. I did, however, have faint hopes that someone would unveil a cheap add-on graphics system. And there was another economic justification: I'm addicted to Atari's arcade game Tempest, and I'd like to save my quarters.

Unfortunately, it took only about



A picture generated on a Raster Technologies graphics terminal. You might see similar computer-generated pictures used as backgrounds in Revenge of the Jedi *(the next* Star Wars *episode). George Lucas has invested heavily in computer graphics. (Photo courtesy of Raster Technologies.)*



How the TI-55-II makes short work of long problems.

Whenever you can solve complex problems quickly and accurately, you're ahead of the game. And that's exactly what the TI-55-II does for you. By giving you 112 pre-programmed functions (like definite integrals), it allows you to take short cuts without losing accuracy. You'll accomplish a lot more in less time which means increased efficiency.

With our TI-55-II you can tackle problems you thought could only be solved with higher-priced programmables. You're not only getting the standard slide rule functions but also statistical capabilities. This way you can work out linear regressions, permutations and combinations, just to name a few.

The TI-55-II also gives you enough programmability to eliminate a lot of repetitive key punching. Our Constant Memory™ keeps programs and data on tap, even when the calculator is turned off. So once you've entered a formula, you can simply put in the variables to get your solution. The Liquid Crystal Display shows your answers in standard, scientific or engineering notations – clearly and precisely.

We also help you get the most out of your calculator with the Calculator Decision-Making Sourcebook. It gives you step-by-step examples of the best techniques used for solving mathematical, scientific and statistical problems. And we've included a special section on how to program your TI-55-II.

So next time you're facing another time-consuming problem, cut it down to size with the TI-55-II.

TEXAS INSTRUMENTS

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20 minutes to see everything I could afford. Out of the 162 booths, very few were offering affordable machines. But I thought I might as well get my money's worth, and I saw the rest of the show because I may be able to buy something next year; prices seem to be about ready to plummet.

The show's focus was high-priced machines and high-budget companies; there was little interest in consumer graphics. Most of the equipment for sale started at $15,000 and went quickly upward.

Some of these systems were expensive vector systems, but the focus of this article will be on raster-based color graphics. (Raster scanning draws pictures like your television does; an electron beam scans hundreds of horizontal lines from left to right. Vector graphics can draw actual lines—horizontal, vertical, or diagonal—wherever one is wanted.)

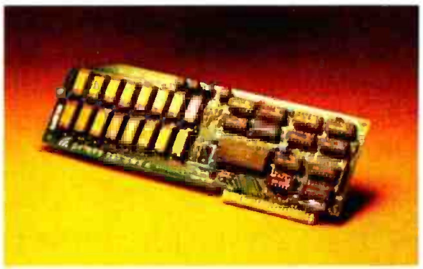
Blueprints Today; Art Tomorrow

Drafting Dan's relatives use a CRT (cathode-ray tube) instead of a drafting board. They are known collectively as CAD/CAM machines, short for computer-aided design/computer-aided manufacture. Airplanes, integrated circuits, and cars are all designed with "eraserless easels" these days; it was a billion-dollar business last year. New CAD/CAM machines, plotters, and printers took up a lion's share of the show. And they're still a bit too expensive for most personal and small-business uses. Even the Apple-based drafting machine was about $15,000. But that's going to come down; my father's first computer, Ezekial, cost $13,000 five years ago. Ol' Zeke can be duplicated for about $5500 these days.

The major costs of computer graphics are easy to separate: memory, CRT, output, processor, and software (roughly in order of price). The mechanical parts have remained high-priced—as my dad puts it, "Silicon is cheap, but iron is expensive." Old machines have gradually been replaced by smarter new ones. The plotter and printer are the oldest (and most mechanical) hard-copy computer output devices. A few new

I run out of memory?"

Most people *do* run out of memory with only 18K VisiCalc* workspace. But you can expand your Apple II* to 177K VisiCalc memory! You can also get 80-column display, lower case letters, and hard disk support—all without buying a bigger computer.



The Saturn expansion system for VisiCalc consists of a preboot diskette, one or more plug-in RAM boards, and an optional 80-column display board. You can put the Saturn boards in any slot. And with all that memory, our software lets you save files on more than one diskette.

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Ask your computer dealer for more details about the Saturn memory expansion systems. See how much bigger and better your models can become!

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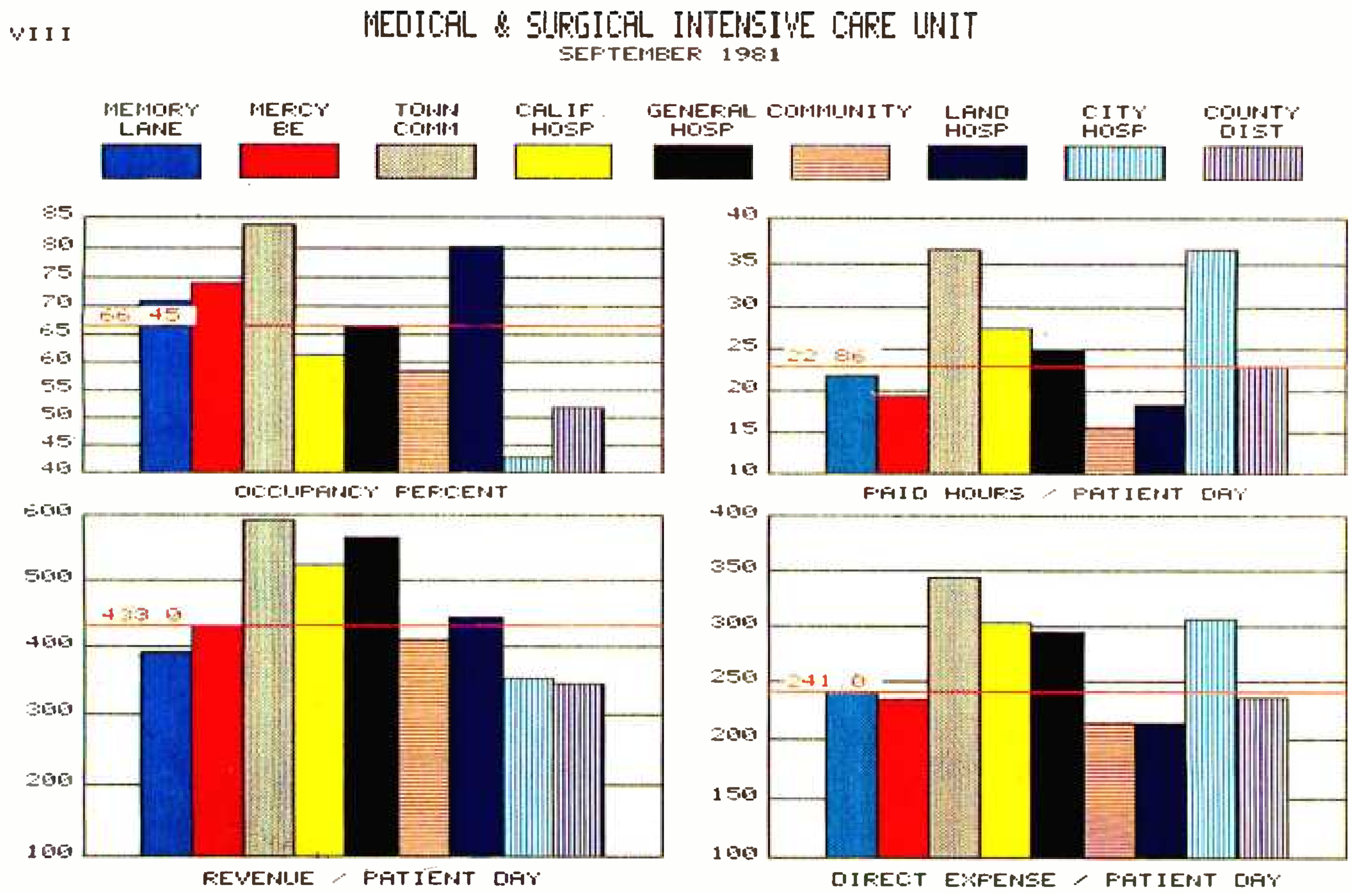

Figure 1: *Color offers opportunities for informationally dense diagrams. This is one of the standard graphs offered by Infographics. (Graph courtesy of Infographics Inc.)*

devices, like the copier/plotter and microprocessor-based miniplotter, have reduced prices. Multipen plotters are slow to make solid colors, and color copiers are still expensive. Everyone may like color, but few can afford it.

Color Output for the Masses

Two companies, Infographics and Comshare Target, announced a color-output service from your data; both use the Xerox 6500 laser printer to generate the final images. The companies are after different markets: one is starting a chain of "graph shops"; the other is selling an Apple-only software package that works over the phone.

Infographics offers transparencies, slides, and prints from your data. It works like this. You bring your rough data to the salesperson/data-entry person at a local retail store, and you select colors and graphs from the examples, resisting the more garish color combinations. The salesperson enters your data and sends it to the printing center, where it's printed and mailed to you (see figure 1). Infographics offers only pie and bar charts, with data entered manually through a menu-driven CP/M system. Unfortunately, it can't take disk files. Normal turnaround is about a week. Infographics is negotiating with a printing house to offer color separations with as little as a 48-hour turnaround.

The other company, Comshare Target, has a service that starts with an Apple II display assembly/transmission program for $175. Called the Image Maker, this package helps you construct bar, pie, or line graphs. Although you can use most other graph packages to make your graphs, you still need the Image Maker to send them. When you're satisfied, you send your images to Atlanta over a modem, where they are run off as slides, transparencies, or paper copies and mailed to you. Comshare Target offers image enhancement for the Apple's low-resolution pictures at no extra cost. (This company also sells the $50 "visiclone" package called Plannercalc.)

Both services run about $10 a slide, though the cost goes much higher for rush delivery. I think several more companies will offer similar services soon, although no one would say anything.

Yes, you can still take pictures of your monitor for slides, but the results are the same as ever. Bad color, long exposures, improper framing, and graininess will keep you from getting good pictures unless you have a $4000 monitor and $5000 worth of graphics equipment. Even then, you won't get results as good as the commercial services offer. Setup, development, and getting the room dark enough are also problems for homebrew systems; if you must have good pictures, these services are worth it.

The new Videoslide 35 from Lang Systems is another alternative; it's a

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No one gives you more in an ergonomically engineered smart terminal than Wyse.

These days there's little room for waste of the corporate dollar. And these days the WY-100 smart terminal looks even better when you compare it to the other guys.

You definitely get more from Wyse — the leader in low-cost, high-performance, ergonomically engineered smart terminals.

To begin with, you get a great looking terminal that features die cast aluminum packaging and takes up a minimum of desktop space.

You also get a terminal with an uncanny way of pleasing people. It comes with an easy-on-the-eyes green phosphor screen. And a fully tilting/rotating display and detached keyboard. (After all, one person's just-right-tilt is another's not-quite-right-tilt).

When the workload seems impossible, horizontal and vertical split screen capabilities with independent scrolling allow you to be in two places at once.

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Of course, all of this wouldn't mean much if you couldn't count on Wyse quality. That's why each WY-100 is put through an extensive on/off testing program.

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35mm camera pointed at a small CRT, designed to make screen copies from nearly any low- to medium-resolution raster system. It produces better slides than you can get with a Dealin' Electronics bargain CRT and your Instamatic. It was so new that a camera hadn't been decided on. A spokesperson said that it would be one of "all the usual suspects." Businesspeople with confidential data might buy one of these rather than risk the services. The Videoslide 35 is built and shaped like a big brick, will retail for about $2500, and will take the new Polaroid instant films.

The VT-100 Battle

Most of the machines I saw at the show were designed almost as stand-alone systems with on-board microcomputers and disk drives. Although the heavy computation still falls on the host, these machines do much on their own. With the number of nongraphics terminals already on the market, though, it's no surprise that add-on graphics kits have been developed for some familiar terminals.

Probably the most hotly contested terminal market in graphics today is VT-100 upgrade and emulation. This Digital Equipment Corporation terminal has been regutted, retubed, revised, and replaced by no fewer than five companies—if you also count the original manufacturer. Included in this group are Data Type, Digital Engineering, ID Systems, and Selanar. Visual Technology produces a VT-100 emulator. The companies claim their monochrome graphics boards ($1000-$1500) can all be installed by sliding in a circuit card. The color modifications require you to send the terminal in for a new picture tube, but allow colorful letters, graphics, and symbols. None of the boards are compatible, so be careful in upgrading your VT-100 terminal.

A few other terminals, most notably the Televideo 900 series, also had upgrades on display, but there was none of the fierce competition of the VT-100 upgrade battle.

Consumer Graphics

As microcomputers and memory get cheaper, the price of the average graphics system has gone down. Since no end to the price reductions is in sight, today's high-end is probably next year's personal. Most people at the show seemed to think that "Joe Basic" had no more need for high-density graphics than he did three years ago for home video recording; fortunately, some companies still have vision. Who would have thought that a cheap, low-density color-graphics system—named after a fruit—would sell almost 400,000 units a year?

Yet I have to agree with those who think the Apple and the IBM Personal Computer are dead ends. Neither has expandable screen memory; both are too dependent on single manufacturers. The personal graphics standard of the future does not exist yet.

One real surprise at the show: Intelligent Systems Corporation, the people who brought you the first 8080-based color-graphics system these many years ago, is still around. It still supports the Intecolor 8000 series, but says it was not a great commercial success. This company also exhibited a new CP/M-based color-graphics system, the IGS.

Scion had a new Screenware Pak for a newly revised Microangelo board; it also showed the Mightyangelo, a stand-alone graphics/text terminal designed to talk to a host machine, and a high-quality monitor. Don't expect to see the Mightyangelo in ads soon; it's designed as an OEM (original equipment manufacturer) machine. Replacements for the Microangelo using the 8086 or 68000 microprocessors might appear by spring.

One significant drop in the price of a good picture has occurred: Amtron was showing off its "under $3500" very-high-resolution monitor having a bandwidth of 50 megahertz—more than eight times greater than that of a home television set! This is very good news indeed, for no one else offers anything similar for less than twice the price. Amtron's announcement may trigger a real price war, lowering systems prices.

If You Have to Ask, You Can't Afford It

A rule of thumb I discovered at the convention: anything in a desk starts at $50,000. A few people are trying to combat this, though. The Electro-Optical Information Systems "dinosaur killer" graphics/frame grabber system, based on a Godbout Compupro S-100 box, starts below $11,000. (A frame grabber stores one TV image for later processing.)

Conrac, longtime maker of monitors, seemed to be running scared of the Japanese manufacturers. Rather than its usual one new product a year, it's shooting for two or more. The Japanese meanwhile showed no systems (yet), but they did show new "bottles" (as picture tubes are known in this business).

No replacements for the CRT were displayed, though many were talked about. Few people seemed to think that CRTs would die. With all the new flat screens on the horizon, I don't think replacements can be ruled out. If CRTs are simplified or superseded, the cost of high-quality graphics will fall drastically.

The biggest crowds at the convention were around Genisco's Spacegraph, a very expensive 3-D-like display. I think 3-D will be useful, though it may take a while (a while, in this business, is defined as longer than to the next NCC). Genisco achieves the 3-D effect with a moving mirror. It's a good way to study objects. The system's major fault is translation to paper, but holograms should solve that. No holographic output devices yet; maybe at the next show.

Trading picture density for colors is a big thing. It allows you to have big, less colorful pictures, or smaller, richly detailed ones. The AED512 graphics terminal from Advanced Electronics Design allows three pixel (picture element) densities: 512 by 512, with 256 colors; 1024 by 512, 16 colors; or 1024 squared, 4 colors. It's

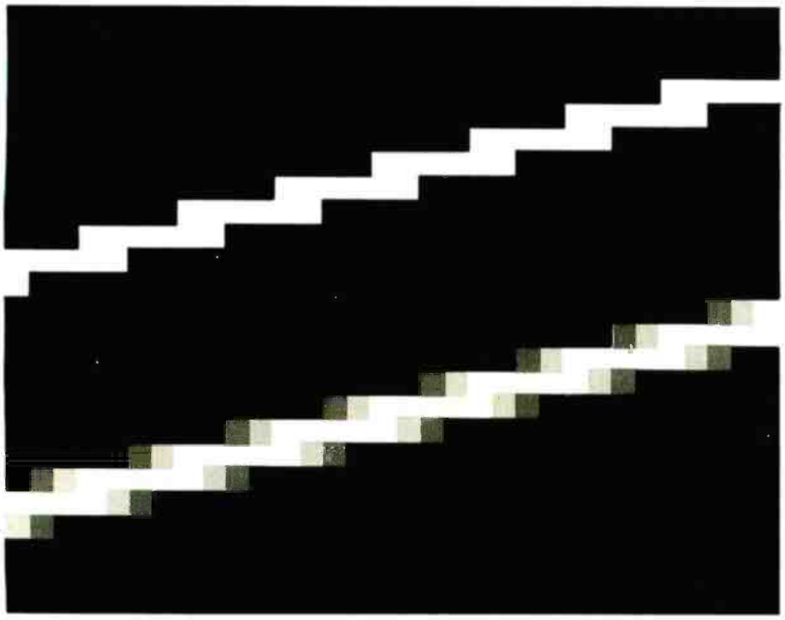

Figure 2: *Anti-aliasing is a way of making edges look less rough. This is accomplished by illuminating the jagged parts at lower intensities so that they blend into the background. The top figure, which depicts a line without anti-aliasing, looks much rougher and unnatural than the bottom one, which has it. The Jupiter 7 graphics terminal is significant because it does this automatically.*

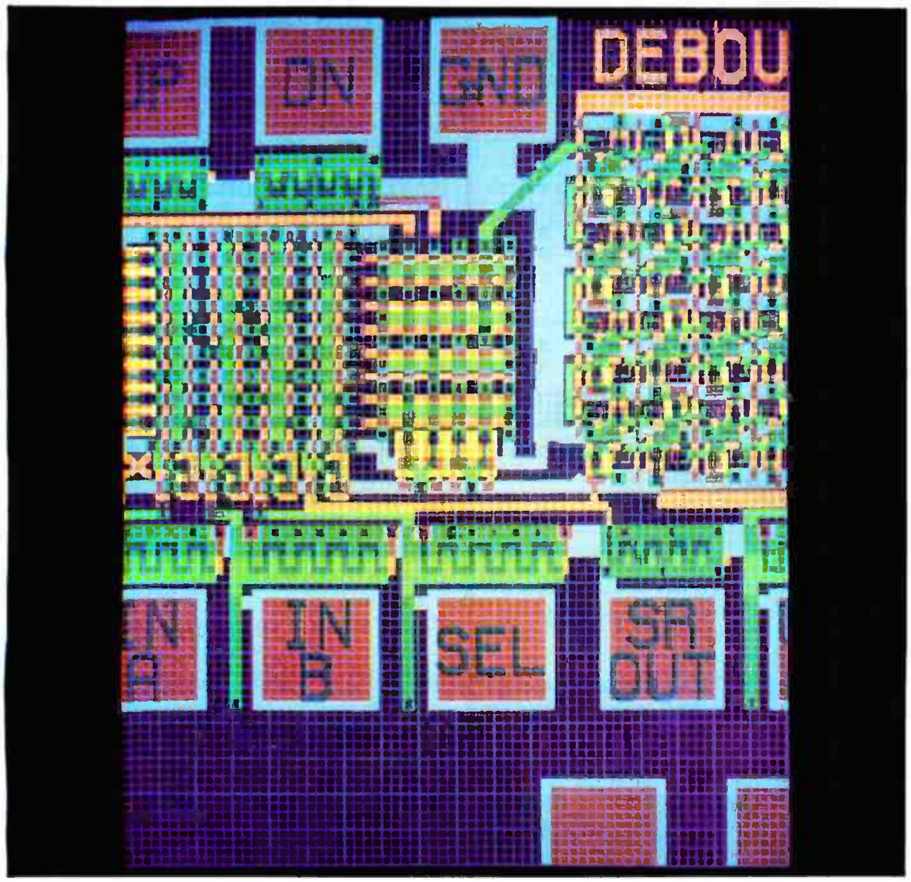

Photo 1: *Computer graphics are used most frequently in designing integrated circuits. This image was produced on a Jupiter 7 graphics terminal. The blue grid is for reference and can be removed by a keyboard command. (Photo courtesy of Jupiter Systems Inc.)*

also relatively inexpensive (under $20,000, currently).

In the computer world, a "standard" seems to be established in only two ways: some very large company sells a whole bunch of something, or a number of small companies sell a few very similar things. Every once in a while this rule is broken; such is the case with the Jupiter 7 graphics terminal from Jupiter Systems.

The Jupiter 7 is surprising. It's plug-compatible with the AED512, which means a standard has been established—without either manufacturer selling very many units. And it has built-in *anti-aliasing* (see figure 2 and photo 1) and two joysticks. Like the AED512 and most of the other big systems, it also has expandable memory; you could start with a smaller display and buy upward later on. Jupiter Systems is one of those "grads-to-riches" stories deemed impossible because of the economy; the company literally did not exist two years ago. A good example of American ingenuity at work.

Another new company, Raster Technologies, was started a year ago by two Rensselaer Polytechnic Institute graduates and now has a full line of medium-priced raster-screen machines. It will probably expand downward soon; its founders realize the size of the marketplace. Steve Coit of Raster Technologies said it best when he remarked to me that "the Polaroid Colorpack II of the video world is coming."

One of the really amusing developments at the show was the number of CP/M-compatible systems. Nearly everyone, big or small, had CP/M available. I guess the graphics world needed a standard, and they chose the most popular. I had thought that Unix, the much-hallowed system for big machines, would have cleaned up, yet no one but DEC had a single machine running it.

One conclusion I reached before the show was over: even more than other parts of the computer world, graphics people live out of each other's pockets. The computers, most peripheral devices, and even many of the software packages were the same from one booth to the next. So many

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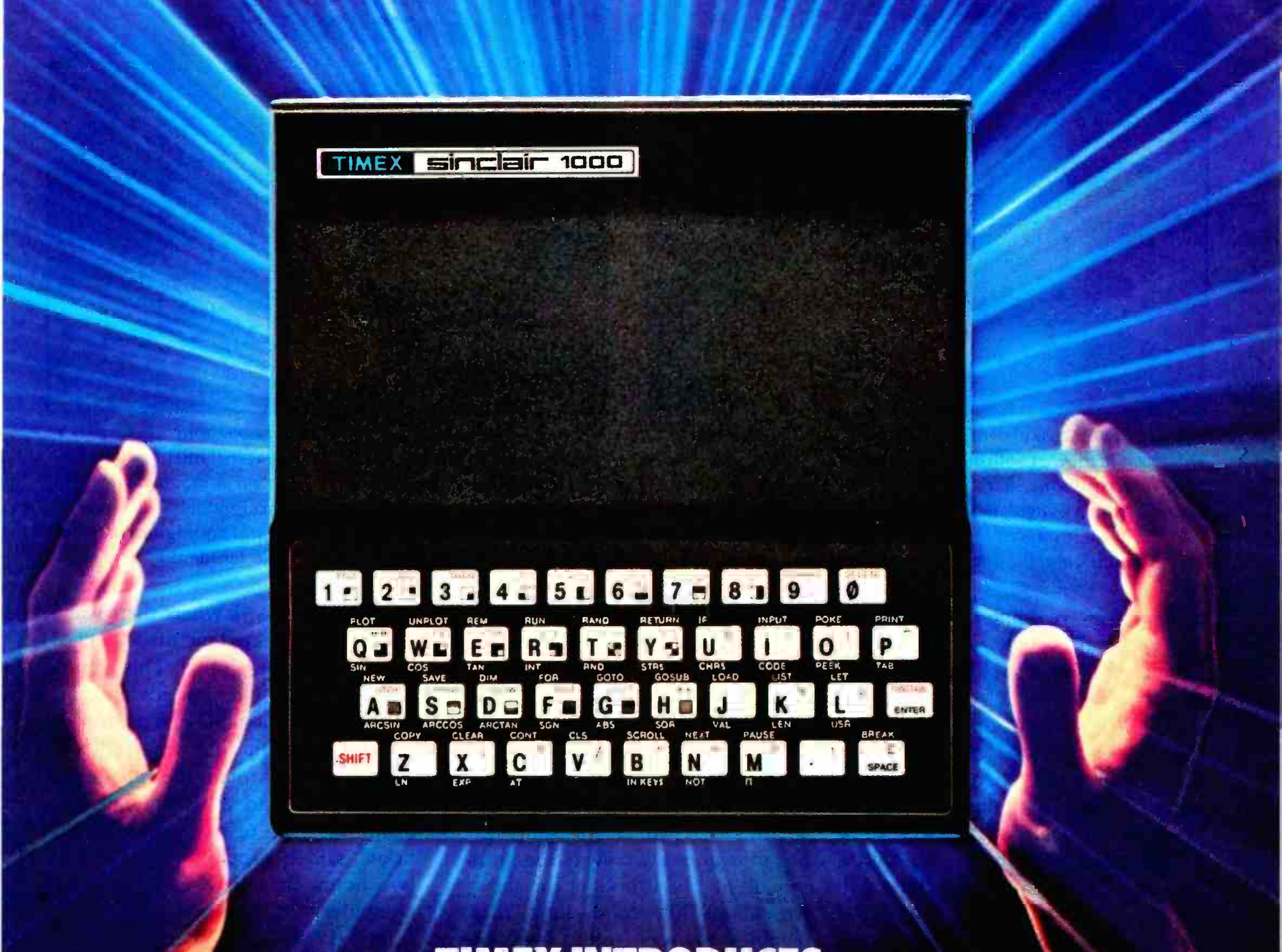

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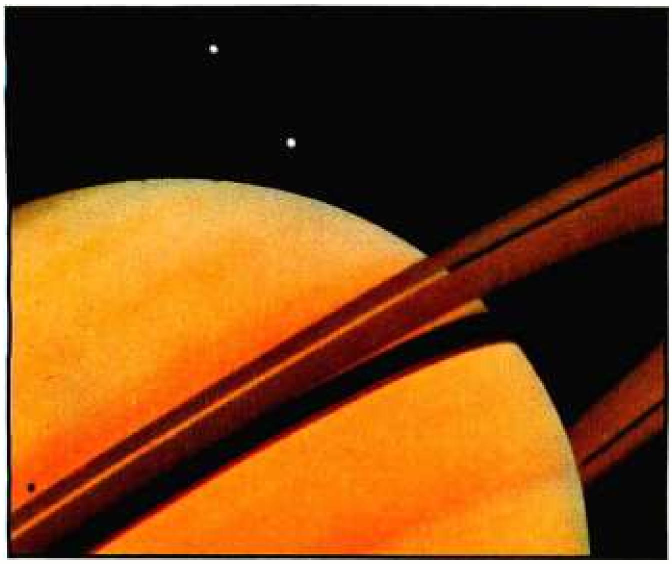
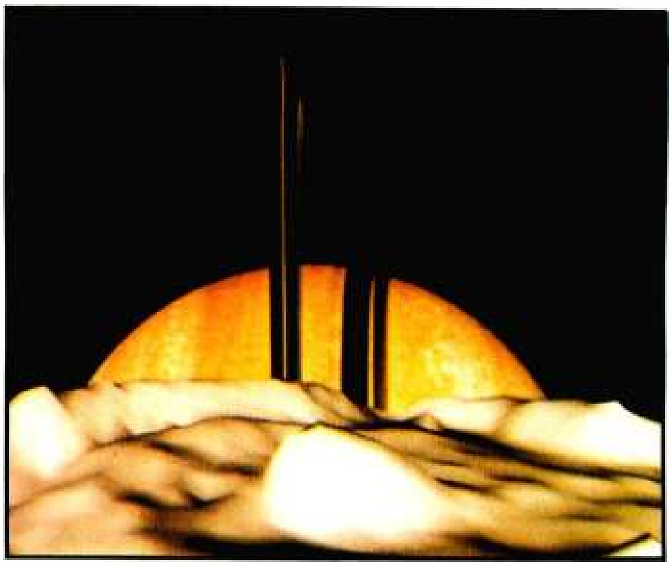

Photo 2: *These two images, "Before" (left) and "After" (right), show how NASA uses computers on planetary missions. "Before" is an enhanced picture of Saturn from Voyager I. "After" was created by Dr. Jim Blinn as a precursor to the Voyager II mission to Saturn; this frame from the short film* MIMAS — Voyager II Saturn *shows Saturn rise as the spacecraft passes near a moon. Saturn was created from Voyager and Pioneer mission photos; the moon is random mountainous terrain on a spherical model. The images in* MIMAS *were produced on an Evans & Sutherland Picture System II connected to a Digital VAX computer and photographed with a 16mm movie camera. (Photos courtesy of Jet Propulsion Lab/NASA and the author, from Dr. Blinn's JPL terminal.)*

companies were doing the same thing that several people at the show wondered aloud what kept them all in business.

Real-Time Images

Computers have caused revolutions in many disciplines; computer graphics is just starting to. The graphics designer who works with a computer-based layout machine will never go back to scissors and glue voluntarily; the animator who is shown how much computers can help will want a machine. Hollywood has started using computers in special effects, as seen in *Tron* (see "Tronic Imagery" by Peter Sørensen on page 48), *Star Trek II*, and other films.

Surprisingly, no one had even the simplest game to show off their equipment. One possible reason: most of this equipment was produced in such a headlong rush that little or no time was left for applications. They will soon realize that games are a good way to pull customers into their booths; and games on these graphics machines could be pretty impressive. Most games I've played are very poor approximations of reality. The line drawings are jagged, and the color displays are washed out and blocky. Also, I tire of tactical twist-and-shoot games. I'd like to write some of my own games software.

The New York Institute of Technology (NYIT) and its graphics subsidiary, Computer Graphics Lab, were talked about in the November 1980 BYTE. The cover of that issue showed a scene from their film *The Works*, a computer-animated feature-length movie, which was supposed to be out in about two years, i.e., now. I saw all of *The Works* at the show; it was about 30 seconds long. Money troubles, I was told. They were hawking a "complete computer graphics animation system" for video tape; when prices go down, you may own one.

Two of the people who worked on *Tron* have formed their own effects house, a company called Digital Productions. Financed by Ramtek, a large graphics company, they set up shop in Hollywood a few months before the show with a Cray-1, the world's largest general-purpose computer, and are ready to generate images for the movies. This isn't the only company doing this, but it is certainly the only effects house with that much processor. They should produce some eye-popping stuff for movies as soon as next year.

Proof that "getting a bigger hammer" (or more computing power) produces better images was obvious at the Ikonas booth where there was a computer-generated picture of a glass sphere sitting on a table. This picture is a few years old, but it's amazing nonetheless. The table had a checkerboard tablecloth that was reflected and refracted through the sphere; the sphere even had a shadow; it was beautiful. One of the people at the booth said it probably took one to two hours on a VAX (a super minicomputer) to generate that single frame. (Photo 2 shows another image generated on a VAX.) Now you see why Digital Productions bought a Cray-1.

Forecasts for the Future

I came to a conclusion at the show: I'm going to wait before buying anything. The future holds the promise of large price drops. I learned a great deal at the show about personal graphics, small-business graphics, and the future. Coupled with what's been old hat in science fiction for about 30 years, I'll make some predictions for what's ahead.

The companies to watch: Jupiter Systems, Raster Technologies, and Florida Computer Graphics. They will probably expand downward into the low-priced business market, which most of the big companies ignore as too small. Of the manufac-

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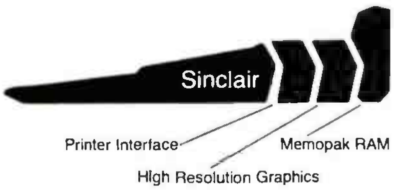

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New products coming soon Memotech will soon be introducing four new Sinclair compatible products: a high quality, direct connection keyboard, a digitizing tablet, a 16K EPROM and a disk drive. Watch for our future advertisements.

For More Information

The following is a list of the more interesting exhibitors at the National Computer Graphics Association meeting. Of course, the prices of most of these systems are a bit high for personal-computer budgets, but these prices should drop soon.

Personal-computer graphics boards for the S-100 bus:

Cambridge Development Laboratory
36 Pleasant St.
Watertown, MA 02172
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Digital Graphics Systems Inc.
935 Industrial Ave.
Palo Alto, CA 94303
(415) 856-2500

Scion Corporation
12310 Pinecrest Rd.
Reston, VA 22091
(203) 255-1526

Add-on color-slide machine:

Lang Systems Inc.
1392 Borregas Ave.
Sunnyvale, CA 94086
(408) 734-3332

Graphics by mail (color-graphics service):

Comshare Target Software (Apple only)
1935 Cliff Valley Way
Atlanta, GA 30329
(404) 634-9535

Infographics (retail outlets)
201 Shipyard Way, Suite E
Newport Beach, CA 92663
(714) 675-4385

High-resolution monitors ($3500):

Amtron Corporation
5620 Freedom Blvd.
Aptos, CA 95003
(408) 688-4445

Graphics modifications for the Digital VT-100 and Televideo terminals:

Data Type Inc.
2615 Miller Ave.
Mountain View, CA 94040
(415) 949-1053

Digital Engineering
630 Bercut Dr.
Sacramento, CA 95814
(916) 447-7600

Digital Equipment Corporation
129 Parker St.
Maynard, MA 01754
(617) 493-4885

ID Systems
4093 Leap Rd.
Hilliard, OH 43026
(614) 876-1595

Selanar Corporation
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Santa Clara, CA 95050
(408) 727-2811

Visual Technology Inc. (VT-100 emulators)
540 Main St.
Tewksbury, MA 01876
(617) 851-5000

Manufacturers with mid-priced graphics terminals ($10-20,000):

Advanced Electronics Design
440 Potrero Ave.
Sunnyvale, CA 94086
(408) 733-3555

Chromatics Inc. (68000-based systems)
2558 Mountain Industrial Blvd.
Tucker, GA 30084
(404) 493-7000

Electro-Optical Information Systems (low-priced image processing)
710 Wilshire Blvd., Suite #501
Santa Monica, CA 90401
(213) 451-8566

Florida Computer Graphics
1000 Sand Pond Rd.
Lake Mary, FL 32746
(305) 321-3000

Intelligent Systems Corporation
225 Technology Park
Norcross, GA 30092
(404) 449-5961

Jupiter Systems
2126 Sixth St.
Berkeley, CA 94710
(415) 644-1024

Raster Technologies Inc.
9 Executive Park Dr.
North Billerica, MA 01862
(617) 667-8900

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Ikonas (raster-based systems)
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Raleigh, NC 27619

turers currently in the personal-graphics market, Scion seems more likely than Cambridge Graphics Lab or Digital Graphics to lower prices while raising densities.

The production of manuals and technical reports is one of the best uses for computer graphics. Larger companies and newspapers already use big computers for this. At least one service already offers completely automated typesetting as an adjunct to printing: Wordplay (in Los Angeles) charges $6 to $8 an hour for word processing and $0.10 to $0.50 a page for output. In the future, books will be easier to produce; the high cost of typesetting (largely due to retyping) will fall rapidly when the customer can provide a disk. It is usually far cheaper to reorganize text than to retype it.

Someone will synthesize a truly common graphics control language, I hope. (Several were represented at the show, but no standards yet.) The fall in memory prices will allow very-high-density graphics machines in a few years.

With the S-100/IEEE-696 bus now adopted as a standard, familiar S-100 houses will bring out new graphics boards. We will see 64K-byte memo-

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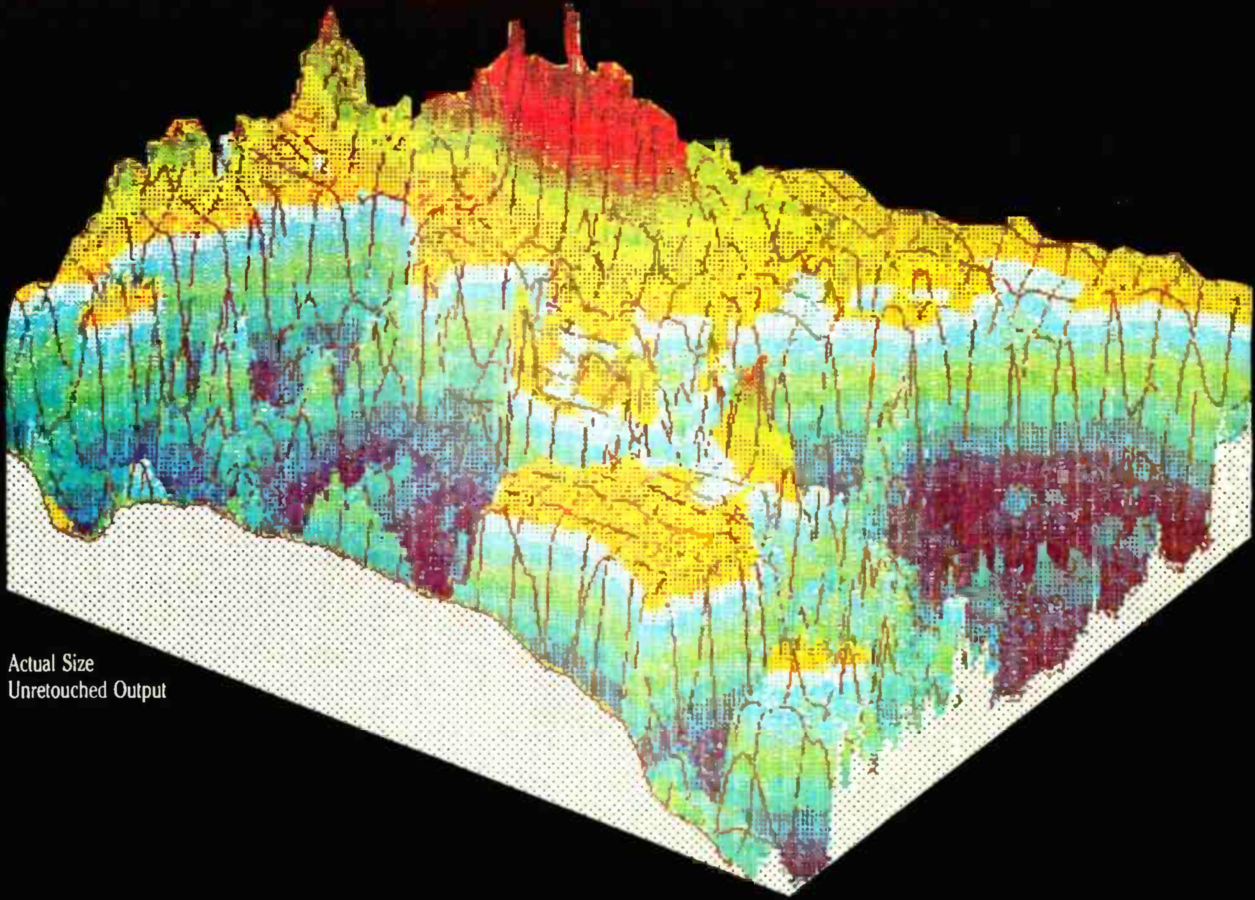

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ry chips, and the new 16-bit microprocessors will drop in price drastically. I foresee at least one new S-100 graphics board for $1500-$2000 rivaling the complete 9-board Microangelo graphics system ($9175). It'll take a lot of small companies by complete surprise.

New stand-alone graphics terminals using the RS-232C interface at lower prices (probably made-over Zenith Z-19 terminals and such) and several budget-priced (below $20,000) complete computer-animation systems will be unveiled by next year's show. The prices for add-on color printer/copiers will fall to consumer levels within two years.

Software is going to get much faster. Rumors of a drop of two orders of magnitude in processing time have been floating about for a while now. This software should cause quite a flap at the next NCGA. Such developments will be added into personal graphics soon after they are made public.

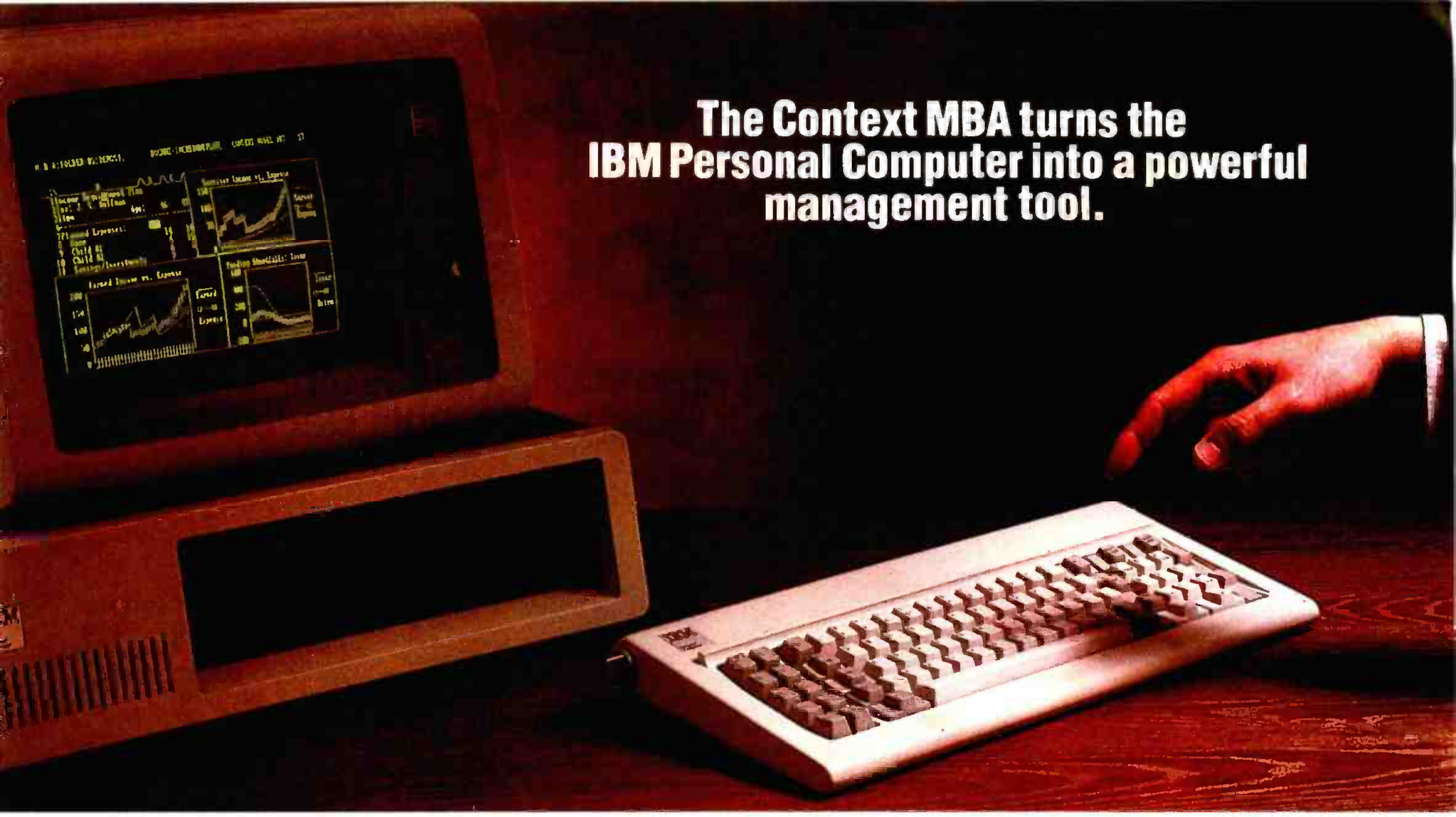
A CP/M-based picture-handling standard should appear by spring, with provisions for various terminals and languages. At least one graphics-handling chip, not designed for any particular system or company, will appear and make homebrew haywires easier. (Since this article was written, this appears to have happened with the NEC graphics-handling chip.)

The Far Future (2-5 Years)

A standard for computer mail, text only, will settle within two years. It will use normal phone lines and transmit at 300/1200 bps (bits per second). The monochrome-mail graphics standard should follow. It may look suspiciously like current facsimile. Provisions will be made for television display; at least one TV manufacturer will announce the terminal, TV, frame grabber, VTR, graphics generator, and electronic-mail machine all-in-one console soon thereafter. A color-mail standard may have to wait a new TV standard, or one of the videotex standards could be adopted as a color-mail standard.

It is my fervent hope (but not prediction) that a higher-density television standard can be reached within the next five years. Movies, graphics, and electronic mail would benefit from mass acceptance of a dense display. The biggest problem is the same as for current color TV: compatibility. Just as all black-and-white TVs had to receive color broadcasts, the argument will be made that a current-day set should be able to receive the new standard. Unfortunately, this would mean another generation of lousy sound and abysmal images.

Not more than five years hence, the home-computer animation machine will be the typewriter of the amateur moviemaker. Script and cartoon will be made on your home computer, saved on your home VTR, and then sent off to your local cablecaster. More than anything before, home computers point a way toward greater individual artistry.■



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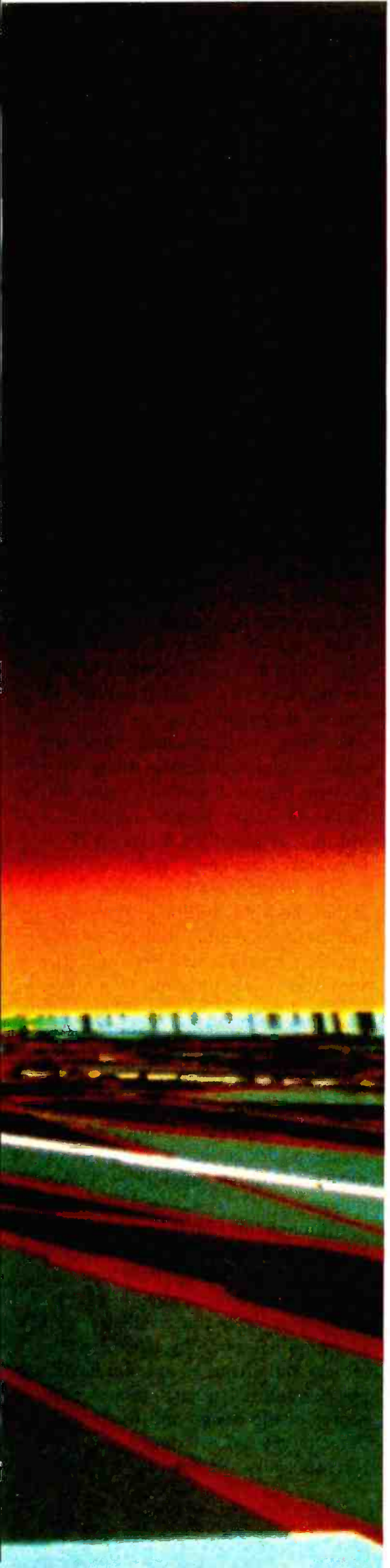

TRONIC IMAGERY

Peter Sørensen
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"It will remind you of something you have never seen before!" is what everyone working on *Tron* says with a mischievous twinkle in the eye. Obviously, the statement is an in-joke of sorts. But in spite of the fact that it seems to describe an impossibility, there *is* some truth to it. The visual pyrotechnics in *Tron* have been used only briefly before in features—spectacular effects developed by the same visual physicists whose laboratory has been that of contemporary television commercial design and production. Thanks to them, every person in the world with access to a television set is a connoisseur of sophisticated motion graphics techniques. But before *Tron*, only scant examples of these techniques had found their way into the cinema.

With the current rage in video games and home computers, *Tron* is a timely fantasy. Inspired and guided by writer-director Steven Lisberger, the plot revolves around the premise that a separate universe exists in the software of computers which is parallel to our own space-time. The story concerns the life-and-death adventures of a master programmer and video game champ named Flynn (Jeff Bridges), who gets transferred into that alien electronic world and must discover a way out. The software environment is populated by entities that are the alter egos of "users" in the real world, including Alan Bradley (Bruce Boxleitner) whose program's name is TRON—mightiest of the electronic warriors—and the unscrupulous Dillinger (David Warner), whose surrogate is the evil Sark. The software characters are all aglow with electricity that courses through the patterns of circuitry on their costumes. They drive or fly many kinds of vehicles which have also been programmed into the computer—some of which were originally intended for video game use, such as speeding light-cycles, battle tanks, and flying antigravity Recognizers.

About the Author

Peter Sørensen is a Los Angeles-based computer graphics consultant who has designed and directed special effects for film and video. He is currently designing computer scene simulation for a French science-fiction movie.

This article is excerpted from a longer work published in Cinefex, *POB 20027, Riverside, CA 92516. We'd like to thank its editor and publisher, Don Shay, for making it available to us.*

Triple-I's glistening representation of the master control program's exterior.

Flynn puts these all to good use at various times as he is pursued and hunted by the enemy. Eventually, Flynn and Tron take a solar sailer, flying on a beam of light, with the ever-nasty Sark close on their heels in his gigantic, levitating aircraft carrier. Their goal is to get to the Master Control Program—or MCP—the ultimate villain in the film, in order to make it release Flynn back into the real world.

For the special effects industry, *Tron* is a double-barreled breakthrough in that it makes use of two very exciting new tools for the special effects kit—computer generated imagery and back-lit, enhanced live-action. Because of this, there seems little doubt that *Tron* is destined to take a prominent place in the Hollywood history books, marking the beginning of a new era, particularly with respect to its computer generated imagery—or CGI. No doubt, later on in this decade we will look back on the achievements of *Tron*'s electronic imagery as primitive, pioneering efforts. But while these new imaging techniques are in some ways rough around the edges, they are the kinds of pioneering breakthroughs that open up new worlds, and against which subsequent efforts are measured.

"I think," said Harrison Ellenshaw, "that *Tron* will do for the computer graphics industry what *Star Wars* did for motion control." Ellenshaw is the associate producer on the picture and cosupervisor of special effects. "The number one thing that appealed to me coming on the film is that it's an original, and it's unique, and it's not a copy. Four out of five films in Hollywood are copies of something else." Supervisor of effects Richard W. Taylor, whose personal touch can be seen throughout *Tron*'s electronic world, reinforced and elaborated further. "There has never been a film that's used this particular collage of technologies. This film really runs the gamut of techniques because we're actually combining two opposites, in that, on the one hand, the computer simulation is an extremely new technology and is replacing very labor-intensive types of work, and on the other hand we are doing the backlit compositing of the actors, which involves handpainting of hundreds of thousands of cels and as many as 40 hand-flopped passes under the animation cameras per scene."

Everybody working on the film has voiced the opinion that the credit for this movie goes to Steven Lisberger—"an energy ball," as one person put it. They also point out that he persisted with *Tron* despite the customary proclamations that it could never be done. That Walt Disney Productions' new management perceived the possibilities and put up $17 million for the film is no accident, because the studio has been aware for quite a while that it was time to get back into the pioneering spirit—and this is a pioneering movie.

". . .if you design for the computer, sometimes you limit your contribution."

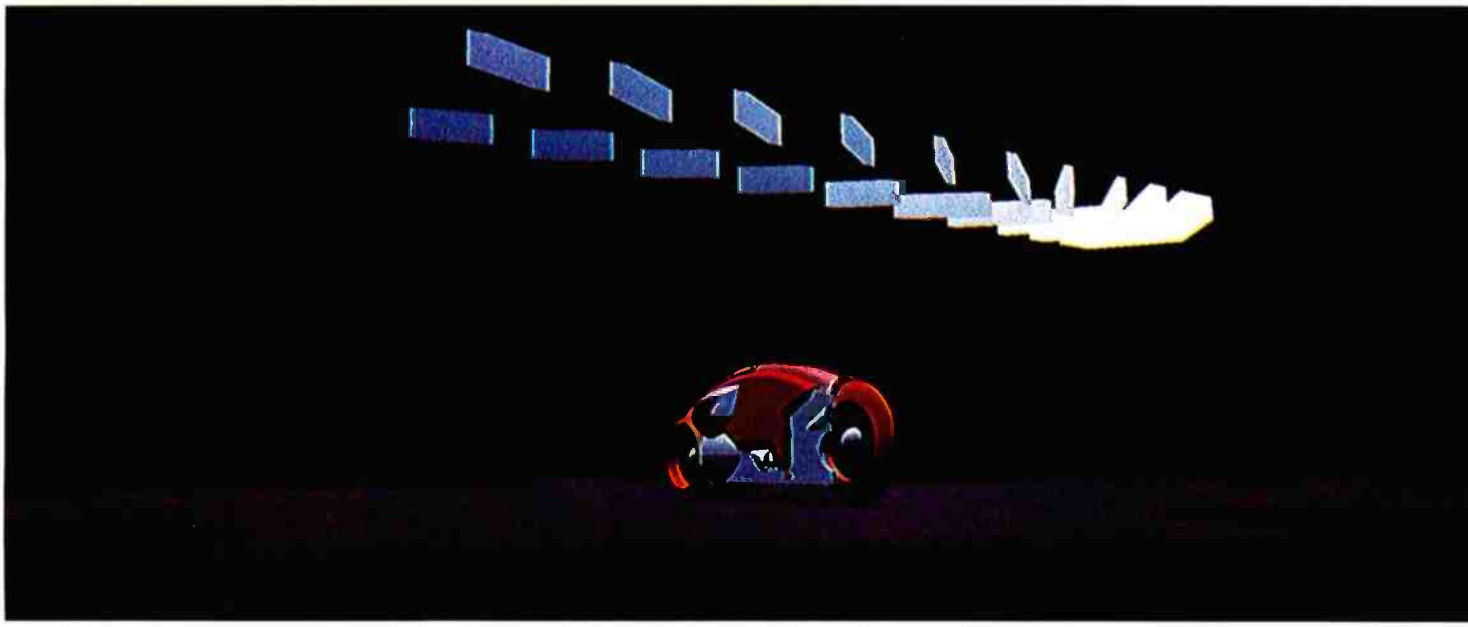
"I spent about two years doing research on the story, and there were an incredible number of drafts. One of the most difficult things about writing *Tron* was the fact that it was a totally alien environment, where whatever ideas one wanted to generate one had to think up from scratch. When you've got a fantasy world, you find that it's incredibly exciting to be able to invent everything; but after awhile it can almost become an overwhelming task when you realize that *every* single aspect of the environment has to be generated. But I was really intrigued with the duality of the two worlds in the film. There's the real world where the 'users' live, and there's the theater of the electronic world. The whole concept is based upon the idea that for each one of us there exists a body of information in the electronic dimension. Whether you're in there through your driver's license, or whether you're in there because you're writing elaborate computer programs, *somewhere* in there is *you*—on the other side. And the notion is that the two entities want to communicate and be in touch with each other. But that's not always the way computers are designed. They can sometimes be more oriented towards a dictatorship, where you can't reach your information unless you go through some master control program who decides when you can intercommunicate with the electronic world.

"I explored just about every way to do the film that you could think of—video composition, bluescreen. We storyboarded the film many times and eventually arrived at the techniques we're using. It was always our intention to take advantage of the computer scene simulation capabilities, and I had kept abreast of advances in that area for two or three years prior to the writing of the picture. The whole idea was not to go to the computer companies and say: 'We want you—if you're so good with your computers—to generate a dog for us. Can you do that?' Well, of course, they can't. But we did know what they *could* generate. And the whole notion is that the things they do—the high-tech vehicles, props and landscapes that they're capable of putting out—lend themselves perfectly to our video-game land.

"The thing that's interesting to me is that the whole notion of computers has been incredibly barren of any visuals. I consider myself a visual person, and it was amazing to me that it's so literary and so filled with numbers. The first instance that I saw of high technology starting to orient itself to a visual side was through computer games—which is a perfect marriage. Computer games sort of create a bridge for people to appreciate the other capabilities of computers."

Although this film is very much the personal expression of Steven Lisberger's vision, nevertheless, the stylization and designing of the effects, the sets, the vehicles and costumes has certainly been a group effort. And of special note for having been involved in just about every aspect of the design and the look of *Tron* is veteran art director and effects specialist, Richard W. Taylor.

"I was asked by Steve to handle the back-light techniques and to pull together a group of people who knew those technologies, and to invent a way of organizing that technology for a full feature-length film rather than a 60-second commercial. Initially when I got involved with the project it was in the computer simulation area, because very early Steve came to Information International Inc. (Triple-I) when he was forming this project up, and at that time the characters in the electronic world were going to be hand-animated. But he definitely knew that he wanted to use computers to do the environments. When he originally contacted Triple-I, he wanted a rough test of the computer simulation. The test definitely showed the potential. It showed that it could be done. And it was at that time I started getting involved in helping organize the overall film."



Syd Mead created the vehicular concepts for Tron, *including the tank and light-cycles, which were then computer generated by MAGI—one of four computer imaging companies involved in* Tron.

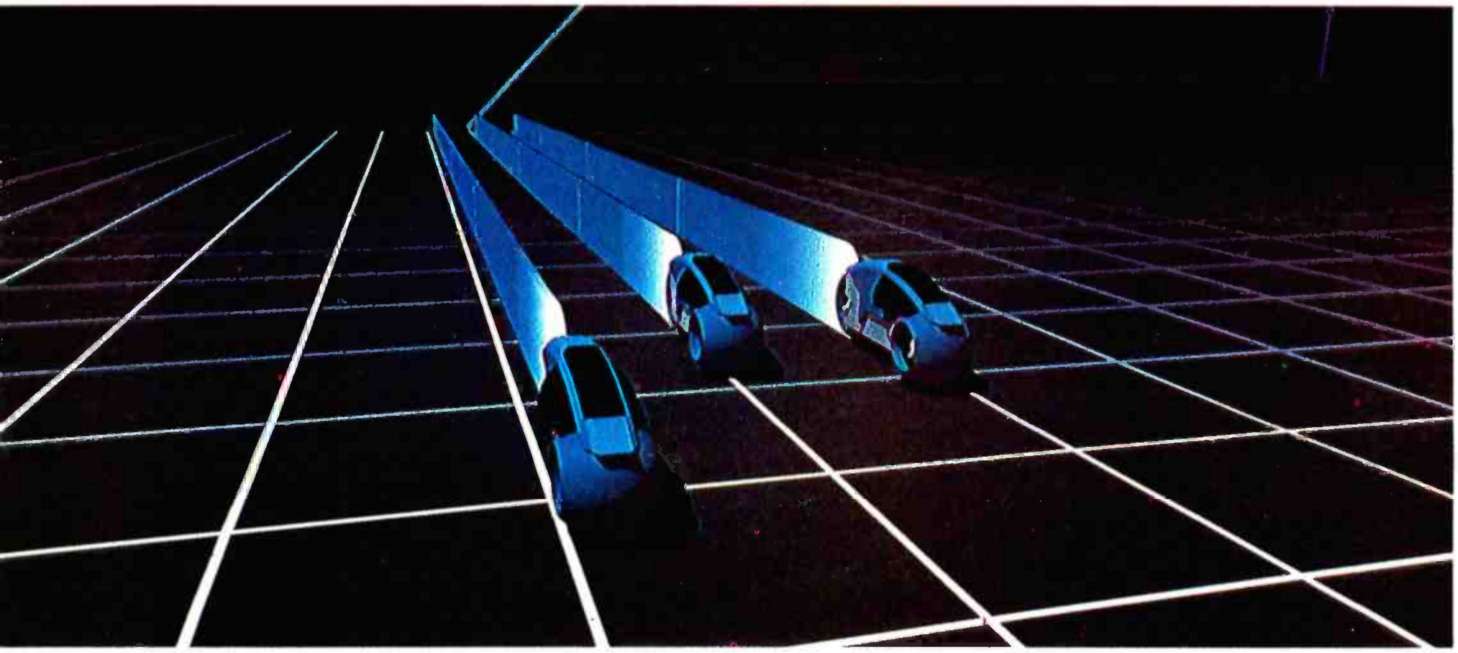
Soon after Lisberger secured the backing of the Disney organization, he brought on some top-notch design consultants to create vehicles, sets and costumes that would give *Tron* an especially sophisticated look. He borrowed Moebius (Jean Giraud) from *Heavy Metal* to design costumes which would take advantage of the back-lighting technique; got airbrush master Peter Lloyd to design and color many of the architectural backgrounds; and brought in Syd Mead, the dean of futuristic design, to create most of the vehicles and many of the sets for the film. "Steven almost gave them a blank slate," said Harrison Ellenshaw. "He told them: 'This is the story. Go nuts and design it!' So they did. That's very rare in a film. And much of what Syd, Moebius and Peter came up with has actually been used. We've used 90 percent of it, and very little of it got watered down or changed."

Syd Mead has been painting carefully thought-out visions of the future since the 1950s—and those visions have literally helped shape the present. He has consulted for many manufacturers, including Ford, American Motors, Volvo (the next generation of its cars is being influenced by his suggestions) and the Lancia Delta's interior. The Norelco shaver currently on the market is basically his design. Rather recently he has been in demand for motion picture work, starting with *Star Trek*, then *Blade Runner*, and now *Tron*—with more to come.

"I was originally hired by Steve and Don to do vehicular concepts for *Tron*. That included Sark's aircraft carrier, the light-cycles, tanks—and the solar sailer, which eventually Moebius took over. Once I had gone through those and Steve started to see what I was giving him, I moved into some of the terrain ideas—the canyons that the light-cycles race through, the game arenas, and the graphics on the game arenas. I also did interior sets for Yori's apartment, Sark's headquarters, the tank, the solar sailer and the binocular-like inside of the Recognizer. For the city complexes, Steve wanted something very different, and so we decided to sort of sink them into the terrain level—rather than have them built up—which produced a very sinister look to the whole thing. For Sark's headquarters we wanted a miniature arena—which I put on a platform—and then Sark's headquarters is sort of jutting out, a semicircular fixture that revolves around the perimeter of this pit.

"Steve became fascinated with the look we were getting in the terms of solid—sort of solidified—graphics which matched the computer capabilities and the look of the electronic world that he was after. He didn't want to bias me to designing for the computer capability. He wanted to take an idea and then confront the computer people and see what they'd do with it. I've worked with computer people—having been a consultant to Phillips Electronics, in Holland, for 11 years—and I already knew that if you design for the computer, sometimes you limit your contribution."

Mead's intuition for what things will be styled like a decade hence is what corporations are looking for when they hire him. "What they hire me to do is to provide sort of an 80 percent accurate guess about where they might be going. This can be as elaborate as working with their lab people and visualizing an accomplished engineering concept or marketing idea. Mostly this is for their internal consumption—to enlarge their visual vocabulary 5 to



The light-cycles tear off across the game grid to engage another team of opponents. At this point, the sequence becomes computer generated, with the high-speed light-cycle footage generated by MAGI.

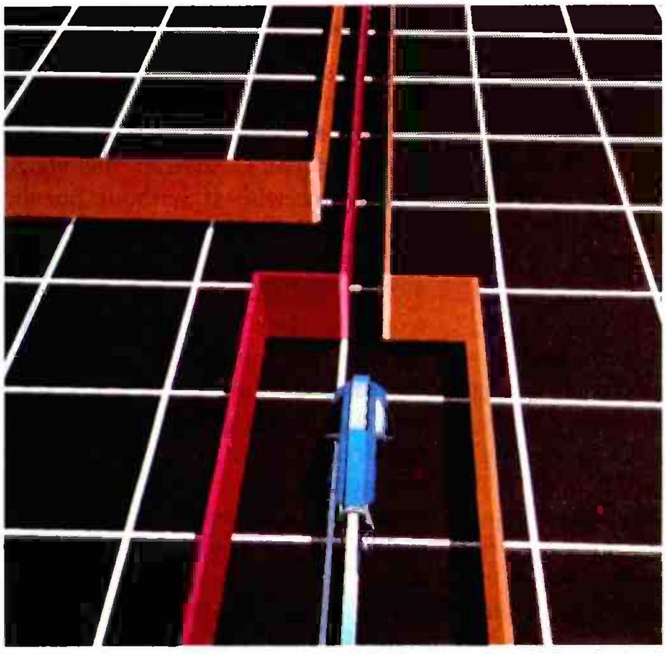
10 years ahead of what their production designers are working on. That also alerts management and corporate heads to get ready for what their design people might start to work on. Design staffs tend to get very insular, and design directors that I've worked for hire me deliberately to offset that sort of incestuous inbreeding."

Tron is an example of a film that had its effects well planned out from the beginning. Still, many people were skeptical that it was too ambitious an undertaking. "That's why Steven had to do a test before the studio bought the show," explained Ellenshaw.

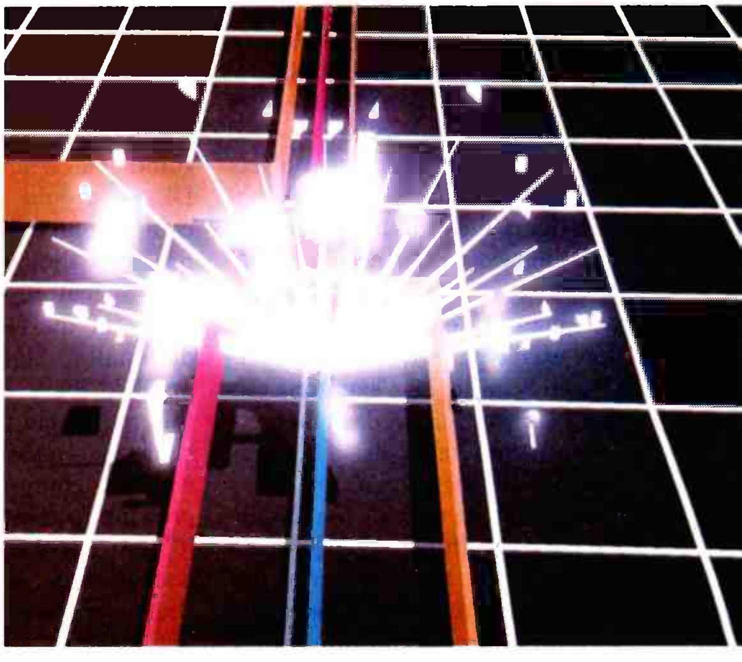
"We shot on the animation stand like it was an optical printer, in the sense that we were hand-drawing all the mattes that were required—frame-by-frame, cel-by-cel—and they were all shot with back-lighting on the animation stand. Certainly, some of this could have been done on the optical printer. You could have shot some of it bluescreen for example, but that would have been far more limiting. Considering we have 53 minutes worth, it was actually faster to do it this way. I'd hate to think of doing 53 minutes of opticals!

"The 53 minutes of the electronic world was shot first in 65mm, on Double-X black-and-white film. The reason for the large format is to maintain quality. You take a piece of 65mm negative that has been developed and you put it into a photoroto—which is nothing more than an enlarger—and you enlarge each frame onto a 12½- by 20-inch piece of kodalith transparency film. You process it with continuous-tone chemistry, and what you get out is what appears to be a black-and-white cel with a photograph on it. That is then taken and a contact print is made of it on the same kind of film—but it's processed this time with high-contrast chemistry, so what you get is a high-con reverse of the first. Now, if there's a person in the scene, you have to produce a body matte to hold that person out from the background. When you make the negative enlargement, the black lines that were the circuit designs on the costumes become clear, so we could light them up; but the black behind the characters also became clear, so we had to make what we call a circuit-reveal, and to do that you have to paint out all that clear area behind the characters. Then you have to make a matte for the face and the reverse of that—a face-reveal—where everything is black but the face. And there we just add a little more exposure to the face, to make the face a little lighter than the body. When you put this on the animation stand, you combine photo elements with at least two cels. For example, when you do the backgrounds you always have to have a body matte over it. When you expose the circuit on the costume, you put down the high-con and the circuit-reveal. Then you run through the one element, shooting it, and you back up the film, run through another element, back up the film, etc.—as many as 25 passes on one piece of Vistavision film. We never went smaller than Vistavision. Since the release prints are in 35mm Panavision and 70mm, we shot in Vistavision to maintain quality.

"It's really beautifully simple. The complexity comes when you think about the *volume* of work. We have 75,000 frames of live-action in the electronic world. That means we have 75,000 continuous tones, 75,000 hi-cons, 75,000 body mattes, 75,000 circuit-reveals. Forty percent of the time we have face-reveals and face mattes; 15 percent of the time we



Racing along at breakneck speed, the cycles slice into right angle turns without even slowing—but if an opponent fails to maneuver a turn, or collides with the trail left by another cyclist, he is destroyed.



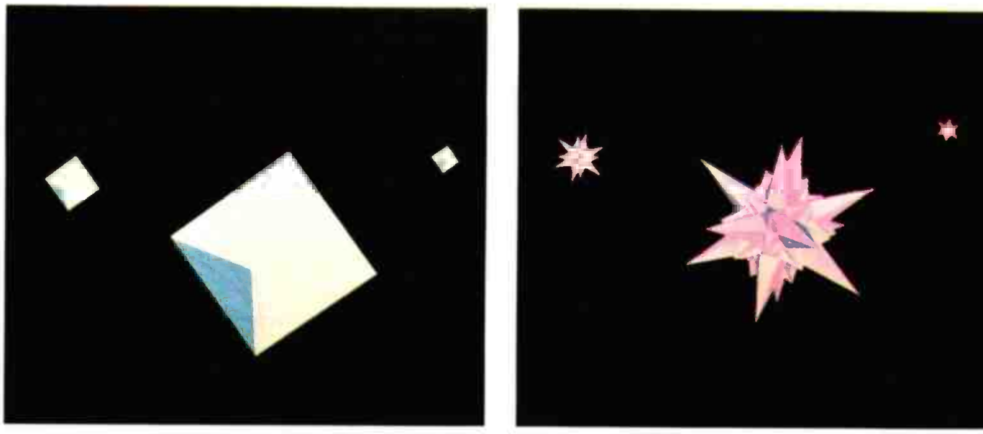
Unable to avoid the converging trails of his opponents, an ill-fated light-cyclist is smashed to atoms.

Robert Abel and Associates employed its vector graphics system to produce a computerized cityscape for Tron's *opening title sequence.*

have eye-reveals. And we've got 700 backgrounds to worry about—some of which are set pieces that you may have to generate separate elements for, some of which are computer generated, some of which are painted. If you took all of the elements—not counting backgrounds—that we used on the film, and stacked them 5 feet high, that row would be 58 feet long! I had to figure that out just to see how much room we would need to store it."

Working closely with Richard Taylor was technical effects supervisor John Scheele. Like everyone else on the *Tron* project, he described the experience not only as a unique evolutionary development in itself, but also in the context of the Disney environment. "Our challenge as a production was to come into this studio, with its tremendous history in pioneering animation photography, with all this massive camera equipment at our disposal, and get it converted over to computer control and to a whole new set of standards. Steve had spent six months in earlier tests just to prove to Disney that the process would work, and now the changeover had to be really pushed. On top of this was the constraint of time, working against a summer release when none of us could accurately predict how soon the effects could be wrapped up. Normally, Disney would allow four years to complete an animated film; but *Tron* has been thought of more as a live-action feature, even though each frame of the electronic world is individually handled and rephotographed. Nobody had actually done this particular process before—especially on a mass scale—and we didn't want to compromise the quality in pressing to meet the deadline. So my job has also been to expand the production base sufficiently to get the shots composited, and still leave time for reshoots and fixes of problem scenes. At least we weren't trying to jam the shots through optical printers. The whole collage of effects—photo cels, inked overlays, effects animation, backgrounds and computer generated plates—were all designed to be assembled on the animation stands to avoid that bottleneck.

"One of our key problems from the start was to find a way to modulate the intensity curves of the effects during the picture, so that the viewer could stay with it without burning out his eyeballs! It's one thing to grab somebody's attention for 60 seconds on TV; but that kind of visual blitz would just be too much over 50 to 60 minutes of composited film. So one of the thrusts of the effects design was to create a dramatic tension in how we turn it on, tied into the story structure and action. Steve made up a map of ascending and descending curves—something we could orchestrate the effects to—and carefully chose when to pull out all the stops. To accomplish this, we had to create a system—with programmer Peter Blinn—for light animation that could marry up to the camera stands. We had computer controlled stepper



Digital Effects produced the "Bit," an electronic companion to Clu, which floats about and answers yes-no questions by metamorphosing back and forth from an octahedron to a spiky sphere.

Computer image choreographer Bill Kroyer previews a series of frames at a Chromatics video terminal linked up via telephone to MAGI's master system located across the continent in New York. The images, though low in resolution, allowed Kroyer and associate Jerry Rees to preview an in-progress shot within minutes of its completion and direct any desired alterations before the scene was played out in high resolution.

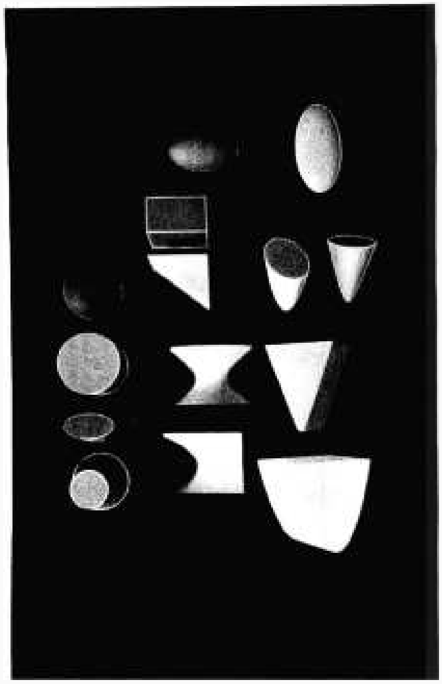
motors on the camera drive and a dissolve shutter that allowed us to create intricate curves and waves of exposure."

The important contribution of Blinn's was the development of a computer program that varied the intensity of light for the glowing back-lit effects, freeing the camera people from having to adjust the f-stops on a frame-by-frame basis. "I was working on graphics on a Cal Comp plotter at Midocean, using analytic geometry in various incarnations. That experience in sinesoidal curves helped me to write a program that controls light intensity from one frame to the next in a sinesoidal way, so we can choreograph the lighting in a scene. It saves camera work because they just have to enter a few numbers before they start the shot and then not worry about it after that—it just clicks off the proper exposure, rounded to the nearest thousandth of a second."

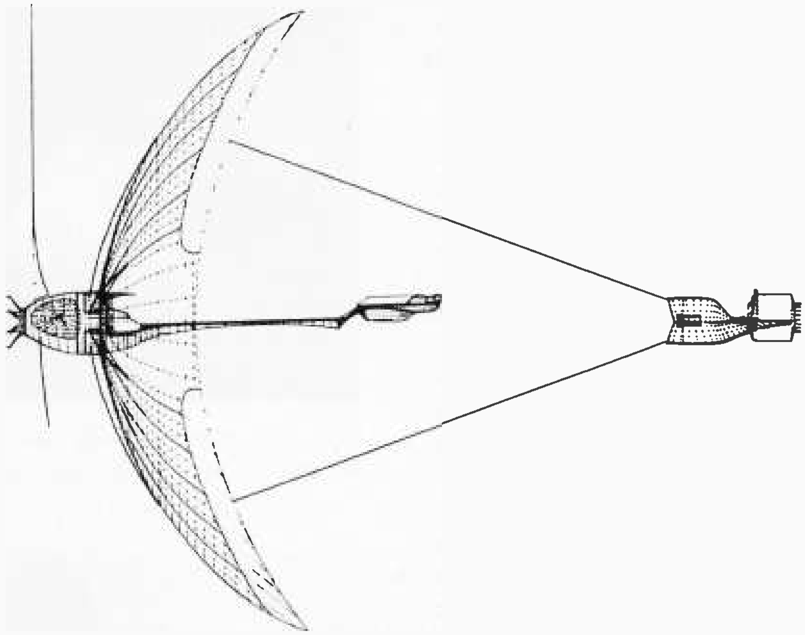
The drawbacks of conventional compositing have inspired research into other ways of compositing images, including digitally with a computer—scanning the film elements so they are converted to an electronic signal, manipulating and keying the images into each other, and finally scanning them back onto film again with a laser or a high-resolution cathode-ray tube. But that technology is still in the experimental stages. "*Tron* could have been done entirely on a digital film printer," said Harrison Ellenshaw, "and we wouldn't have had to blow up the cels and there would've been no reason to have inking and painting. The film printer could have taken care of the matting. It would've been expensive to build; but whatever it cost, you'd get that back in one picture. *Tron* could have saved so much money, and then they would have had a beautiful film printer—and the next picture would be gravy! Anybody who has a digital film printer will have a path well-beaten to his door. It's going to take some hard work, and then *woosh!*—all the optical printers go into the museums!"

A digital film printer was out of the realm of possibility for *Tron*, however. "In designing this film and the process to composite it," Richard Taylor explained, "we had to generalize things down to a series of givens that limited the amount of testing. The idea was to get things resolved, get the designs, techniques and equipment defined, find the right personnel, get the common vocabulary of the technique embedded in everybody's DNA—and then go for it."

Tron was also a very complex project logistically, principally because of the frame-by-frame back-lit special effects work involved. In order to keep everything smoothly coordinated, a computerized frame-by-frame bookkeeping system of scenes was employed. Shelley Hinton, assistant scene coordinator to John Scheele, was responsible for keeping the system up-to-date. "I had to keep track of every scene in the film—its footage, the elements involved, and what was happening to them within each department. I put together a



Unique among digital imaging companies, MAGI forms its computer generated subjects by adding together or subtracting out "primitives"—geometric solids in a wide variety of shapes and variable sizes which are preprogrammed into their computer for ready assembly into whatever shape is desired.

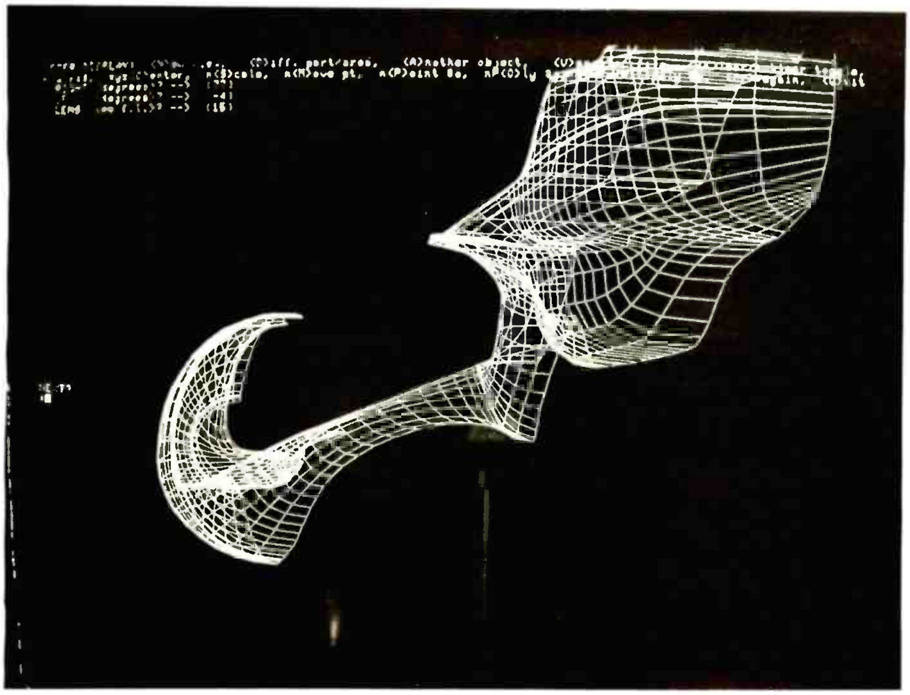


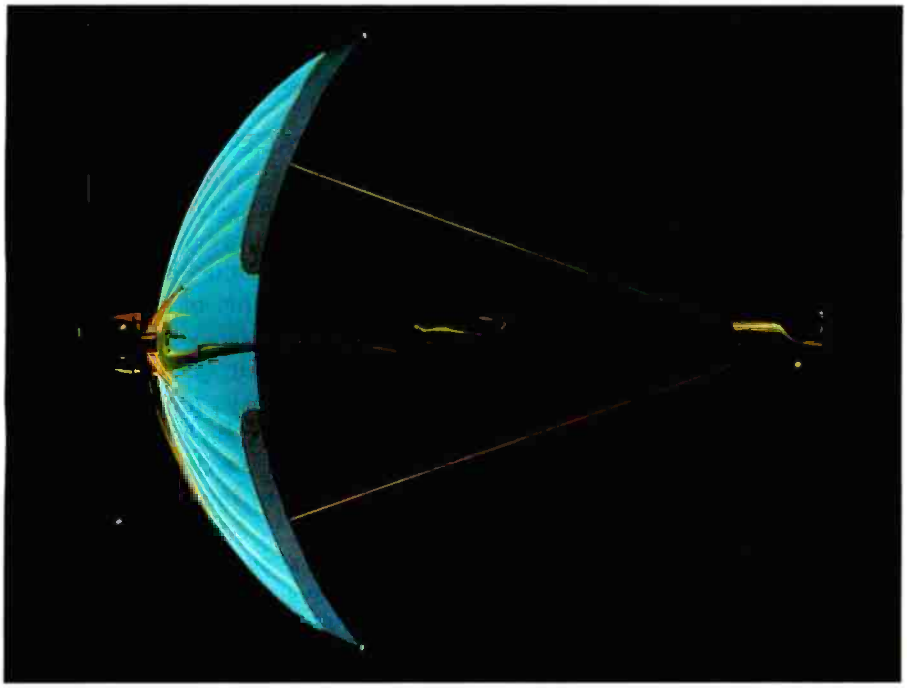
Triple-I uses blueprints to digitally encode the shape of any given object into its computer. Once that has been done, the computer has a three-dimensional representation of the object in memory and can conjure it up from any perspective. [Opposite top] The underlying database for the solar sailer as encoded in the Triple-I computer. The solar sailer passenger module displayed in vector form on a video screen. [Opposite bottom] The completed solar sailer, with its constituent polygonal facets smoothed out and its coloration defined.

master log for the entire film, frame-by-frame, and kept track of it in a word processor. I'd get information from the editors and they'd tell me how long each scene was and what it consisted of; and from that information everyone would know what they were dealing with—whether the scene was to be shipped overseas for ink and paint application, and so forth. The data was also vital to Michael Fremer who was doing the sound effects electronically, since any changes that the editors or directors made were reflected in the log's daily update. Once a week I made a printout of about 24 pages and sent everybody a xerox, just to keep them informed of the changing length of the scenes and of the shooting schedule. It became an organizational mainstay, and everyone in the department referred to it. Without it, there would have been chaos. We started out with charts that were penciled in and changed by hand; but the word processor was really the most efficient way, because everything could be kept on the floppy disk. If we'd been doing it by hand, it would have been a mammoth task—it would have taken a whole team working full-time."

While the back-lit effects in *Tron* stand out as the most obviously novel thing about this film, the computer generated imagery may go by the average viewer relatively unnoticed. Many will probably think the computer generated scenes were accomplished with miniatures, stop-motion or even cel animation. But people familiar with those techniques will immediately be aware that an entirely new technique—unlike anything else—is being employed, and that one thing after another is being done that would be impossible by any traditional method. With computer generated imagery, it is possible to have an object change its shape with a metamorphosis effect—called "interpolation" by the computer people. Or it is possible to "really blow-out the point of view of the camera," as Richard Taylor put it. "We move it through objects and fly from micro to macro positions." And simulated objects can be made to move in any way at all—unrestricted by pylons or track length the way models on motion control systems are. Creating scenes with CGI is like having at your disposal a flawless airbrush artist who can paint thousands of paintings a day with photographic realism, getting perspective and shading absolutely perfect—and without any discontinuities in the dimension of time, either.

The computers that do this work must be programmed with formulas on the nature of light, optics and the geometry of perspective. They take all that, and more, into consideration when they generate the scenes a director has asked for. Though it's an incredibly complex subject to get into, essentially it's very simple. You tell the computer what the shape is of the object you want to animate, its color, its motion and where the light is coming from—and from there, the computer just calculates what that image





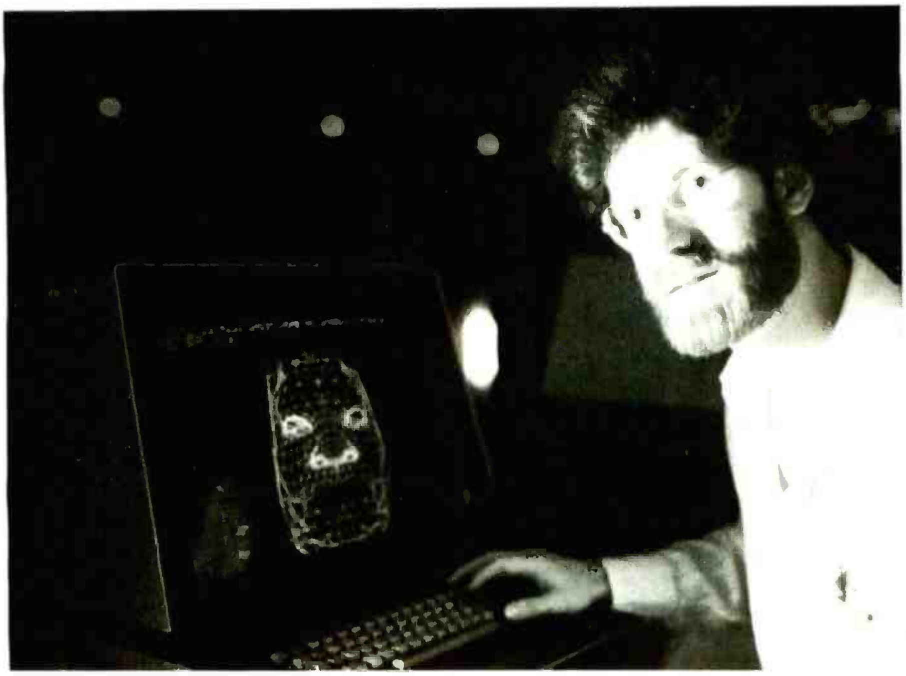
would be, point-by-point across the picture, and displays it line-by-line on a cathode-ray tube, similar to the way a TV picture is generated, only slower and with higher resolution. Said Harrison Ellenshaw: "Once you get into it, even a layman such as myself—and I certainly know nothing about programming—can understand the basic process and how it's accomplished. Then you can get it. But it's difficult to explain Kleenex to an aborigine."

It does not take a crystal ball, however, to see that this technology, still in its earliest formative stages, will eventually become one of the most important developments in the history of media—not only for its ability to do the impossible in terms of special effects, but because eventually it will be possible to substitute simulated scenes for location shooting and expensive sets in all kinds of productions. And while at present it is very difficult for computers to generate images of organic things like plants and animals, research into those areas is advancing rapidly. So it's just a matter of time before there will be entire software zoos and botanical gardens available to work with, just as there is presently a rapidly growing inventory of vehicles and architecture.

Some of the first computer generated scenes completed for the movie were of the light-cycles. When effects animator Dave Stephan (who does all of his work by hand) saw them, he echoed everyone's initial reaction on their first exposure to CGI: "When those cycles turn the corner, skidding and tilting and rushing towards the camera, I thought: 'Wow, that's great stuff!' I wanted to see more of it; I wanted it to last all day."

Richard Taylor was involved with the CGI work from the time Lisberger first came to Triple-I to explore the possibilities for using digital scene simulation in *Tron*. "Other than the back-lit part, my responsibility extended to the computer simulation design and coordination, so that it fit into the whole process and so that everybody had a common vocabulary. This film is really the first full-blown use of computer simulation as a regular production tool. It's not just one little vignette—we did a lot of footage.

"I looked objectively at the film across the board, and it was immediately apparent that no one of the computer simulation companies was going to be able to handle the load. Each has its own hybrid system, and none of them shares common software or techniques—each one has its own way of looking. Plus we decided that we wanted to composite this film in Vistavision, and none of these places—other than Triple-I, who were starting to work in Vistavision with the digital film printer—did Vistavision film recording. All of the companies had to convert to Vistavision and to our alignment system. We had to create a system that everybody agreed upon; and then we had to create our own field charts, animation exposure sheets and everything else right down the line. It was just like building the whole thing from scratch. Everything from the labels on our boxes to the way we define the



names of objects and elements is all unique to this particular film. So I looked at the computer work to be done on the film and decided that we'd have to break it up among two or three companies. Then, stylistically, I tried to decide, by the kinds of techniques the different groups had, who should do which parts. As a result, Triple-I dealt with the part of the film that used the more complex craft and images, and MAGI (Mathematical Applications Group Inc.) dealt with some of the more elaborate choreography. The load was equally shared and both companies did a super job. MAGI did the first half of the movie and Triple-I did the latter half, because there's a very specific stylistic point where things change—from the solar sailer on out. They're leaving the game grid and heading off to the MCP's domain, and the simulation gets more and more real as you get closer to the MCP.

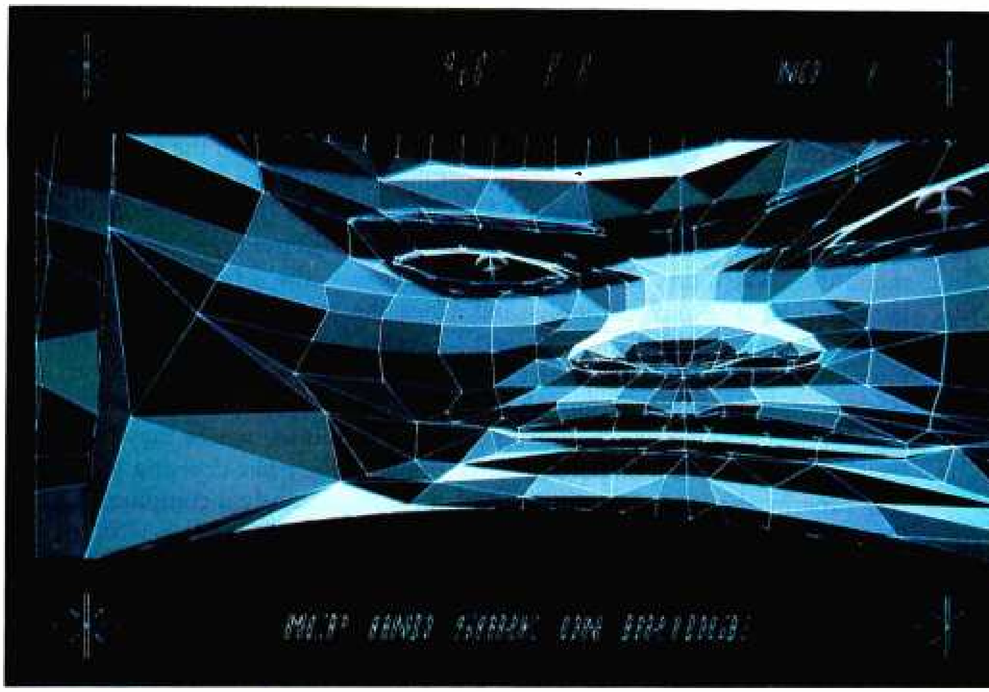
"With MAGI's system it is quite easy to choreograph the object, and we got motion tests from them very quickly. There are some limitations to the nature of the objects that they create. As a matter of fact, as a result of doing *Tron*, they've improved a lot of things in their systems, because I asked that they implement some things like depth-cluing; and they didn't have transparency. We challenged them to implement and they responded.

"Triple-I's system is different in many ways. MAGI computes the scenes off to tape and then the tape plays the Celco film recorder. So when it's actually filming it's very dependable. Triple-I has a unique hybrid system. Everything that is a shaded picture goes through one central processor and plays that off to a high-resolution film recorder. But it has to process everything linearly, which means that you have to go

Information International's Larry Malone calls up the face of the master control program on his computer display terminal. Per Syd Mead's design, the MCP was fashioned in the shape of a cylinder—revolving and changing colors as its mood shifted.

through motion tests, set the look of key frames and shoot production on that system; and so its dependability has everything to do with how it will run. If it breaks, their productivity stops. So part of their improvement was to make their equipment more dependable so they could run without glitches. In computer simulation that is the biggest problem—even the best systems have glitches, or some other occasional artifact.

"Part of my responsibilities in handling the simulation was to educate everybody in the film to the potentials that were there—to make sure that if we were going to make a camera move that we'd do something you wouldn't normally do with traditional miniatures, to keep people thinking in terms of what simulation can do that's different than traditional filmmaking. The thing I kept trying to emphasize was to use computer simulation for its unique qualities and not to imitate some other reality. Really try and make both the design of the objects and choreography unique to that technology."



Both Triple-I and MAGI produced computer generated still photographs for use as backgrounds in some of the back-lit sequences. While MAGI's generally had to be enlarged from Vistavision format and airbrushed, Triple-I's—which could be played out in a larger 4 by 5 format—were able to be used without modification. For a sequence in which the MCP—in polygonal facet form—communicates with Sark aboard his carrier, Triple-I generated a series of 16 slightly different background plates which could be enlarged onto kodalith cels and then alternated from frame to frame, using standard cel animation techniques, to suggest that the character was speaking.

In order to generate the 15 minutes or so of digital images needed for *Tron*, the two primary CGI facilities—MAGI and Triple-I—were kept working full-time on the project for the better part of a year. In addition, two other companies supplied cameo CGI scenes—Robert Abel and Associates, who produced the opening title sequence and the transition to the electronic world; and Digital Effects Inc., who did the "Bit," a little geometric sidekick that floats around accompanying the hero in the tank battle sequences.

Scene coordinator Deena Burkett was in charge of the scenes in which it appears. "The Bit is a character who floats around inside the tank with Clu—Jeff Bridges. And Clu talks to the Bit while he's driving around fighting bad guys. The Bit is always changing back and forth between two geometric shapes that mean 'yes' and 'no.' To answer questions he stops changing for a moment—the octahedron shape means 'yes' and the spiky shape means 'no'—but most of the time he's floating around just mumbling to himself. Originally, the Bit looked something like a billiard ball, but as time went on we realized that it's hard to make a sphere show expressions. The final design for the Bit was worked out by Richard Taylor and animator John Norton, who was with the Bit from the beginning when Syd Mead first came up with the idea."

Along with all his other duties, Richard Taylor designed the *Tron* logo and opening title animation that was done at Robert Abel's. "I felt that we needed a symbol for this film that was a new-looking logo. Syd Mead and I designed the typeface; and when we were all happy with it, I storyboarded the title sequence. Having worked at Abel's and knowing their capabilities and having great respect for them, I wanted to do some work there. I knew there were certain things they could do that would just fit perfectly into the style of the movie. So when I storyboarded the opening title sequence, I didn't try to fit a square peg into a round hole. I didn't want them to invent too many new things—I just wanted to nail it. You do these things as directly as possible because you don't have the luxury of fiddling around with every little detail when you're doing a feature of this size."

Syd Mead, on the other hand, prefers to intentionally ignore the needs of the computer graphics systems when he designs things for them to generate, because he feels that it's important to force the computer (and its programmers) into new areas of stylization. Having paid scant attention to the computer's needs, Mead expected it might well have difficulties with his designs. "The surprise was that the tank went through very smoothly, because it's essentially a rectilinear solid with rounded edges and MAGI has a program that they can apply to the edges which just sweeps off the corners with a constant radius. The light-cycles, on the other hand, were very difficult—matching what is essentially a rounded blade shape onto a ball which is the front wheel. One of the problems with generating computer simulated scenes is that the more complex the 3-D structure is, the more expensive it is to create it. So in designing for these systems one tries to avoid the kind of complex 3-D detailing that is currently popular in miniatures. We didn't want to get into designing 3-D niches, nooks and crannies. The problem was to get visual texture without getting really very complicated. So, I introduced flat, optical-scanner-like bar graphics—the kind you find on packages in the supermarket—as the answer. I knew they would be familiar to the audience. We used them in the channels. They infer a right-left bias to the channels, presumably for the benefit of the vehicles."

Just as the back-lit portions of *Tron* were so complex that they required several scene coordinators to share the creative and organizational work, so also the 15 minutes worth of computer generated scenes required two people functioning as CGI choreographers, to plan the action and setting for those scenes. Starting with the vehicles and objects designed by Syd Mead and the others, and working closely with Steven Lisberger and Richard Taylor, were two young explorers of visual dynamics with impressive backgrounds in cel animation—Jerry Rees and Bill Kroyer. Their highly developed sense of motion and the other subtleties that go into classical animation made them well-suited to the task of choreographing the action in the synthesized environments created by the digital painting machines. Kroyer, who was the animation director of *Animalympics*, was with *Tron* from the very beginning. Before that, he had worked for several years doing animated commercials, and for a while he was with Disney, working on *The Fox and the Hound*. It was then that he met Jerry Rees, who had earlier worked on *Pete's Dragon* and *The Small One*, and who had been doing top-quality animation since he began at Disney's as a teenager.

"*Tron* is setting some precedents that will be springboards for a lot of spin-off developments," Rees predicted. "Computers are so exciting—the horizons are endless. I think they are the most significant thing that's come along, because with them there are fewer steps between the artist and the film. It seems like the artists are getting closer to the final product with this new technology."

Because the *Tron* project was so big, the studio was forced to bring several large trailers on the lot for additional work space. Kroyer and Rees worked in one of these temporary studios, where they had their desks, some basic drawing tools, and most importantly a computer display terminal that hooked up with the big computer at MAGI—located across the continent, in Elmsford, New York.

With computers, there are fewer steps between the artist and the film.

"The terminal was a Chromatics 9000," Bill Kroyer explained, "hooked up by a phone modem that received binary signals over the phone lines from a modem on the computer at the MAGI facility. Their computer generated the binary blips that the images consisted of; and with the phone hook-up it sent those blips to us and our Chromatics reproduced the digital picture. We couldn't do any programming on the Chromatics—it functioned just as a monitor to receive and view the animation coming from MAGI. We could change the speed of the animation and view it in different ways, but we couldn't actually create the scene.

"To plan a scene, Jerry and I worked out the basic action of a sequence with storyboards. We'd go over it with Steve, and then break down the scenes into animation frames. We'd do rough storyboards of all the main poses within the scenes so that the computer operators could understand the look we were going for and the action. But we'd give a much more detailed description of the scene by outlining the speed of the objects, the architecture, the environment, the lighting, color and texture. We defined everything in the scene—every movement, every color and every action we completely wrote out in terms of distance, direction and time. The computer operators were then able to take all those things and translate them into cold, hard numbers. After that, their computer would send our computer a low-resolution test, generated with just 80 scan lines of resolution. The tests looked kind of blocky, but we could see enough to tell if the staging, action and timing were what we asked for. It's a very inexpensive way to look at the scene because the computer doesn't have to generate several million pixels as it would have to do on a high-resolution picture. Since it is such a very low resolution and the computer is generating so few pixels, it is possible for it to send those few pixels over the phone line fairly quickly, so we could view the tests almost immediately on our terminal.

"But we didn't have this display terminal system when we started on the movie. In those days, MAGI would photograph the tests on black-and-white film, send them to us through the mail; we'd view them, call MAGI on the phone and react to them; MAGI would then film a correction, send that to the lab, get it back, send it to us; and *then* usually at that point we would be ready to go for a 'hero,' or high-resolution. So for a typical scene we might have four or five days between the initial test and the okay for final high-res. But with our Chromatics, they'd put their phone in the modem device and immediately send us the low-resolution scene. It'd usually take about an hour for our terminal to receive and translate the blips into all the frames we needed. Then we'd punch a button and view the scene, and we'd call them back and react to it. We'd give them the corrections, and then they'd immediately program the corrections and send us the scene again. So in a matter of four or five hours we'd have a chance to see and respond to the scene twice—which was usually all it took for us to go for a hero. As a result, we cut our time down from

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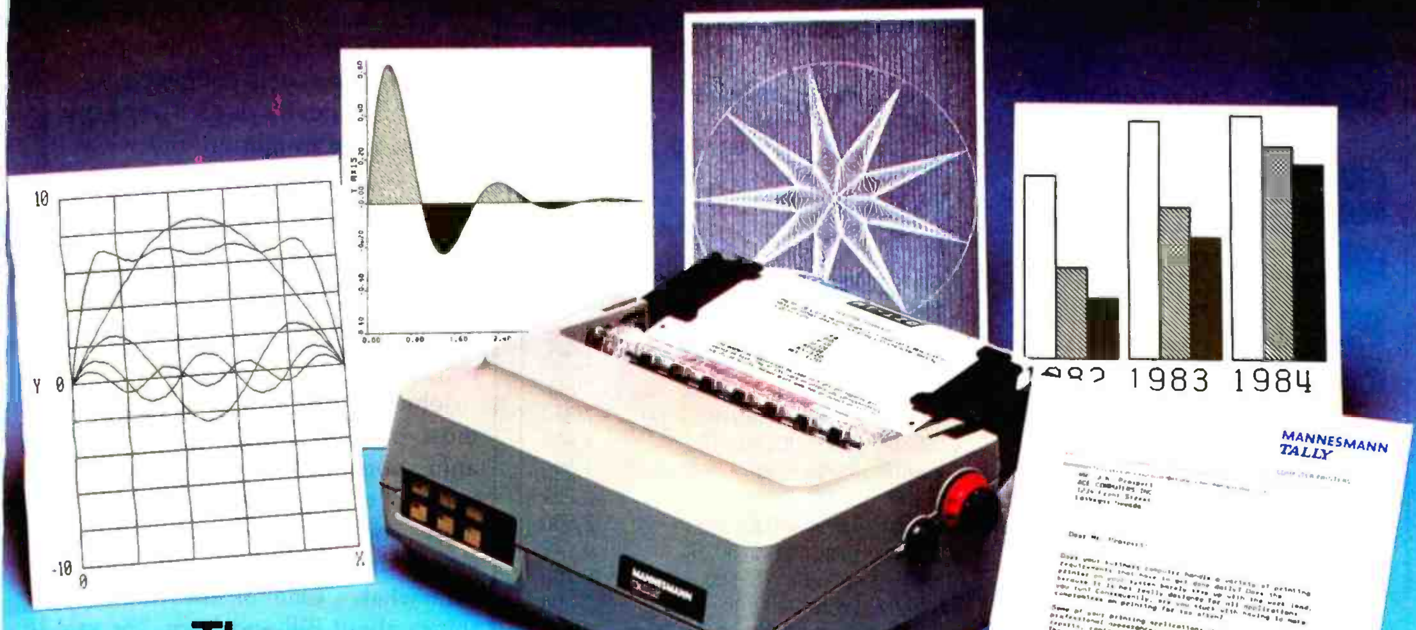

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five days to five hours. It really speeded up the whole process and allowed us to have a more efficient time flow and scheduling. And from the creative point of view, it was much more stimulating to be able to work on something and get that done before moving on to the next step, rather than having to be working on several scenes at once.

"We were also able to get one high-res picture at a time—in about nine minutes. The system could give us up to a thousand black-and-white pictures to view in motion; but when it came to full-color, high-resolution, we could only get those singly. So we couldn't see color motion. But we could see color stills, so we were able to check and see that the shadows and color and all those things were correct."

John Norton, who worked for the most part with hand-drawn effects animation, had an opportunity to keep an especially good overview of Rees and Kroyer's choreography, since their territories overlapped somewhat. "One of the interesting things about Bill and Jerry," he said, "is that they're both Disney animators. And in laying the moves out for the computer, they were putting in a lot of organic movement—ease-ins and ease-outs, anticipation and follow-through. You'll notice that in the scenes with the light-cycles. At first they're confined to a game-board arena and move mechanically there—with all this right-angle movement. But once those light-cycles break out of the arena, there's this really nice shot of them taking this beautiful curve, banking and turning as they escape. I don't think computer animation is going to replace conventional animation. It's just another tool for the animator. I think it may someday replace some of the labor—ink and paint and in-between. But the animator will always be there using this new tool. It only takes a minute after seeing the computer stuff to know that it's here to stay. And I love the metamorphosis effect. The Recognizer I designed has these two arms it can merge together into one big pogo stick, which it then uses to stomp on

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things." (There's a very definite old-time cartoon flavor to some of this newfangled stuff, to be sure!)

Bill Kroyer and Jerry Rees planned the CGI scenes on the West Coast for production at MAGI's facility in New York, from which the scenes were transmitted back to the terminal Kroyer and Rees used for their approval. Larry Elin was the person at the MAGI end of the transcontinental data link-up—in charge of the production team there which included Nancy Campi and Chris Wedge. MAGI's process, called Synthavision, is unique among CGI production methods. "In our software," Elin explains, "there exists what you could think of as three-dimensional volumes. These are preprogrammed primitive shapes that are already in the computer. There are spheres, cubes, cones, ellipsoids—those are some of the simple ones. There are also free-form bodies like hyperbolic paraboloids. It's a lot like building with blocks. Everything that we build in our system is built from these simple shapes. They can be added to each other or subtracted from each other, made larger or smaller and their proportions changed in any way, making it possible to make complex-looking things. This process is called combinational geometry—or solids modeling."

All other digital imaging systems use a different method based upon forming the objects out of lots of little flat surfaces, like the facets of a gemstone, and thereafter calculating the light that strikes these polygonal facets and how much of it reflects into the theoretical camera lens. But it turns out that one of the most time-consuming aspects of that kind of software is the time it takes for the computer to figure out which objects and parts of objects are naturally hidden from the camera's view. "One of the good things about the Synthavision method is that we don't have hidden lines to sort out. So the calculation time is really small compared to the time required when you build a picture out of polygons. The problem solves itself with our ray-tracing process."

For the folks at MAGI, it turns out to be a lot simpler to trace the light *backward* from the imaginary camera, rather than to calculate all the light that might or might not be coming *towards* the camera. "We actually fire rays from the camera at the scene, one ray for each pixel. So everything naturally takes care of its own hidden lines because the first thing you hit accounts for that particular pixel. At some point along the way it'll hit something, and then the computer figures out at what angle it hit it. That angle's relationship to the light source will determine what gray level that particular point of color should be." In effect, what is out of sight is out of mind for the MAGI computers.

The founder and president of MAGI—oldest of the CGI operations, dating back to 1966—is Dr. Phillip Mittelman, who is a physicist, not a programmer. "We were in the business in the first place to do calculations involving nuclear radiation transport; and so everything we were doing had to do with tracking rays through things. The company was working on these radiation problems, and the techniques we developed were something where you describe the real world in terms of three-dimensional objects. We'd trace radiation—neutrons and gamma rays—through this three-dimensional world; and we observed that if we traced *light* rays around, instead of neutrons and gamma rays, we would, in effect, simulate photography. And that's the basis of our whole idea—a true simulation of photography." In essence, MAGI evolved their unique method of working with geometric primitives because when they were dealing with radiation the objects they were concerned with had to behave as though they were solid objects—it was not sufficient to just concern themselves with the surfaces of things. Now, of course, solidity no longer matters in their computations, but the legacy of their early work lies in their hidden-line-free way of doing things.

MAGI has a unique method of working with geometric primitives.

"At one time we showed our work to some people and they said, 'My gosh, you've solved the hidden-line problem!' We said, 'What's a hidden-line problem?' We were quite naive. We were totally independent and out of touch with the world of picture making that was going on in Utah, and places like that, where they were making images the more common way, with polygons and so forth."

"You don't have to be a programmer to use the Synthavision system," Larry Elin explained. "In fact, all of us on the production team come from film, art and animation backgrounds. The work we do is very much analogous to motion control systems, except that instead of using real models and real cameras, we're just generating the pictures based on instructions that we give to the computer. In effect we build these models, but we build them digitally into the computer. Then we define the motions that we want these things to go through. And the same for the motions that we want the camera and the aim point and light sources to go through. So we build models, but we don't build real models—we build mathematical models. And we program motions, but we're programming the motions for these mathematical models—not for things dangling from the ceiling on wires or anything like that. In a way, we are akin to stop-motion animation, but we're not limited by real solid objects. We're dealing with things that are really just ghosts! So we describe these things and motions to the computer, and the computer is able to calculate what these pictures would really look like if everything were just the way we described them.

"The first step in our process is to build whatever it is that we want to animate from these simple shapes. The next step is to put the objects all into the scene together—in the places in three-dimensional space where we want them to start when the scene begins. Then we put in the movement commands, using our 'director's language.' The next step is to select

some key frames to look at—to make sure that all the commands we've fed into the computer are really making happen what we want it to do. So we test the input by calculating some key frames. Once those frames are calculated we can look at them on a 1000-line screen terminal; and from there it's easy to determine whether or not we need to make some changes in our input file. The next step is to calculate what we call a pencil test (a term appropriated from conventional animation, which refers to test films of the animation in its earliest pencil-drawn stages) which is a low-resolution, black-and-white line drawing animation of the scene. Usually we can do this in a very short period of time. Most of the scenes in *Tron* were an average of about three-and-a-half seconds long—or about 84 frames—and we could calculate 84 frames in about an hour. Then we viewed them at speed on the monitor. At that point we could modify movements. If we didn't like the way something was moving, or if we thought something was moving too slow, we could make those changes. Then it was time to let the Disney animators, like Bill and Jerry, see what we'd done. So we'd transmit the same pictures we'd been looking at on our monitor over the phone lines to their monitor in California. Then they'd tell us whatever modifications they wanted us to make. Once it got to the point where we all liked what we had, then we'd compute and photograph the scene at high-resolution—in Vistavision format—and that was the finished film that we delivered to Disney. Our high-resolution would be the equivalent of 1800 lines if it were on 35mm.

"We also provided pictures which were used by the Disney painters as guides so that they could paint backgrounds for use with the back-lit live-action. They'd paint an exact duplicate of what the computer scene looked like, because then they could shoot it on the animation stand, which saved them from having to go through opticals."

In contrast to MAGI's combinational geometry and ray tracing, almost all other CGI companies use methods similar to those employed by Information International. Triple-I's approach works best for creating complex objects with elaborate coloring and simply stunning surface characteristics. Their engineer, Bill Dungan, spoke about some of the features of the system: "We have a program that was written by Craig Reynolds for his master's thesis at MIT, called ASAS—Actor/Scriptor/Animation System—and it's with that program that we choreograph our scenes. Not only do we control movement, but we also control colors, lighting and all our parameters. You can animate everything independently and change colors all over the place. What comes out of this is the format for our shading program, which is called TRANU—the New Transparency Algorithm—which has had codes added to it over the years by many people, like Jim Blinn, Frank Crow and Gary Demos—who did a lot of things—and I think it actually started at Utah, where so much of the early work was done."

Triple-I's method of making objects is quite different from the building-blocks approach used by MAGI. "The first thing that happens is that Art Durinski encodes the blueprints of an object using a digitizing tablet. The blueprints have the object made out of polygons. If the object has curves, they are approximated with lots of these little polygons which will be rounded off later. Then—when our program reads that in—each of the polygons will have colors assigned, and the algorithm converts all the vertices of the polygons into the coordinate space. Then, when you've got a lot of polygons in there, the computer has to figure out which ones are in front. It does this in scan-line order—left-to-right, top-to-bottom—and at each scan-line it tries to figure out which one of the polygons, being cut by each point on each line, is in front."

Triple-I commonly uses two methods to round off all those flat polygons into smoothly shaded curved surfaces. "There's Gouraud shading, which will do a linear gra-

dient across the polygon. Then there's Phong shading, which will interpolate a 'normal' across it, and the computer computes the direction where the surface-normal is pointing with respect to the light source and the observer, to get the gray value. If we're working on an object that's got smooth curves like a sphere—and we're making that out of polygons—what we do is we average the polygon normal around a point and come up with a normal for a vertex. Then we use where the observer eye-point is, and where the light sources are (relative to the object) to figure out where the highlights should be."

Thus it is that the object is given form and solidity by virtue of its realistic shading and highlights. That's self-shading, which is quite a different matter from calculating the shadow that the object will cast on the floor or on other objects in the scene. "The shadow-casting program was implemented by Frank Crow. First, from the light source's point-of-view, the boundary edges of the object are figured out. From there, it makes invisible polygons that define the volume where the cast shadow is. Then, when you're working on any given point in the picture, if the point being calculated enters that volume and strikes a surface, the computer knows that surface is in shadow. But if it goes through and exits the volume out the other side, it knows that there's no shadow on anything it strikes there.

"As for transparency, when you look at objects in the real world and say, 'What makes them do that?' you find out that there are actually several different kinds of transparency. There's one transparency that is the colored-filter approach, which is when, for instance, you have a blue object and you put a red filter in front of it, you get black. The other type of transparency is like if you have a blue object and you have a red beam of light crossing in front of it—you're still going to see the blue, but it will be averaged in with the red. It depends on what it is you're trying to simulate, which may be a combination of both effects." A good example of the latter type of transparency is the diaphanous sail of *Tron*'s solar sailer.

"We're getting to the point in computer graphics where we can make a lot of things look totally real. We don't want it to look like it's done by computer, obviously. We want to reach the point where you cause people to suspend disbelief." The fact is that Triple-I already has the ability to do that with certain kinds of things, which prompted Dungan to quote Arthur C. Clarke's third law: "'Any sufficiently advanced technology is indistinguishable from magic.' Now—right now—computer graphics is magic. In computer graphics we can do things that are impossible. We can have objects levitate or pass right through one another, and we can have metallic objects interpolating their shapes. You just couldn't do that any other way. I would say the future in computer graphics is going to be

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magical; and I think *Tron* is going to be the busting loose point."

Very important to the visual continuity of *Tron* is the hand-done effects animation, produced under the supervision of Lee Dyer. It seems as though few people outside of the field even know that effects animation exists.

There are some 15 minutes of effects animation in *Tron*, but you have to keep your eyes open to see it, because most of the scenes last but an instant. "The effects in this film are very geometrical compared to traditional animation effects. Steven didn't want anything done that was like anything previous to this picture. That was hard. But I think we've achieved it in many ways—like the interactive lights on the characters, for example, when the disks are played and so forth. The interactive light we did keeps the bodies from being flat. And we also throw shadows on the floor—for three or four frames maximum—just enough to give dimension to the picture. When Tron raises his disk, it looks like there's a light bulb behind the disk creating the light on his body; and yet, that effect is totally animated. The second you see a live-action character, you know the scene is not computer-generated. Flynn is zapped into the computer world using effects animation.

"In the first scenes with the racing light-cycles, there were brief transitional shots where we had to paint the bikes by hand around the live-action characters. Then, with our scene done, the computer animation of the bike race begins. But the nice thing for me about this is the fact that the animated special effects are so close to the computer animated effects that you can't tell them apart. When you see them cut together, the marriage is very good—it isn't distracting to go from one type of animation to the other. It's the first time, I'm sure, that this has ever been done. And even though I've been in effects for over 22 years, this has really been a learning experience for me."

Working closely with Lee Dyer were John Norton and his assistant Dave Stephan. Norton was responsible for designing the computer-generated Bit character—in association with scene coordinator Deena Burkett—and the Recognizer flying machine generated by MAGI. But most of his work on *Tron* is hand-done cel animation, stylized to look like CGI.

Additionally, Norton designed and animated, by hand, a spider-like mechanical creature called the "grid bug." "Computer people talk about 'bugs' in computer systems, and I always felt that we should do something with bugs for the film. So I came up with this grid creature that lives inside the computer and eats things. Bill worked them into the storyboards, and at first we decided to do them with computer simulation at Triple-I; but it came back to me to do, because they were too busy. So I did about 15 feet of film that was shot back-lit on the animation stand to try to make it look as much like CGI as possible. The idea was that these creatures camouflage themselves as part of the electronic grid; and then they appear, sort of rising up out of the grid to menace you. First there's just one who appears, looks around and runs off. Then we cut to a longer shot of a whole herd of these bugs galloping off and out of the scene."

When all the whiz kids from the land of video commercials arrived at the land of Disney, there was intense culture shock for both sides. To John Scheele, the mighty Disney animation equipment seemed to symbolize the gap that had to be bridged. "The Disney method has come to include little peculiarities that are unique only to itself. The pegs on their cameras are set apart differently from the Acme standard; the field centers are different; the cameras are all just a bit odd from what you see elsewhere. And because this studio is its own world, those little things have never changed and are totally woven into the system. Somebody—and not even Art Cruickshank can remember who's to blame—tried to draw an inch on the original field chart, and it came out 0.954 inch instead. That was back in the Thirties; and ever since, that's been the 'Disney inch.' So now Triple-I and MAGI have this strange field chart encoded into their

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systems, too, and that guy is still getting his way!

'The biggest problem was that Disney's animation stands hadn't been updated since *Fantasia!* They have such incredible craftsmen here—nothing is made that won't last through the ages. The camera stands—especially the multiplanes—are like monuments and memorials to Walt, Ub Iwerks, and everyone who's worked there. And it's a shame, on that level, to even mess with them. There's a real reverence and care for the equipment and physical spaces here, as well as for the people and traditions; and that's been a special pleasure for me. There's kind of a mutual attraction that's gone on—people who've known each other and worked together and figured this stuff out, and who've been waiting for a chance like this to really put it all together on the screen. It's a pretty incredible blend of talents and personalities—people who've worked at Abel's, at Gehring's, on *Star Trek*. It's the best team that could be brought together for the project. And these areas—the back-lit effects and computer imagery—have never been a part of Disney's in-house repertoire until now, so we're really contributing something to the studio. To their credit, Disney recognized the potential of this film and these techniques, and have let a whole new brood inside its walls—one that didn't work its way up the ladder. That's caused some inevitable friction. But the studio has always been supportive, and it's a healthy situation to have some new blood. And we're obviously excited to be able to work here at Disney, where it all started."

How well people react to change in their environment has a significant impact on their quality of life. The confrontation between computer generated imagery and the proud tradition of animating by hand is a fascinating one that has just now heard the bell sound for round one. "It's like making the adjustment to hyperspace," said Bill Kroyer. 'The big irony is that the older guys like Eric Larson, Frank Thomas, and Ollie Johnston will love this computer generated stuff. They're ready to see something new happen, and they always have been. The thing about the Disney studio is that the old-time guys were very innovative, because Walt was always demanding of them to move on to new things. They always complained that once they learned how to do something, Walt made them do something totally different on the next film. When you look at the old Disney animated films, the styles change completely from one to the next. We found that the old guys had a real love of innovation and an open-mindedness. But when Walt died that bravery of innovation stalled here at the company. Once he was gone, they tried to stay within the parameters as they were then. The whole mentality was: 'We do what we do best—which means that we keep doing what we've *been* doing.' But what you ended up with was a situation where you had young people coming in who knew all about the meaning of animation and what it was trying to achieve and its potential; and they found that they weren't going to be allowed to innovate at all here, but only to keep repeating what had been done.

"Jerry Rees and I came here with dreams to do Disney-quality animation, not to *redo* Disney-quality animation. But we found ourselves boxed in until this project came along. Now we are able to apply *all* the things that the Disney animators have learned over 50 years—that we have inherited from their experience—and show that the entertainment principles that they struggled to learn can be applied to the totally different computer medium. And we feel especially great about the fact that we're doing it at Disney, and that Disney is the first to benefit."

Shelley Hinton reflected on the Disney studio's past—its ups and downs, and where it's heading: "*Tron* represents a timely turnaround. I have a mental image of the studio after Walt died—with it being left to his cohorts to protect from the vultures and coyotes that could come to pick the place apart. Opportunists might have tried to take advantage of a studio without its founders. So I im-

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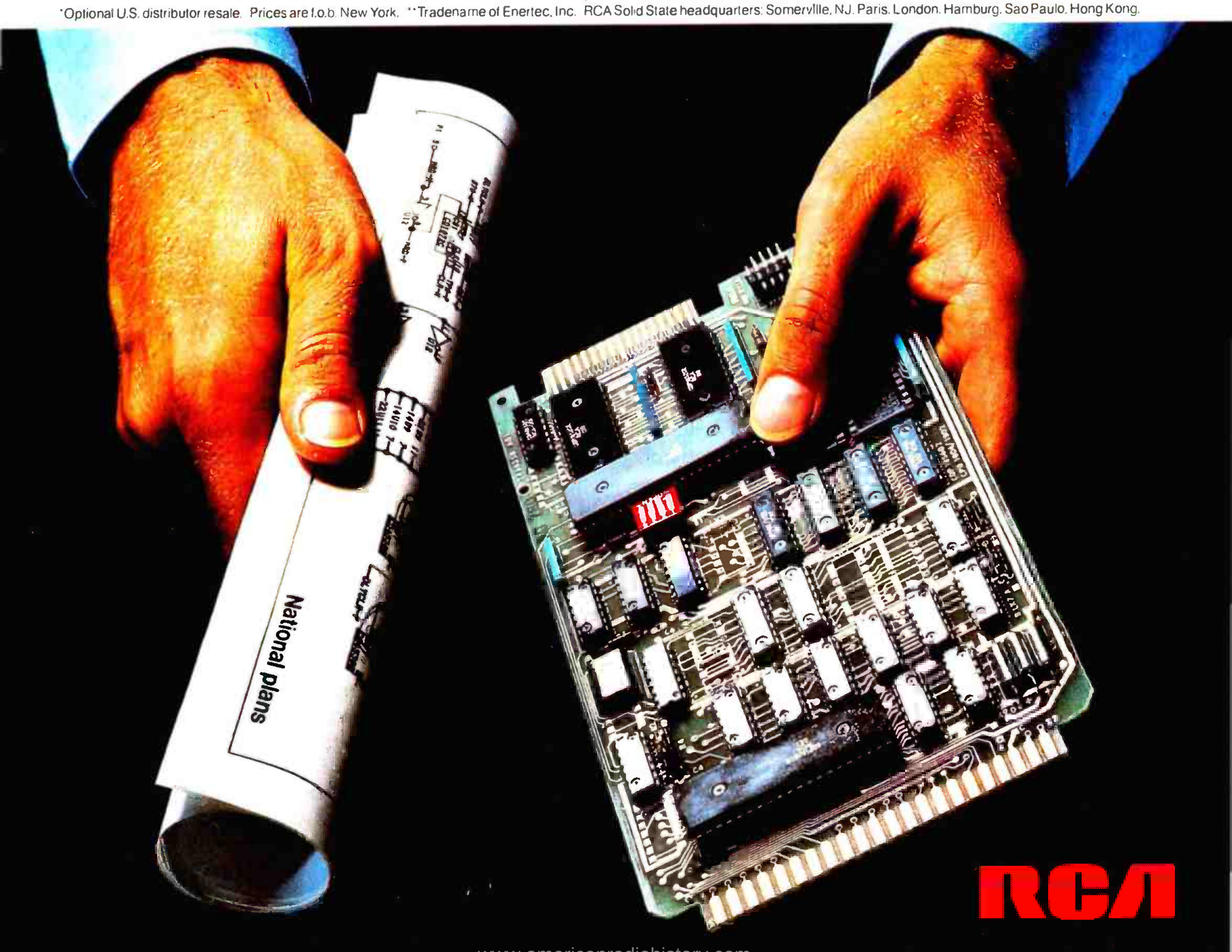

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agine it was necessary for the survivors to examine the tried and proven elements—the high standards and idealism that had built the Disney legacy—and maintain them as the status quo. This evolved into the Disney Formula' that's become so familiar. The flip side of that, though, is that these same guidelines became constraining boundaries." So a place that had been a Mecca for innovation and creativity appeared to stagnate for a decade or so, and much of the public became disenchanted with the Disney product. But eventually it became obvious that it was impossible to stop the clock. "They've been through that period; and now there are new people, new minds, and new ideas to add to a strong foundation. Those who have been here awhile really represent the heart of the studio, and there is a lot to be learned from them. It seems the right time for the combination of old and new. The prevalent attitude at the studio is one of optimism. They're ready to say: 'Let's move forward. We've survived the deaths of Walt and Roy and we're continuing to grow. Let's take a look at what we're founded upon and apply it to the present and future.' Now I'm looking forward to some really progressive new projects here—to being a state-of-the-art company—because that's what we're based on."

The concluding remarks of most *Tron* workers almost inevitably include some thoughts about the promise that the new tools used on the film hold. To the common man, computers have come to symbolize the most dehumanizing aspect of technology—and not without some justification—but these are just tools, not to be blamed for the uses to which they have been put. Only recently has the public begun to realize that computers can be made to do beautiful things. Coming from the center of the computer graphics explosion, Richard Taylor said philosophically: "I'm continually asked if computers are going to replace people in the arts. A lot of people seem to think of them as a threat. The thing is that computers are *not* a threat. I think they're just as evolutionarily natural as a tree. When consciousness evolves into matter, eventually machines are a result of that evolution. The digital watch on your arm is as natural as the flowers in your garden. Apparently, when consciousness evolves, it starts inventing wheels, fire and easier ways to do things. Eventually, it makes machines—and computers are just one of the more recent evolutions.

"Computers are like anything else. It's the way man uses them. I think a computer is really just an instrument of expression—like an organ or a piano. It's how you play it that eventually resolves what value it has. They don't replace people and I don't think they should be intimidating to people. It takes people to play them; and it takes imaginations to give them value. They certainly aren't going to replace animators or musicians. They're just here to help us express ourselves more clearly."

Steven Lisberger had similar thoughts. 'There is this fear people have that eventually actors are going to be replaced by computer characters. I don't think it is valid at all. The only thing that the technology is going to do is provide the actors with new places to go and new ways to go there. I myself have a fear of technology taking the humanness out of our lives and creating a barrier between people. The notion in the film is that, if anything, the technology should make people more accessible to each other, rather than creating frustrating walls between us. I have a dream that with computers eventually films will become interactive, and that eventually they will be designed where audiences can participate in the picture. Depending on how involved or skilled they are, the audience could actually affect the outcome of the movie. If you had a really hot audience, the good guys would win; if you didn't, the bad guys would win. The audiences' reactions would determine which way it went."

'The nice thing about computer generated animation," Larry Elin concluded, "is that there's really no end to the possibilities for it. The technology is literally a fetus. *Tron* is going to be thought of as the maternity ward of computer graphics in entertainment."■

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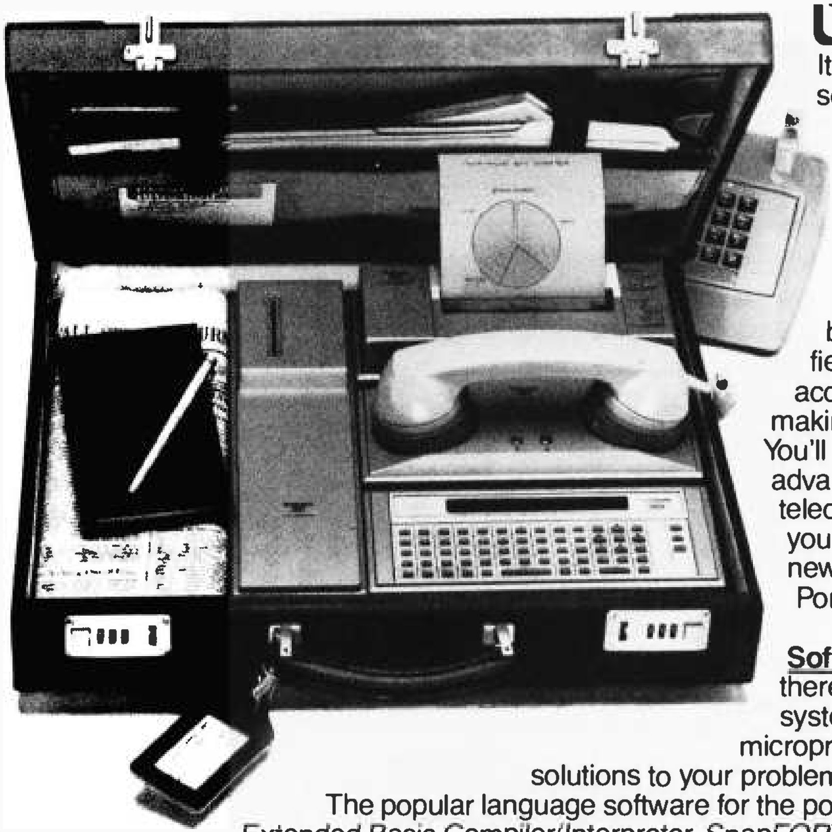

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Build the Circuit Cellar MPX-16 Computer System

Part 1

Any peripheral device designed to be installed in the IBM Personal Computer can be plugged into this 8088-based system.

Steve Ciarcia
POB 582
Glastonbury, CT 06033

Let's see. What's next? A computer-controlled bird bath? An early-warning radar transponder? How about a satellite-tracking system? Something simple.

After this series of articles is over, I am going to write about uncomplicated construction projects for a while. You'd think that after doing 50 or so projects over the past four years I'd have learned to recognize when uncontrolled invention was getting the upper hand, as it did in this month's project.

I was caught up in the fervor that resulted from the introduction of the IBM Personal Computer. As I had already written two articles on the Intel 8088 microprocessor used in the IBM machine, I quickly decided to jump on the bandwagon and purchase the first IBM PC (as it's called by its owners) that I could get my hands on. I've found myself in agreement with the prevailing opinion that the IBM PC is a solid design and well supported, but it's relatively expensive to upgrade.

The design of the MPX-16 had to be a team effort.

Somewhere along the way I had the absurdly ambitious idea of presenting a Circuit Cellar construction project on building a full computer system based, like the IBM PC, on the Intel 8088 microprocessor. (After all, I've done many microprocessor projects before.) And somewhere further along the way I decided to do it.

Design Concepts

Certain questions had to be addressed, of course. Should I try for a 10-chip design or splurge and make it 20 chips? What kind of expansion-bus scheme should the system use? What about supporting software? Could I design a small 8088-based computer and call it a development system?

The initial stages of design moved very quickly, and in a few weeks I had put together a prototype of a 64K-byte 8088-based trainer or development system. It was a compact design with limited input/output (I/O) capability but with relatively little expansion potential, lacking an expansion bus. It could have served well as a Circuit Cellar project. However, owning a so-called development system has come to mean that you are on your own: you won't get much support for either software or hardware. If the project was to have any real significance, support had to be available, and the burden of providing support would have been mine.

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Photo 1: *The Circuit Cellar MPX-16 single-board computer system, which uses the latest technology to provide lots of low-cost computing power. The five-layer printed-circuit board contains 120 integrated circuits including most common peripheral-device interfaces; furthermore, any peripheral-device card intended for use with the IBM Personal Computer can be plugged into one of the I/O-expansion slots. There are nine slot positions, but only five sockets are installed initially.*

There was only one answer: compatibility. The project would have to be compatible with peripheral-device expansion boards and software designed for some popular computer system. The logical choice, given that I intended to use an 8088, was to make my project compatible with the I/O-expansion bus of the IBM Personal Computer. (The only real alternative was the S-100 bus, but somehow in my fervor the IBM PC route seemed more natural. S-100 fans should look up reference 1.) Consequently, IBM PC memory and I/O-expansion boards, available from numerous sources, could be used to expand this new computer.

But in making this choice, I opened Pandora's box. I was already committed to producing the article, but making my little prototype bus-compatible with the IBM PC was like fitting the *Queen Mary* into a bathtub. Scratch one prototype; start thinking about the "system board."

Ten minutes later, I realized that this would have to be a team effort. I would need assistance in developing the design, the documentation, and the software, so I enlisted help from a few friends and other engineers to form the design team.

At that point, team (or rather, committee) dynamics came into play. If you give a committee 3 square inches of empty space on the printed-circuit board, they'll want to increase performance by packing 10 more integrated circuits into it. Essentially that's what happened to my little trainer board. Not only would the resulting system be bus-compatible with the Personal Computer, but it would overcome some of the expansion weaknesses of the IBM machine by incorporating many peripheral devices as part of the basic design. Instead of a board that could be expanded into a system, this new computer would be a complete system that had been shrunk to fit on a single board.

Design Characteristics

The result of our effort is called the Circuit Cellar MPX-16 Computer

1. 5-MHz Intel 8088 main processor
2. optional Intel 8087 numeric coprocessor
3. 256K-byte on-board-user-memory capacity, with parity
4. two RS-232C serial input/output ports
5. three parallel input/output ports
6. on-board controller for either 5¼-inch or 8-inch single- or double-density floppy-disk drives (up to four)
7. supports the CP/M-86 operating system directly, with BIOS in EPROM
8. nine expansion slots (five connectors provided), bus-compatible with IBM Personal Computer
9. sockets for 64K bytes of 24- or 28-pin EPROM
10. four independent DMA channels
11. sixteen levels of vectored interrupts

Table 1: *Features of the MPX-16 computer system.*

System, shown in photo 1. Consisting of a single 9- by 12-inch five-layer printed-circuit board containing 120 integrated circuits (ICs), the MPX-16 is completely compatible with the expansion bus of the IBM Personal Computer and contains the following features: provision for an optional Intel 8087 math coprocessor, 256K bytes of RAM (random-access read/write memory), serial and parallel I/O ports, floppy-disk controller, expansion slots, and support for Digital Research's CP/M-86 operating system. (A more detailed list of features appears in table 1.)

The MPX-16 constitutes a complete, single-board computer system, using the latest technology to provide lots of low-cost computing power. It is designed to utilize all the expansion peripherals that are available for the IBM machine, and because it has so many capabilities built in, you don't have to use up expansion slots for simple jobs like interfacing a printer. Programmers, however, will undoubtedly want more memory. To meet this demand, additional memory boards can be plugged in to provide the system with one full megabyte of user memory. A hard-disk drive can be added easily, and an 8087 mathematics coprocessor can be inserted to multiply the system's raw computing power by a factor of 10 to 100.

The MPX-16 is designed initially to use CP/M-86, but it will ultimately accommodate Microsoft's MS-DOS and any other software that does not use unique features of the IBM Personal Computer. The greatest difference is this: as a stand-alone system, the MPX-16 communicates with the user through a serially interfaced display terminal instead of through a memory-mapped video display and separate keyboard. The BIOS (basic input/output system) module of CP/M-86 is contained in a set of EPROMs (erasable programmable read-only memories) on the board.

The MPX-16 is almost complete on a single board. In addition, you need merely a power supply, a serial terminal, and one floppy-disk drive. To start operation, you just turn on the power, insert a CP/M-86 disk, and start the bootstrap operation. For the sake of appearance, though, you may

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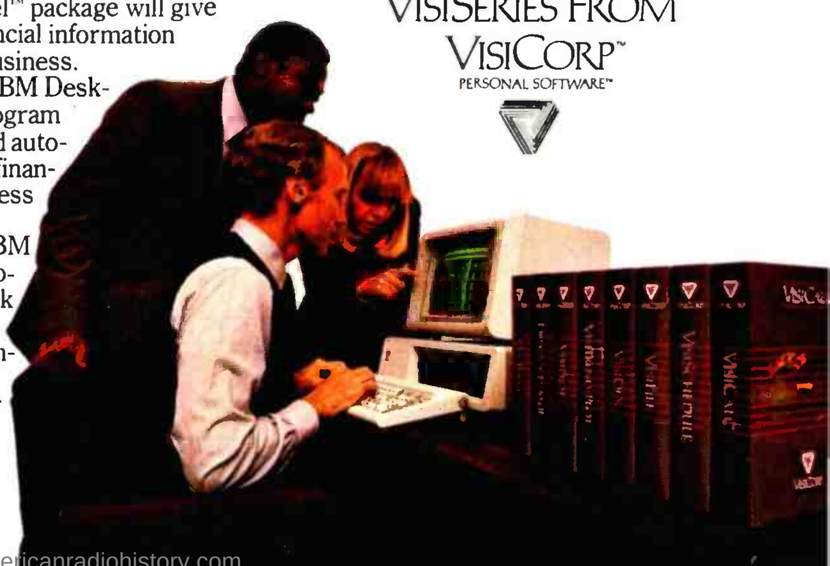

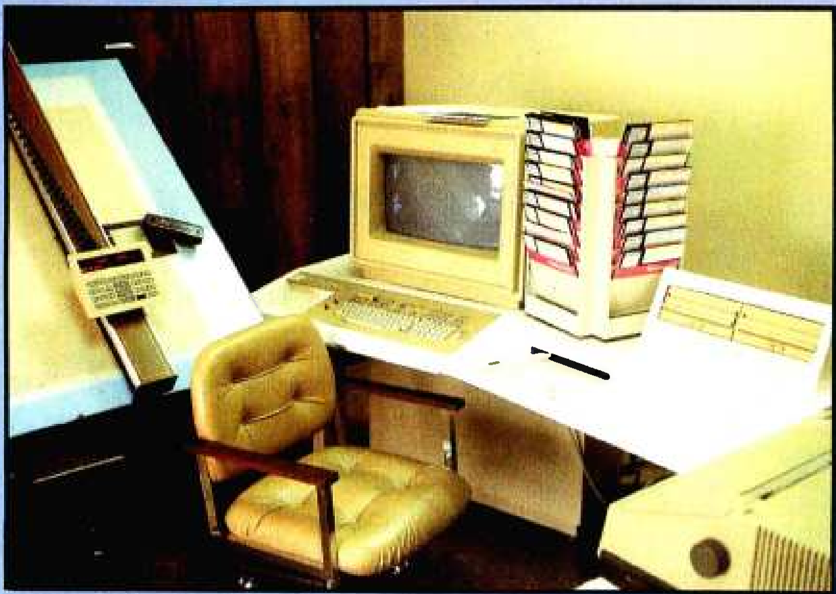

Photo 2: *The Gerber Scientific Instrument Company PC-800 CAD (computer-aided design) machine used to lay out the MPX-16's five-layer printed-circuit board.*

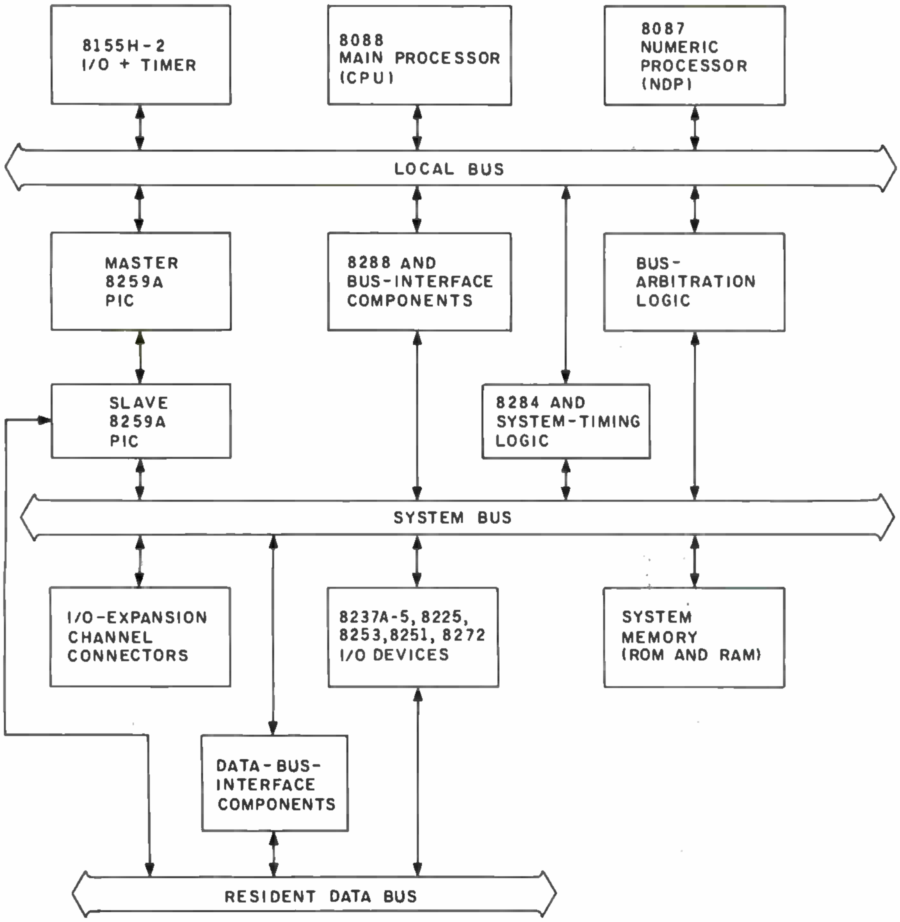

Figure 1: *Simplified, high-level block diagram of the Circuit Cellar MPX-16 computer system. The abbreviation "PIC" stands for "programmable interrupt controller."*

want to wrap up the whole thing in a suitable enclosure; one *should* be available by the time you read this.

Pragmatic Considerations

Obviously, it is impossible to describe the construction of such a powerful computer in detail in a single article. Even dividing it into three parts, as I plan, will be a difficult task; it will take us three months to print schematic diagrams of the entire computer in the magazine. I'll try to be as explicit as I can concerning how the circuitry works, but you must understand from the outset that this is no beginner's project.

The condensation of information here is counterbalanced by the support available from The Micromint, where you can get assembled and tested systems, blank printed-circuit boards, and complete documentation containing all the circuit diagrams plus much more detail than can be included in these brief articles.

Finally, before I start the details, I'd like to say something about the MPX-16's circuit board. Printed-circuit boards are available for building most recent Circuit Cellar projects, and this project is no exception. The only departure from the norm this time is in the complexity of the board.

The MPX-16 contains 120 IC packages. To keep its size manageable, we had to use a multilayer printed-circuit board instead of the relatively simple double-sided boards used in smaller-scale projects. With the aid of a Gerber Scientific Instrument Company PC-800 CAD (computer-aided design) machine, shown in photo 2, we eventually arrived at a 9- by 12-inch board with five layers of connecting traces. This is significant because multilayer boards cost about 10 times as much as standard double-sided boards. But even with an expensive circuit board, I believe that the MPX-16 has unbeatable performance for its cost.

MPX-16 Overview

The functional organization of the MPX-16's onboard components is illustrated in two levels of detail. Figure 1 shows a simplified, high-

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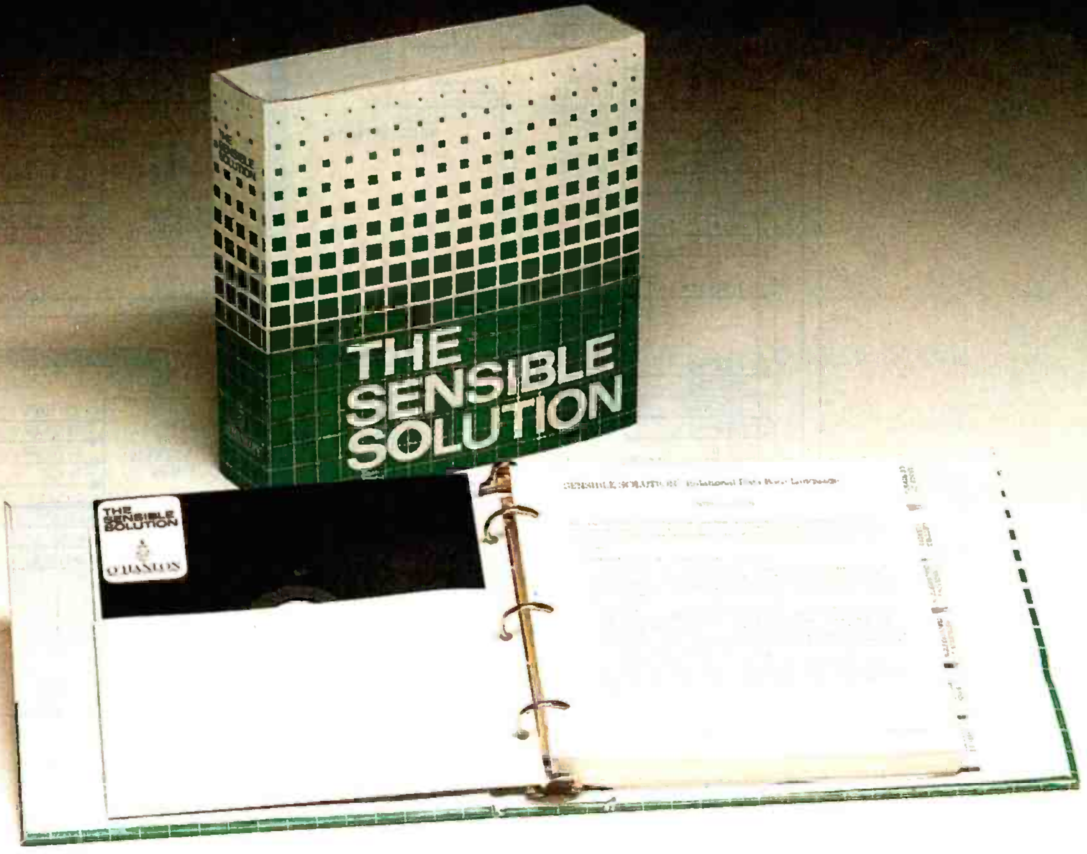

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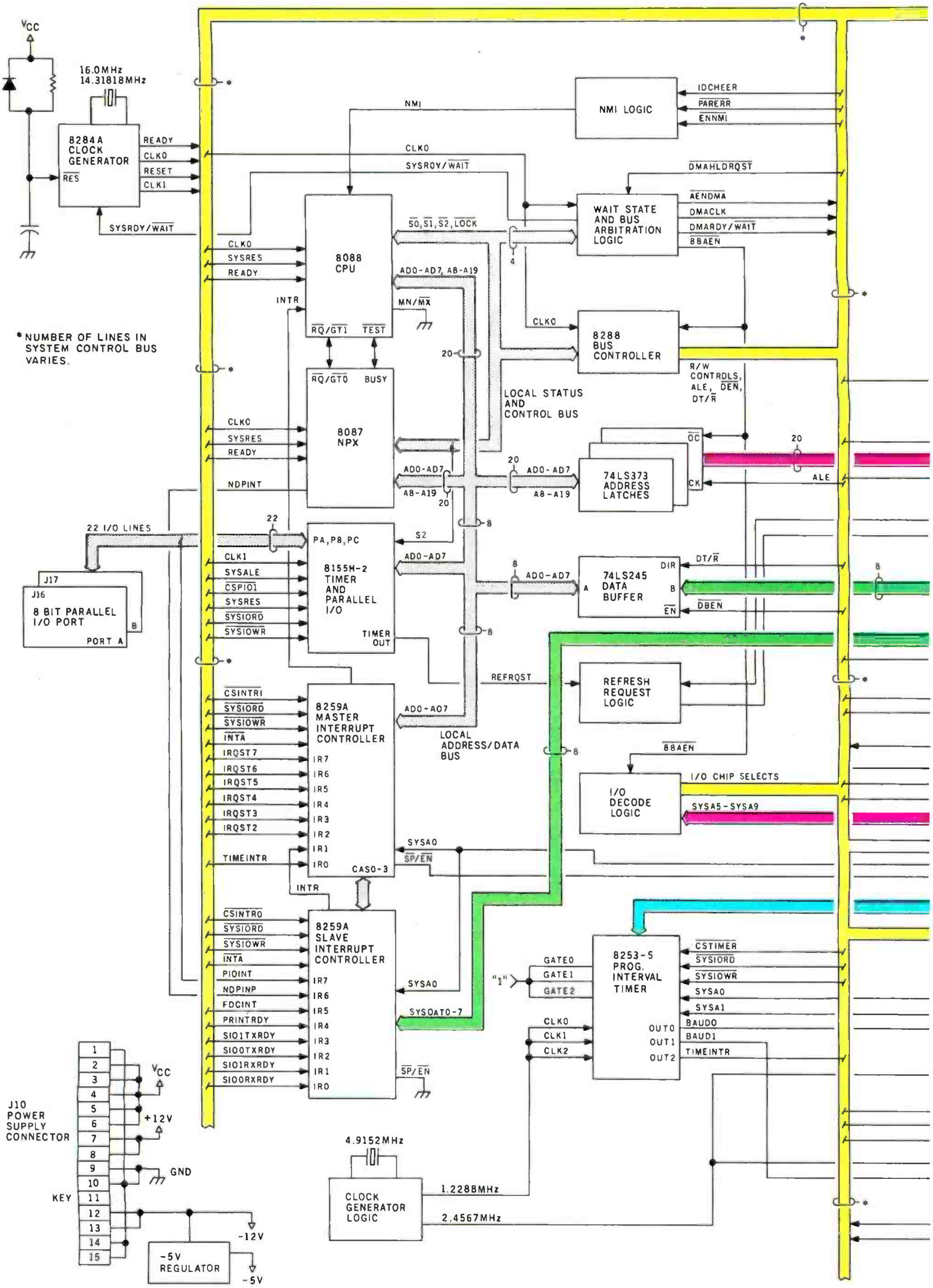
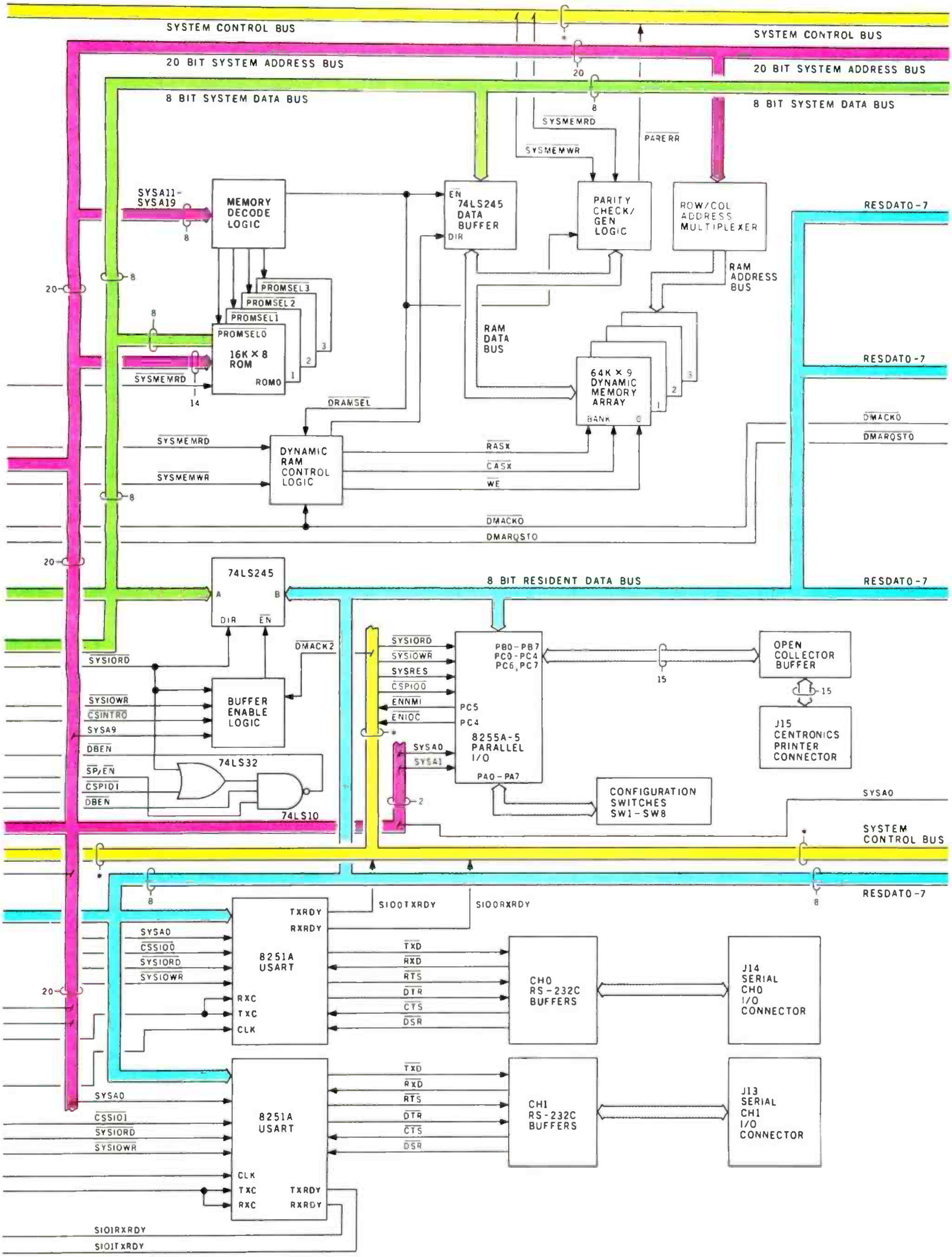


Figure 2: *Complete, detailed flow diagram of the MPX-16 system. (The diagram is continued on page 86.)*


SYSTEM CONTROL BUS
20 BIT SYSTEM ADDRESS BUS
8 BIT SYSTEM DATA BUS
SYSMEMRD
SYSMEMWR
PARERR
SYSA11-SYSA19
MEMORY DECODE LOGIC
EN 74LS245 DATA BUFFER DIR
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RESDAT0-7
RAM ADDRESS BUS
PROMSEL3
PROMSEL2
PROMSEL1
PROMSEL0
16K × 8 ROM
ROM0
RAM DATA BUS
64K × 9 DYNAMIC MEMORY ARRAY
BANK 0
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RASX
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EN
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CSSI01
CH1 RS-232C BUFFERS
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SI01RXRDY
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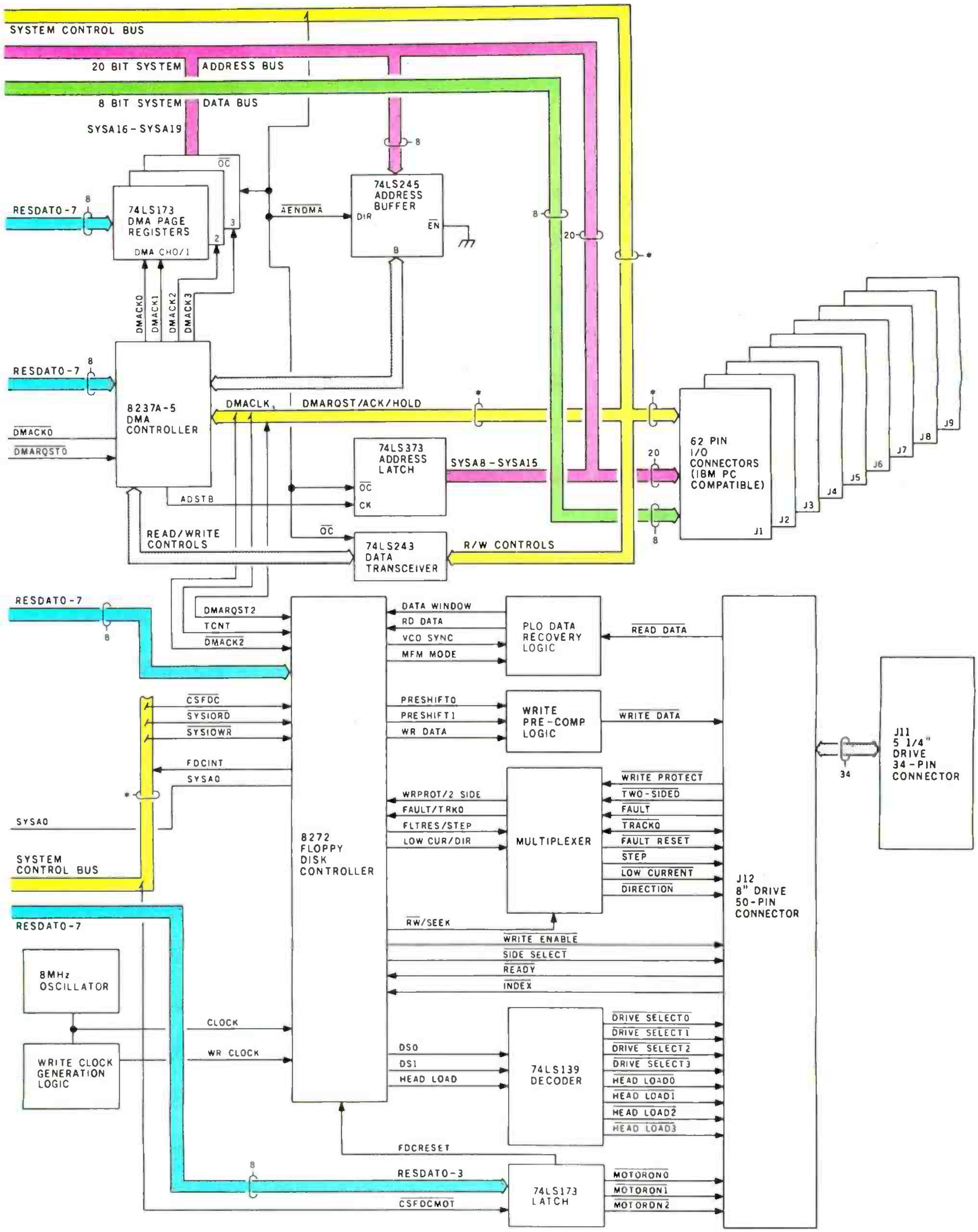

Figure 2: *Continued from page 85.*

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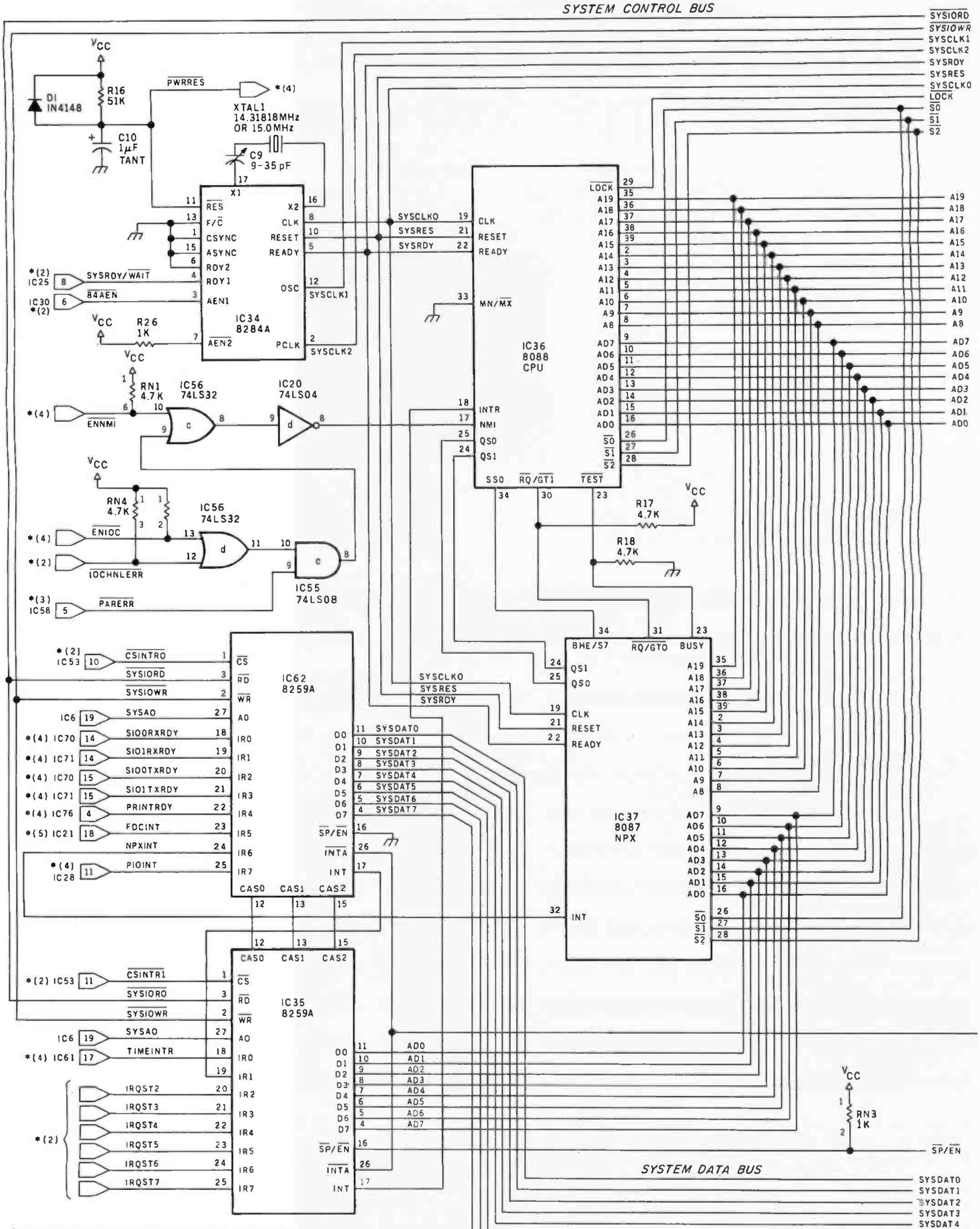
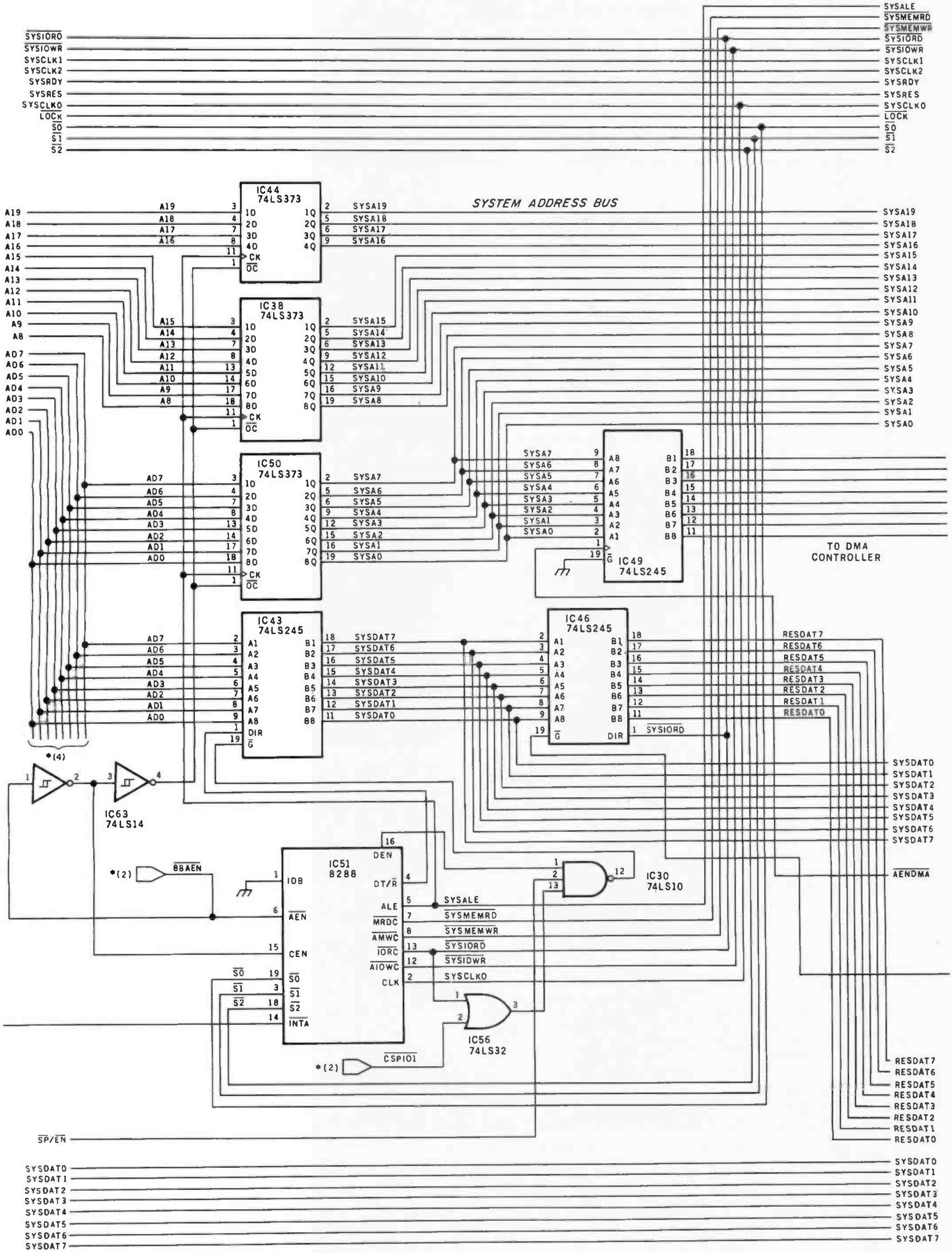


*(SECTION #) DENOTES CONNECTION TO INDICATED PIN OR SIGNAL ON OTHER NUMBERED CIRCUIT SECTIONS.

Figure 3a: *Half of section 1 of the schematic diagram of the MPX-16; the second half of section 1 appears as figure 3b on the next two pages. Sections 2 through 5 of the schematic will appear in December's and January's articles. Many connections to other sections of the schematic are indicated in this figure by the notation *(n), where n is the section number; IC numbers in the other sections are*



given where appropriate. Here are shown the main processor, numeric coprocessor, interrupt controllers, clock generator, bus controller, bus latches, bus transceivers, and miscellaneous components. A table of power connections will be published in the December 1982 BYTE.

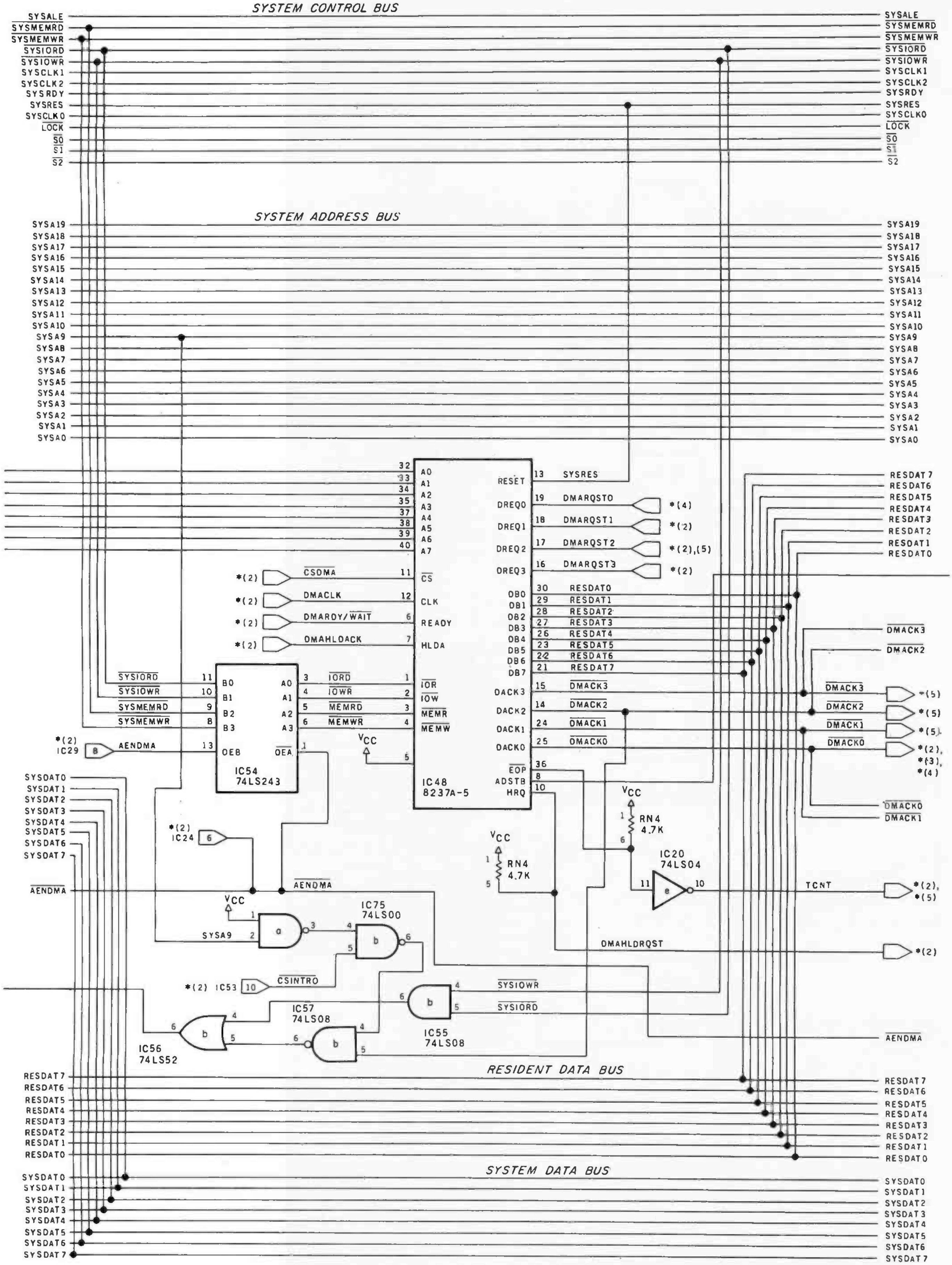
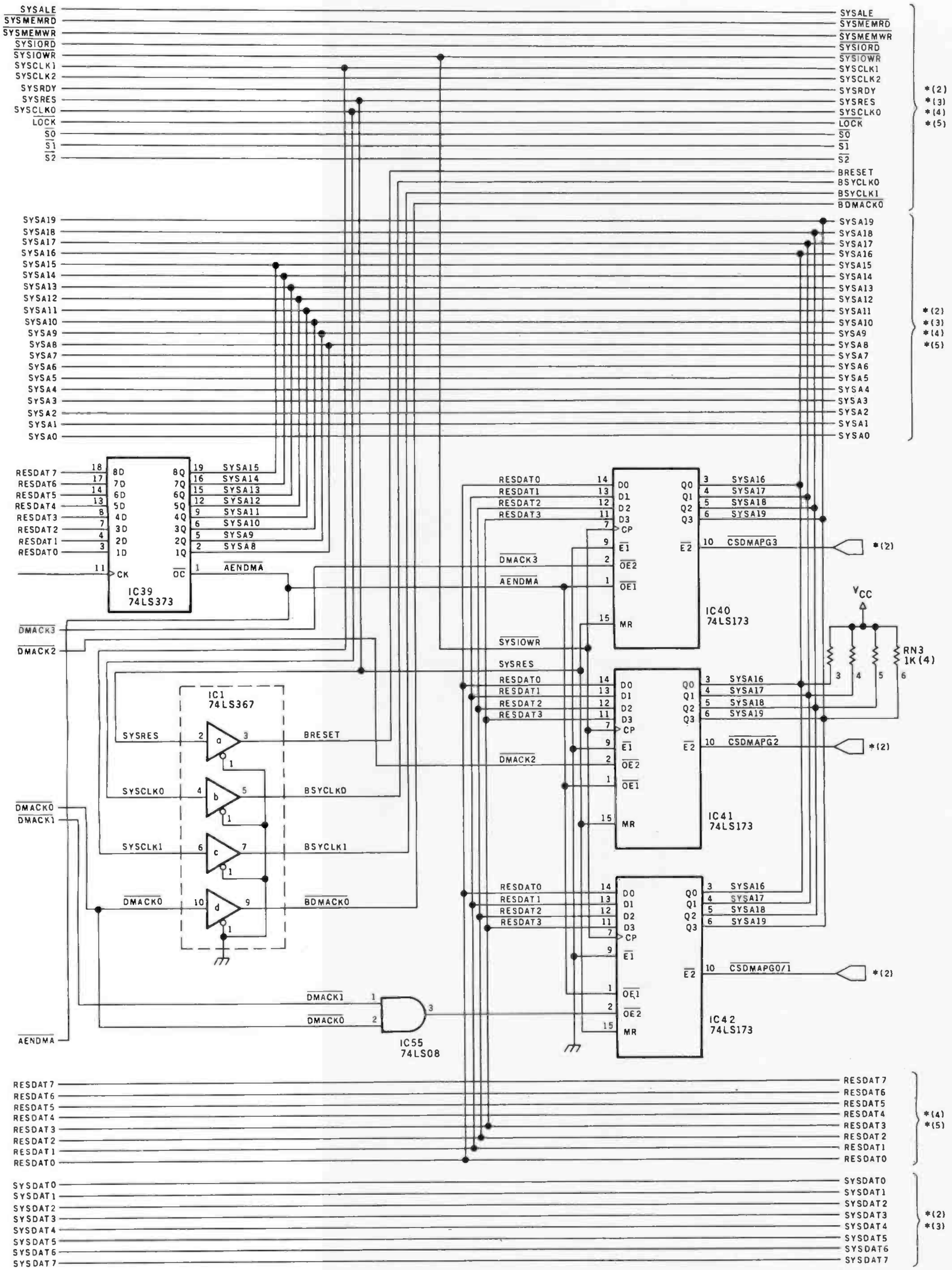


Figure 3b: *Second half of section 1 of the schematic diagram of the MPX-16. Here are shown the direct-memory-access controller; control-signal latches, registers, and transceivers; and various logic gates. Note the large number of bus lines for addresses, data, and control signals. Sections 2 through 5 of the schematic will appear in December's and January's articles. Many connections to other*



*sections of the schematic are indicated in this figure by the notation *(n), where n is the section number; IC numbers in the other sections are given where appropriate.*

Photo 3: *Prototype of the MPX-16 being tested for compatibility with the I/O-expansion bus of the IBM Personal Computer. A Quadram Quadboard (an expansion card for the IBM PC that contains 256K bytes of memory, a serial port, a parallel port, and a real-time clock) is inserted in one of the MPX-16's slots. It works!*

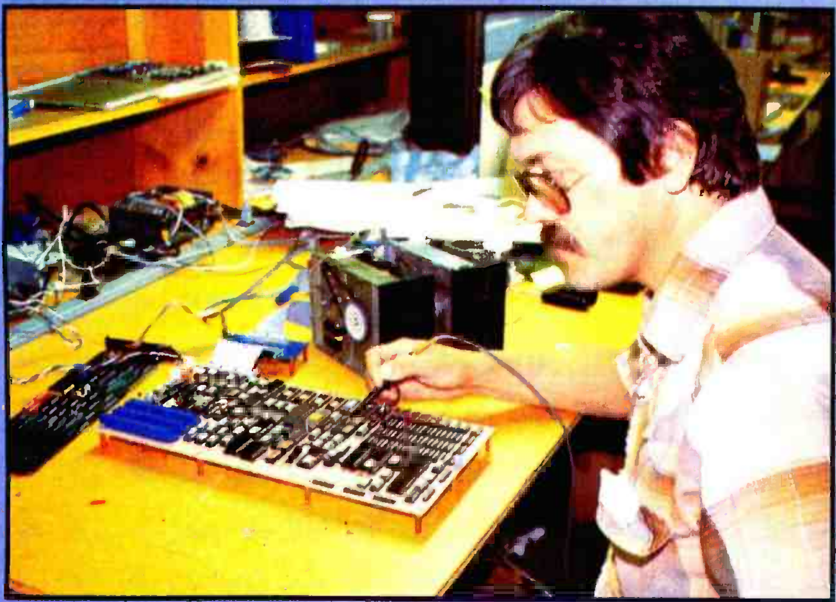


Photo 4: *Engineer Jim Norris of Owl Electronic Laboratories tests the MPX-16 prototype.*

level block diagram, while figure 2 on pages 84, 85, and 86 contains a full flow diagram for all parts of the system.

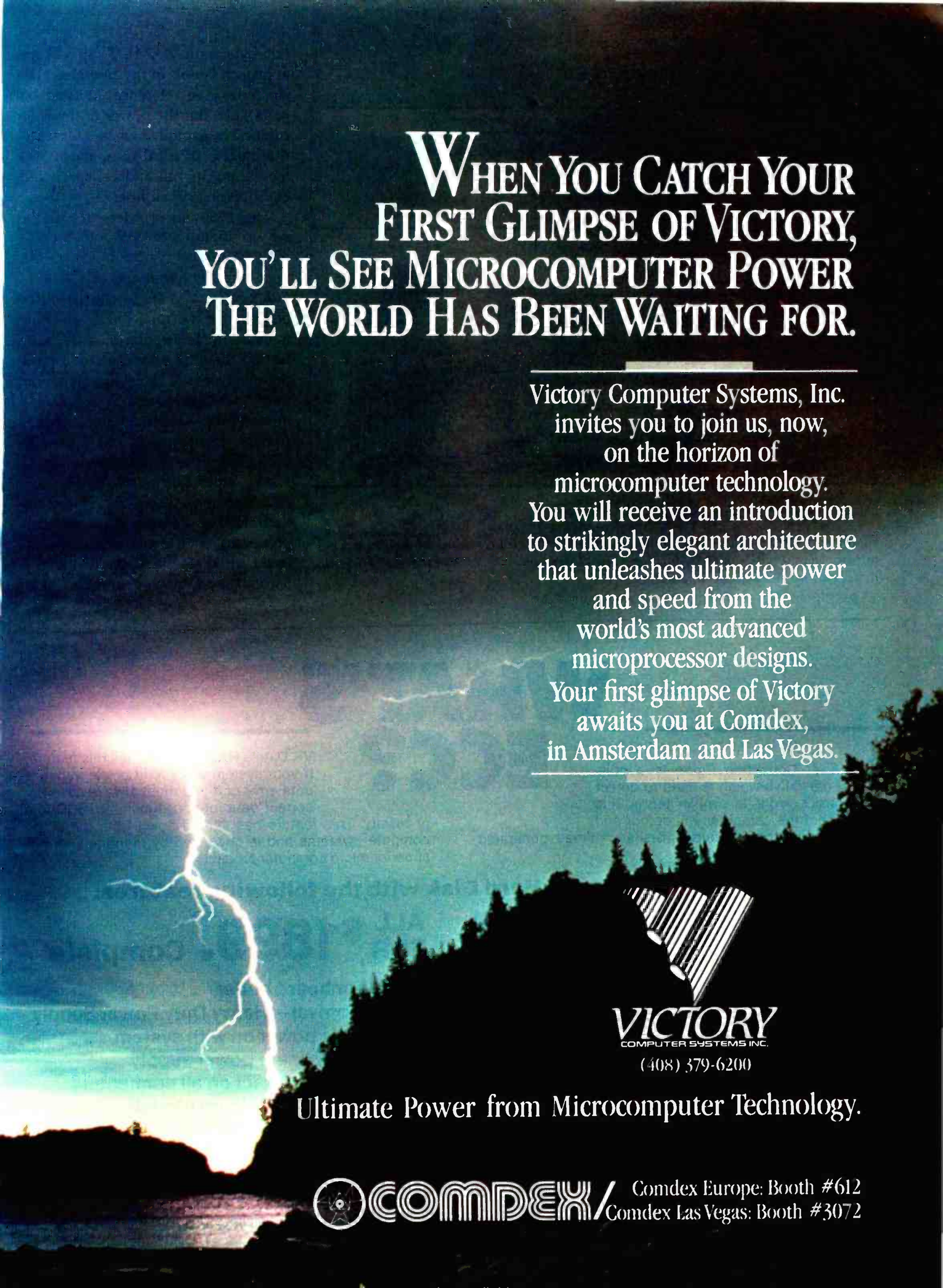
We'll look at each constituent subsystem separately, beginning with the processor and coprocessor; arrangement of data, address, and control signal buses; clock signals; the NMI (nonmaskable interrupt); and the DMA (direct memory access) subsystem. Section 1 of the schematic diagram, which appears as figures 3a and 3b on pages 88, 89, 90, and 91, contains most of these subsystems, although I do mention some things that will show up in schematic-diagram sections to be published in parts 2 and 3 of this series.

Intel 8088 Processor

The new 16-bit microprocessors are more powerful than their 8-bit predecessors. Not only do they operate at faster speed, but the 16-bit chips manipulate numerical quantities in larger chunks, directly address more memory, and offer the programmer expanded instruction sets. But along with the greater capability comes a new set of computer-design considerations.

An alternative to complete commitment to 16 bits is embodied in the heart of the MPX-16: the powerful Intel 8088 microprocessor. The 8088 uses a 16-bit internal architecture and instruction set and possesses a 1-megabyte memory-addressing capability and a 64K-byte I/O-addressing capability, but communicates through an 8-bit external data bus (sort of like putting its data flow through a funnel). The 8088 has a common internal architecture and complete software compatibility with the pure-16-bit Intel 8086 microprocessor. As a result, the 8088 provides an excellent way for designers, engineers, hobbyists, and students to ease into the world of 16-bit computing by taking advantage of its 8-bit-compatible bus structure.

The 8088 can be used in low-cost systems that employ a few multiplexed-bus support chips such as the Intel 8155 (2K-bit static RAM with I/O ports and timer), 8755A (16K-bit EPROM with I/O ports), and 8185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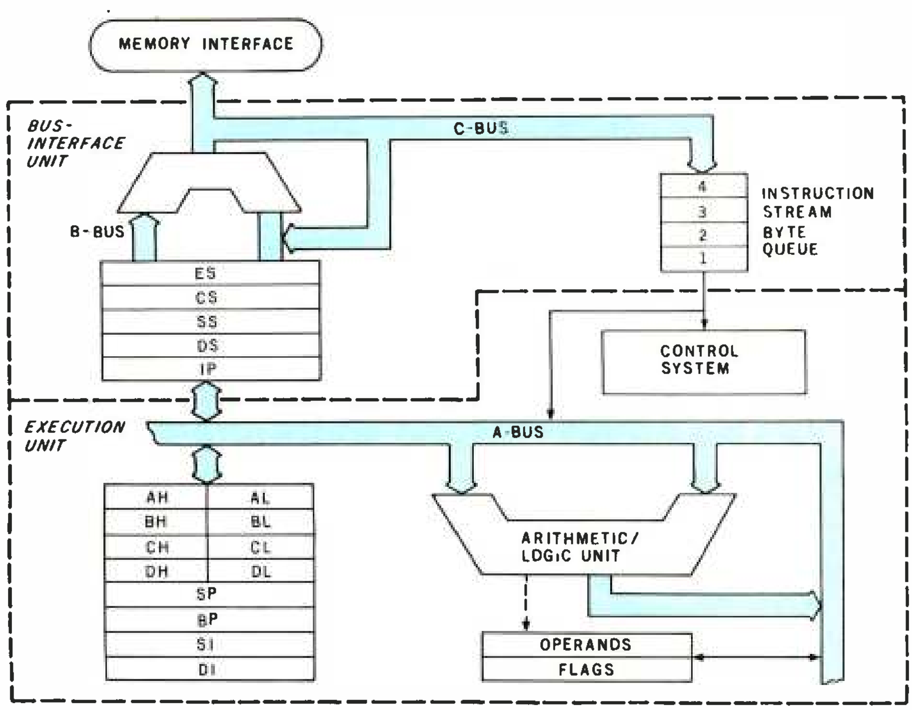

Figure 4: *Functional block diagram of the Intel 8088 microprocessor. Its pipelined architecture, shared with the 8086, increases speed by overlapping the execution of instructions with memory-access operations.*

(1K-byte static RAM). That was the approach I took in my previous article series (see reference 2, listed on page 114). But the power of the 8088 can best be exploited when it serves as the nucleus of a fully expanded system, using its full address space and coprocessing capabilities.

The 8088 microprocessor can be set up to interact with other components in the system in either the maximum or minumum mode. Certain control and status signals differ between the two modes. The selection is made by connecting the MN/$\overline{MX}$ pin on the 8088's package to ground or to +5 V (volts). In the minimum mode, the 8088 functions as a standalone processor, interacting with peripheral devices somewhat like the 8-bit 8085 processor. In the maximum mode, other integrated circuits perform certain specialized functions such as bus control, numeric data processing, and input/output control. In the MPX-16, the 8088 is configured for maximum-mode operation.

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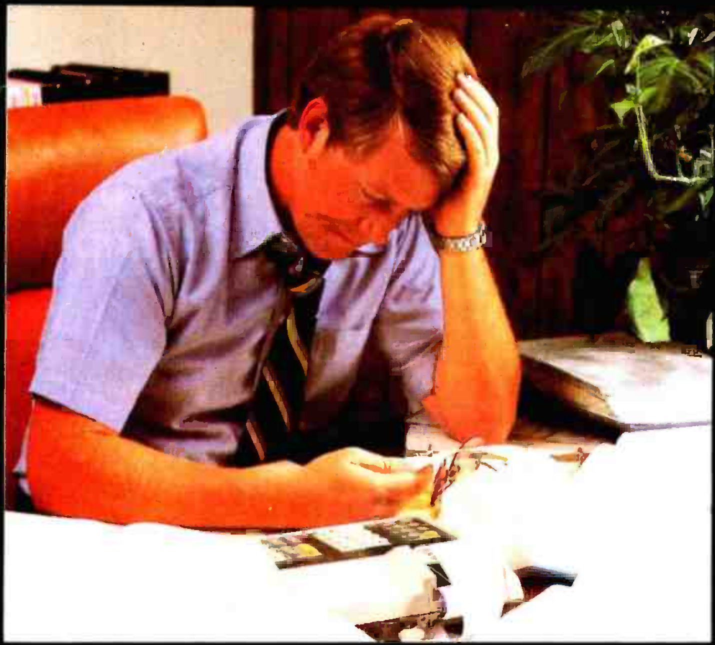

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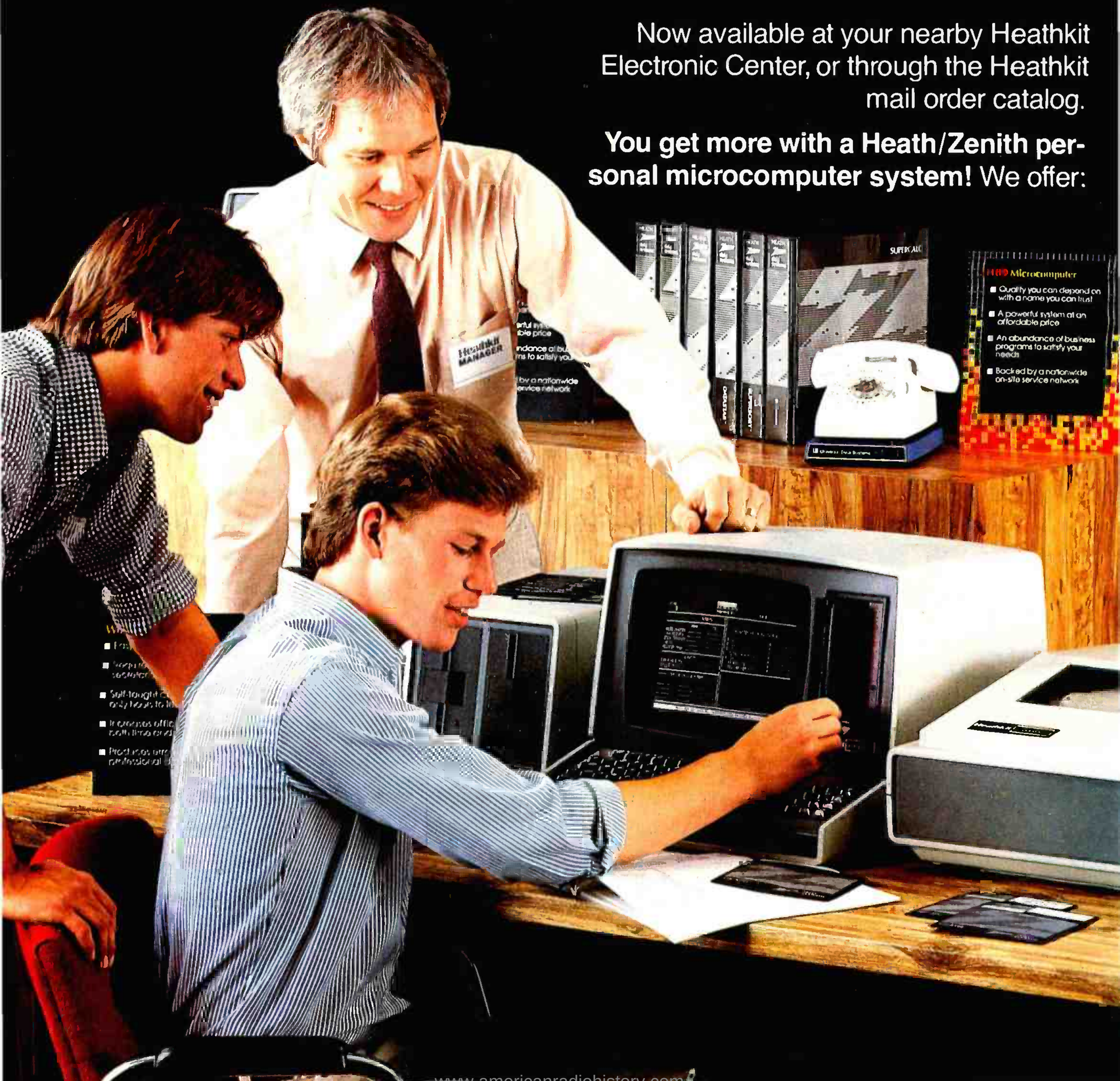

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Architecture of the 8088

The internal architectures of the 8088 and 8086 processors are identical. A diagram of their internal structure is shown in figure 4. The 8088 contains two logical functional divisions—the bus-interface unit (BIU) and the execution unit (EU)—with a logical pipeline between them that provides an instruction queue.

The 8088 uses *instruction queuing* to increase computing speed. A 4-byte instruction queue holds contents of the four bytes in memory that consecutively follow the instruction being performed by the execution unit. These four bytes of instructions or data are brought into the processor before they are to be executed; therefore, when the EU is ready to execute the next instruction, frequently it or the data required is contained already in the queue. Only when the EU needs to access nonconsecutive addresses (or during a few combinations of especially fast-executing instructions) will time be consumed for memory fetches. By not tying up the memory bus as often as its nonqueuing 8-bit predecessors, the 8088 makes the bus available for use by other powerful support devices. The overall result is increased efficiency and faster processing.

The *execution unit* is where the actual processing of data takes place inside the 8088. It is here that the familiar arithmetic and logic unit (ALU) is located, along with the registers used to manipulate data, store intermediate results, and keep track of the pushdown stack. The EU accepts instructions that have been fetched by the BIU, then processes the instructions. It next returns operand addresses to the BIU, processes the operands, and then passes them back to the BIU for storage in memory.

The role of the *bus-interface unit* is to maximize bus-bandwidth utilization (that is, to speed things up by making sure that the bus is used to its full capacity). The BIU carries out this assignment in two basic ways: first, by fetching instructions before they are needed by the EU and storing them in the instruction queue, and second, by taking care of all operand-fetch and -store operations, address

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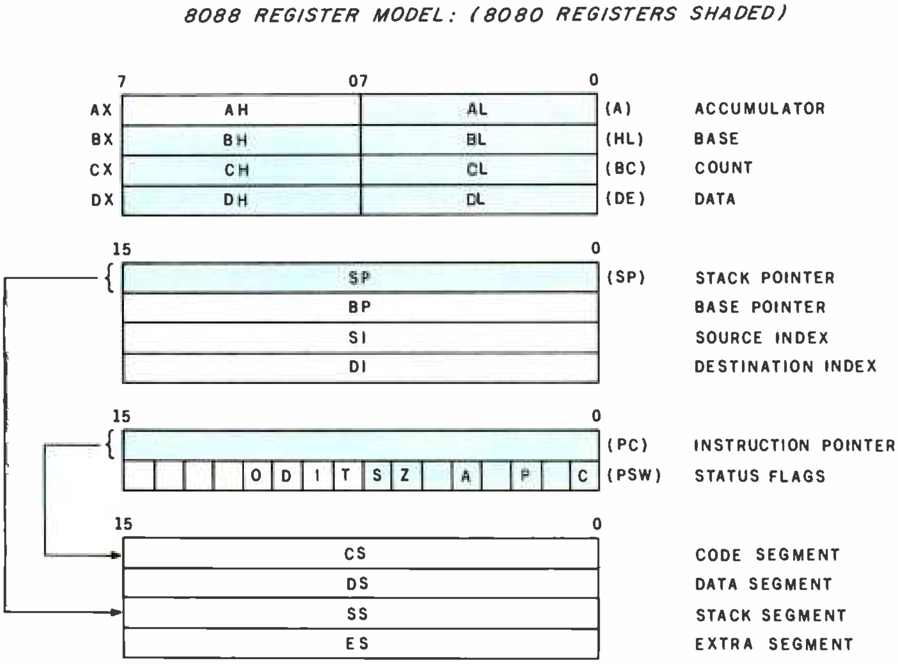

Figure 5: *Programmer's model of the 8088's fourteen 16-bit registers. The shaded registers are the 8080-register subset, that is, the registers that are common to the 16-bit 8088 and its 8-bit predecessors.*

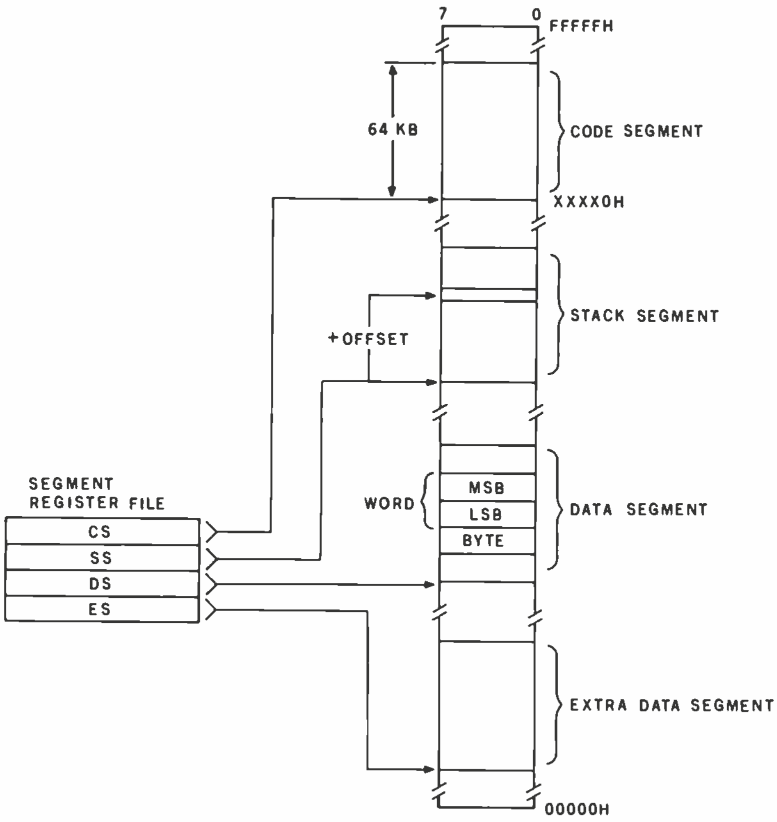

Figure 6: *Memory organization in the 8088. Memory segmentation is used to address up to 1 megabyte (1,048,576 bytes) in segments of 64K bytes. The 8088 creates a 20-bit address by combining a 16-bit offset value with a segment-boundary value stored in one of the segment registers.*

relocation, and bus control. (These actions of the BIU leave the EU free to concentrate on processing data and carrying out instructions.)

Figure 5 shows the programmer's model of the 8088's fourteen 16-bit registers. The shaded registers are the 8080-register subset, that is, the registers that are common to the 8088 and its 8-bit predecessors.

The general registers, also called the HL group because they can be subdivided into high and low bytes, include the accumulator (AX), base register (BX), count register (CX), and data register (DX). The two bytes in any of the general-purpose registers can be operated on separately; for instance, the AX register can be addressed as a 16-bit register, AX, or the high-order byte can be addressed as the register AH and the low-order byte as AL. The same holds true for BX, CX, and DX.

Another group of registers is the pointer and index (or P and I) group. This set contains the stack-pointer (SP), base-pointer (BP, an extra pointer into the stack), source-index (SI), and destination-index (DI) registers. Generally speaking, these registers hold offset addresses used for addressing within a segment of memory. They can also participate, along with the general-register group, in the arithmetic and logical operations of the 8088.

The 8088 uses *memory segmentation* to address this large memory space efficiently; it deals with memory as a set of four 64K-byte segments simultaneously defined (possibly overlapping) within the memory-address space, which is organized as a linear array of 1,048,576 bytes, addressed as hexadecimal 00000 through hexadecimal FFFFF. The 8088 creates a 20-bit address by combining a 16-bit offset value with a segment-boundary value stored in one of the segment registers. Figure 6 shows how this works.

Each of the 16-bit segment registers, the code-segment (CS) register, the stack-segment (SS) register, the data-segment (DS) register, and the extra-data-segment (ES) register, contains a value that can be combined with the 16-bit offset address speci-

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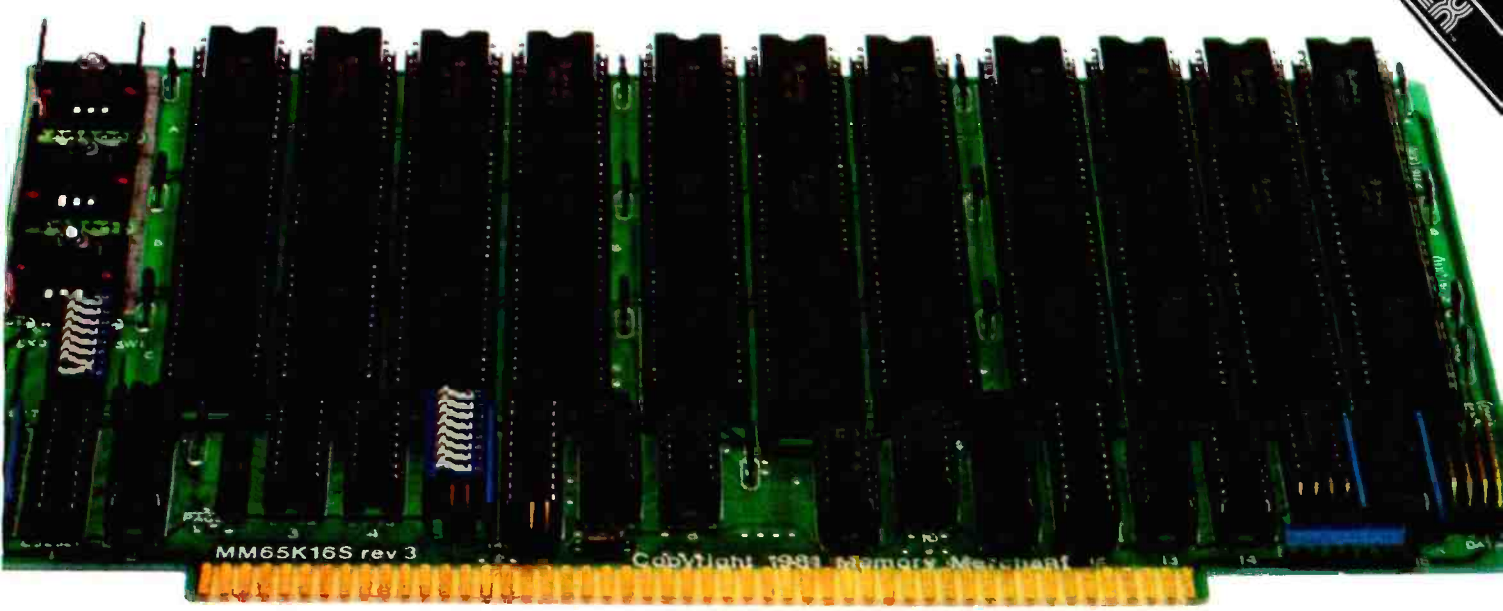

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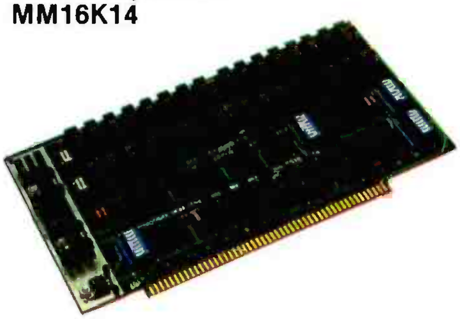

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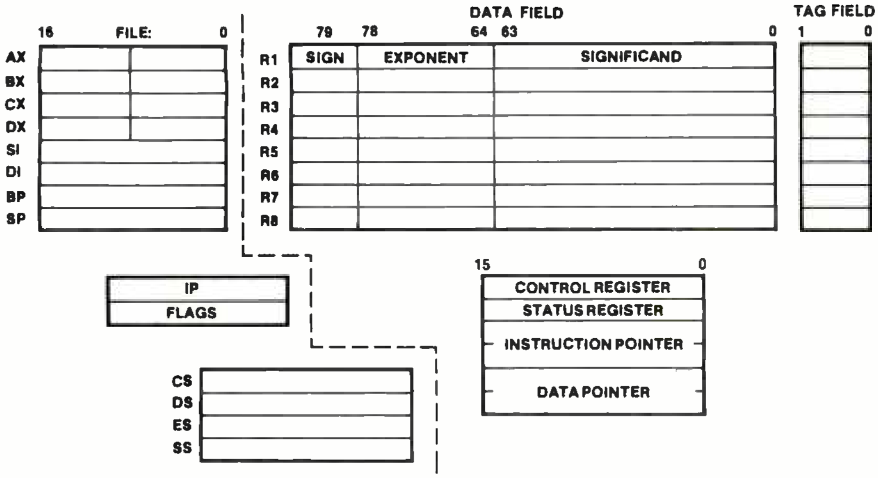

Figure 7: *Programmer's model of the 8088/8087 coprocessor combination. The 8087 adds eight 80-bit registers to the architecture and 68 operations to the instruction set. The 8088/8087 combination can operate on BCD (binary-coded decimal) numbers up to 18 digits long without round-off errors and perform arithmetic on 64-bit integers. (Figure provided courtesy of Intel Corporation.)*

fied by the instruction operand to form the 20-bit address. For instance, the 16-bit value in the code-segment register first has four low-order zero bits appended; it is then added to the low-order 16 bits of the offset address. When the 8088 fetches an instruction or data byte from memory, it comes from the location at the absolute address thereby formed.

The memory is thus divided into four segments: the code segment, where instructions are stored; the stack segment, where the pushdown stack is located; the data segment, where data to be operated on is found; and the extra segment, a 64K-byte data area assignable for any data-storage use. Which code-segment register is used to form the address varies according to what processor instruction is being executed.

The 8088 has both relative and absolute control-branching instructions. When all branch instructions within a given segment of memory are specified in relation to the instruction pointer and the program segment does not modify the value of the code-segment register, that program segment can be relocated dynamically anywhere within the entire address space simply by moving the code, updating the value of the code-segment register, and resuming execution.

The 8087 Numeric Processor

The Intel 8087 numeric processor extension (NPX) is an integrated circuit designed for use with the 8086 or 8088 (serving as the central-processing unit, or CPU) to form a high-performance numeric-data-processing system (called the iAPX 86/20 NDP or iAPX 88/20 NDP in Intel jargon). Its use is optional in the MPX-16.

The 8087 is designed to coordinate its functions with other processors in a coprocessing or multiprocessing environment. As a coprocessor, the 8087 adds 68 machine instructions to the system; these operate on its eight 80-bit floating-point registers, which function alongside the 8088's register set. The 8087 is designed to handle very large numbers; its internal temporary-storage format for floating-point quantities is 80 bits: 1 bit for sign, 15 bits for exponent, and 64 bits of mantissa. A programmer's model of the resulting architecture is shown in figure 7.

Capable of executing arithmetic, trigonometric, exponential, and logarithmic instructions, the 8087 conforms to the proposed IEEE (Institute of Electrical and Electronics Engineers) floating-point standard

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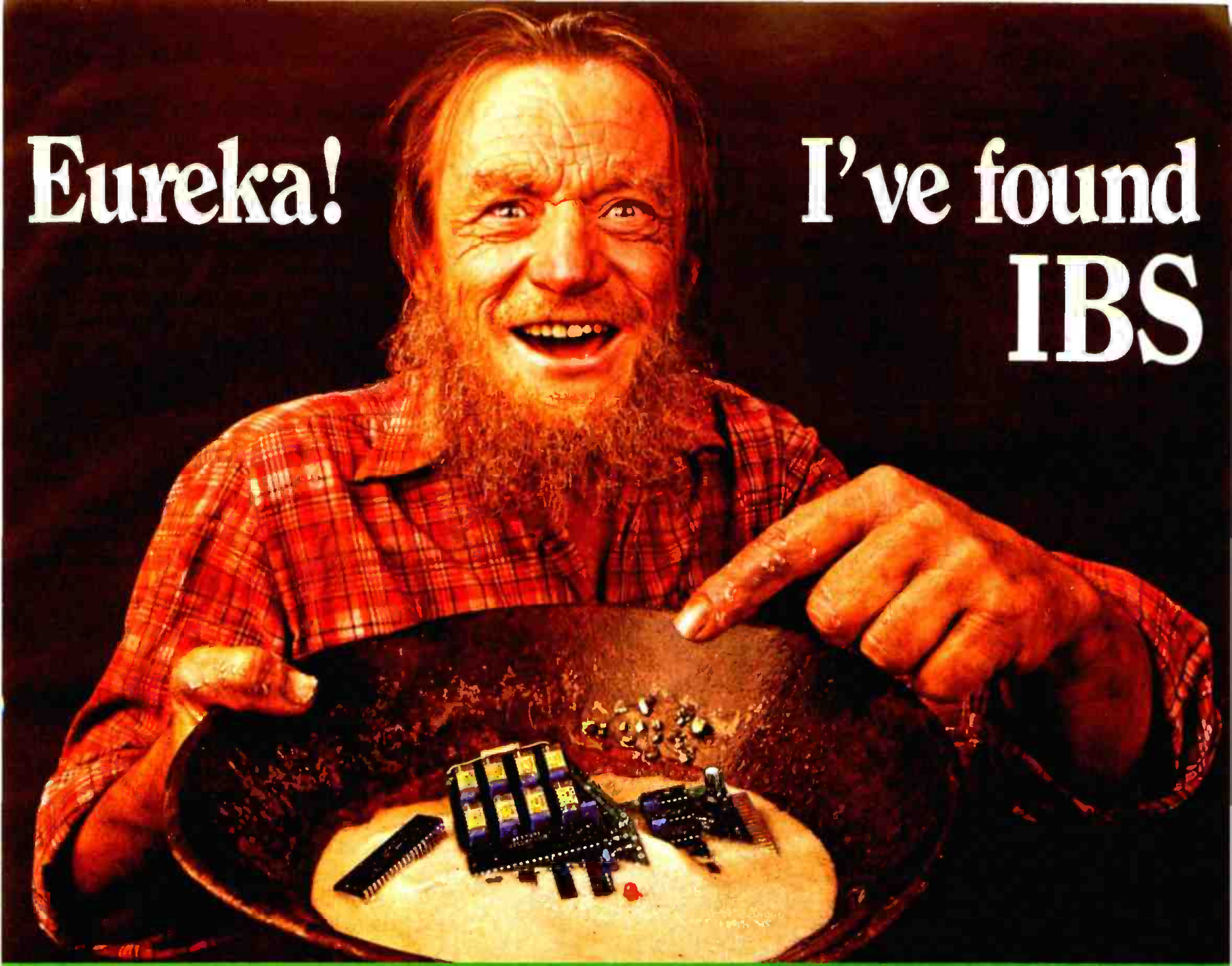

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The 8087 uses its own instruction queue to monitor the 8088's instruction stream, operating only on those instructions intended for it. When a numeric instruction appears in the code, it is treated as an "escape" from the normal sequence by both the 8088 CPU and 8087 NPX; the NPX processes it while the CPU finishes its current task. Concluding that, the CPU either does nothing (if the NPX requires no further data) or it calculates an address and reads a byte of memory which is used by the NPX (the CPU ignores this value in its own computations).

The 8087 is only an extension processor and cannot run by itself. It needs a separate CPU to operate the data, address, and control buses, which provide it with instructions and operands. Once the NPX has started its operation, the CPU may continue executing the main program while the NPX "crunches." This parallel operation of the NPX and CPU can continue until the NPX needs to reference memory. Only then will the processor give the NPX access to the bus (the main processor may, however, continue to process instructions from its instruction queue). A special request/grant line, $\overline{\mathrm{RQ}}/\overline{\mathrm{GT0}}$, is used to pass control of the buses shared between the NPX and the CPU. The relationship between the CPU and the NPX is similar to the master/slave scheme used in less complicated computers, while the protocol is somewhat like hold and hold-acknowledge signals, although more complicated. (Additional processors or coprocessing devices can be attached to the NPX/CPU combination through another signal line, $\overline{\mathrm{RQ}}/\overline{\mathrm{GT1}}$, although no provision for this has been made in the *MPX-16.)*

The amount of time that the processor actually waits to get back on the bus is very small. If it were not for a few stolen memory cycles, the coprocessor's operation would be essentially invisible to the host processor; it's a small price to pay for the great increase in performance for numeric computation. As a comparison, even though it's quite a powerful microprocessor, the pure-16-bit 8086 takes about 20 milliseconds to compute a square root, using a floating-point subroutine. Eliminating the subroutine and using the 8087 instead, the result can be calculated in less than 40 *micro*seconds (the speed-up is similar for the 8088). Such speed is an undeniable asset to high-level languages such as BASIC and Pascal. They not only run faster, but the memory space devoted to floating-point subroutines is saved.

MPX-16 Bus Structures

The MPX-16 system supports two major signal-bus structures, the processors' local bus and the global system bus, as you can see clearly in the simplified block diagram of figure 1 and somewhat less clearly in the detailed diagram of figure 2. Most of the signals in the MPX-16 pass on one or more of the several buses.

The *local bus* is shared by the 8088

CPU and the 8087 NPX (if it is installed), either of which can be the local-bus master. The system bus can be driven either by the local bus under the control of the 8288 bus controller or by the 8237A-5 DMA controller.

The local bus consists of 8 multiplexed address and data lines (AD0 through AD7), 12 address lines (A8 through A19), and 3 status and control lines (S0, S1, and S2), which are connected with the global system bus through three-state buffers. Several other signals, including system clock signals and reset lines, are directly common with the system bus. The local bus can be controlled by either the CPU or the NPX, both of which have on-chip arbitration logic to determine which processor has control of the bus.

The CPU acts as a host processor to the NPX coprocessor. For example, when the 8087 NPX requires use of the local bus to return the result of an operation, it notifies the CPU by placing a series of handshaking signals on its bidirectional request/grant arbitration line $\overline{RQ}/\overline{GT0}$. A ready/wait control line is used to lengthen bus cycles on the local bus, which may be necessary to meet the access-time requirements of slow memory and peripheral devices, or to accommodate a DMA cycle already in progress on the system bus.

The *system bus* consists of 20 system address lines, 8 bidirectional system data lines, and several system control lines. The system data bus drives the system-board memory arrays and the I/O-expansion connectors and is buffered again to produce a "resident" data bus to which most of the on-board peripheral devices are attached. The system control bus consists of all timing signals, bus-cycle-control signals, interrupt-request lines, DMA-request/acknowledge lines, and system-bus-arbitration-control lines.

Control of the system bus is determined by a sequential-logic system-bus-arbitration circuit. The bus is always being controlled either by one of the two coprocessors via the local bus and the 8288 bus controller (with the $\overline{88AEN}$ control line active), or by the 8237A-5 DMA controller (with $\overline{AENDMA}$ active). The simple bus-arbitration circuit isolates the local bus from the system bus whenever system-bus access is given to the DMA controller for direct access to memory by one of the peripheral devices. For the DMA controller to gain access to the system bus in response to its HOLD request, a "locked" 8088 instruction (which must have continuous bus access for the 8088) must not be in execution, and the local bus must be in an idle state. The $\overline{LOCK}$ signal is also active during interrupt-acknowledge sequences, preventing the occurrence of a DMA cycle in the middle of the acknowledge sequence. Since neither of the coprocessors is involved in this bus-request/grant-arbitration sequence, a low input to the RDY1 line on the 8284 clock generator is used to force continuous wait states to be inserted in the local-bus timing cycle

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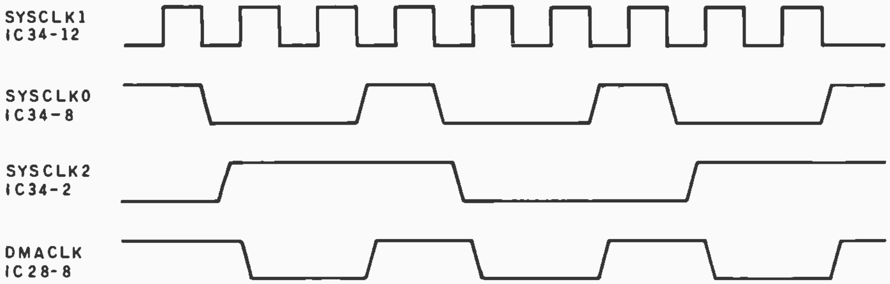

	TYPICAL CLOCK PERIODS (ns)							
	SYSCLK0		SYSCLK1		SYSCLK2		DMACLK	
	CLK_L	CLK_H	CLK_L	CLK_H	CLK_L	CLK_H	CLK_L	CLK_H
15.0MHz CRYSTAL	133.3	66.7	33.3	33.3	200	200	105	95
14.31818MHz CRSTAL	139.7	69.8	34.9	34.9	209.5	209.5	111.5	98

Figure 8: *Timing diagram showing the relationship of the four major system clock signals. The table shows clock-high and clock-low periods for both the 14.31818-MHz and 15.0-MHz crystals in nanoseconds.*

until access to the system bus has been restored to the local bus.

Reset and Clock-Generator Circuits

The power-on reset pulse and all major system clock signals for the MPX-16 system and I/O-expansion slots are generated by an Intel 8284 clock generator and driver (IC34 in figure 3a). The 8284 is designed to provide the optimum clock signal, with a 33 percent duty cycle, at the voltage levels and transition times required by the 8088 CPU (IC36) and the 8087 NPX (IC37).

The 5-MHz 8088 used in the MPX-16 must operate with a clock rate between 2 and 5 MHz. (The 8088-2 version can run at 8 MHz.) The standard MPX-16 operates at a frequency of 4.77 MHz, which is derived from a 14.31818-MHz crystal oscillator. This crystal frequency provides compatibility with IBM Personal Computer color-graphics adapters, which use the 14.31818-MHz OSC clock output of the 8284 to produce a 3.58-MHz color-burst signal. The variable trimmer capacitor C9 is used to make minor adjustments in the clock frequency. An optional 15-MHz crystal can be substituted to operate the MPX-16 at its maximum clock rate of 5 MHz.

The 8284 divides the 14.31818-MHz oscillator frequency by 3 to provide the 33-percent-duty-cycle CPU clock, SYSCLK0. This clock signal is used by many parts of the MPX-16, including the 8087, the 8288 bus controller, the system-bus-arbitration circuit, and the I/O-expansion channels. SYSCLK0 is also used to provide a clock signal (DMACLK) for the 8237A-5 DMA controller. Some Schmitt-trigger inverter sections (IC24, which will appear next month in section 2 of the circuit) lengthen the level-high duration of SYSCLK0 so that the clock requirements of the 8237 will be met. Deriving the DMACLK signal from SYSCLK0 has the obvious advantage of maintaining synchronization between the local bus masters (the 8088 and 8087) and the alternate system-bus master, the DMA controller (the 8237).

In addition to the processor clock signal, the 8284 provides a peripheral-device clock signal, which is one-half the frequency of the processor clock and has a 50 percent duty cycle. The oscillator clock, SYSCLK1, is not used on the MPX-16 circuit board but is routed to the I/O-expansion connectors.

The peripheral clock, SYSCLK2, is used to drive the timer input of the 8155H-2 component (IC47, which will appear in January in section 4 of the circuit). The 8155's timer output is used to generate periodic memory-refresh requests for the dynamic memory on the system board, using the DMA controller (which we'll discuss further presently). The relationship of the four major system clock signals is illustrated in figure 8, which also contains a table of clock-high and clock-low periods for both the 14.31818- and 15.0-MHz crystals.

The 8284 clock generator is also used to generate the power-on reset pulse, SYSRES, which is active high. When power is first turned on, the rising supply voltage activates the Schmitt-trigger input pin $\overline{RES}$ on the 8284, which has approximately 0.25 V of hysteresis; as a result, the SYSRES pulse remains active until a voltage level of 1.05 V is reached on the $\overline{RES}$ input. The resistance/capacitance time constant set by R16 and C10 provides the necessary minimum reset pulsewidth of 50 μs (microseconds). The 1N4148 diode D1 provides a discharge path for C10 when power has been removed.

Nonmaskable-Interrupt Logic

The nonmaskable interrupt (NMI) input of the 8088 CPU is used for handling parity errors in the system-board memory and I/O-channel errors, which are typically also parity errors occurring in expansion-memory modules.

Although the NMI signal is nonmaskable once it gets to the 8088, logic is provided to externally mask the signals that would normally generate an NMI, if desired. Two input lines, PC4 and PC5, of the 8255A-5 PPI (programmable peripheral interface, IC60, to appear in section 4 of the circuit) are used as active-low enable signals. The $\overline{ENNMI}$ signal either enables or prevents NMI signals from reaching the 8088.

One source of interrupts is the $\overline{PARERR}$ signal, which is generated by the system-board circuit that calculates parity values for memory and detects errors. The second source of interrupts is the $\overline{IOCHNLERR}$ signal, which comes from the I/O-expansion slots. The latter signal can be masked by the $\overline{ENIOC}$ control line in such a

way that only system-board parity errors will cause an interrupt. The NMI input of the 8088 CPU is edge-sensitive but must remain active-high during two consecutive CPU clock cycles to guarantee recognition of the interrupt.

The NMI condition is predefined to be a "type 2" interrupt for the 8088, the highest-priority hardware interrupt. Since the vector (control-branching) location has been preassigned to locations hexadecimal 00008 through 0000B, no interrupt-acknowledge sequence is needed in a program.

DMA Controller and Bus Arbitration

Direct memory access has long been known as a way to improve the performance and I/O speed of a computer system by allowing I/O devices to directly transfer data to or from system memory without processor intervention, but until recently it has rarely been found in microcomputer systems. However, more widespread use of DMA has been made possible by semiconductor manufacturers, which have developed new ICs that make DMA much more easily provided. The MPX-16 employs one such integrated circuit, the Intel 8237A-5 DMA controller (IC48 in figure 3b on page 90).

Four independent channels of 20-bit-address direct memory access are supported by the MPX-16 system. Two of the DMA channels are available on the I/O-expansion bus to support high-speed data transfers between external peripheral devices and memory. A third channel, used by the floppy-disk-drive controller, is connected to the I/O-expansion bus for compatibility with the IBM Personal Computer.

The fourth DMA channel is used to provide the periodic refresh signal for the on-board dynamic-memory array, as well as any expansion memory boards, in which each row address of the dynamic-memory chips must be accessed. During system initialization, the TIMER OUT output of the 8155H-2 is set up to trigger a dummy DMA transfer approximately every 15 μs. The DMA channel is pro-

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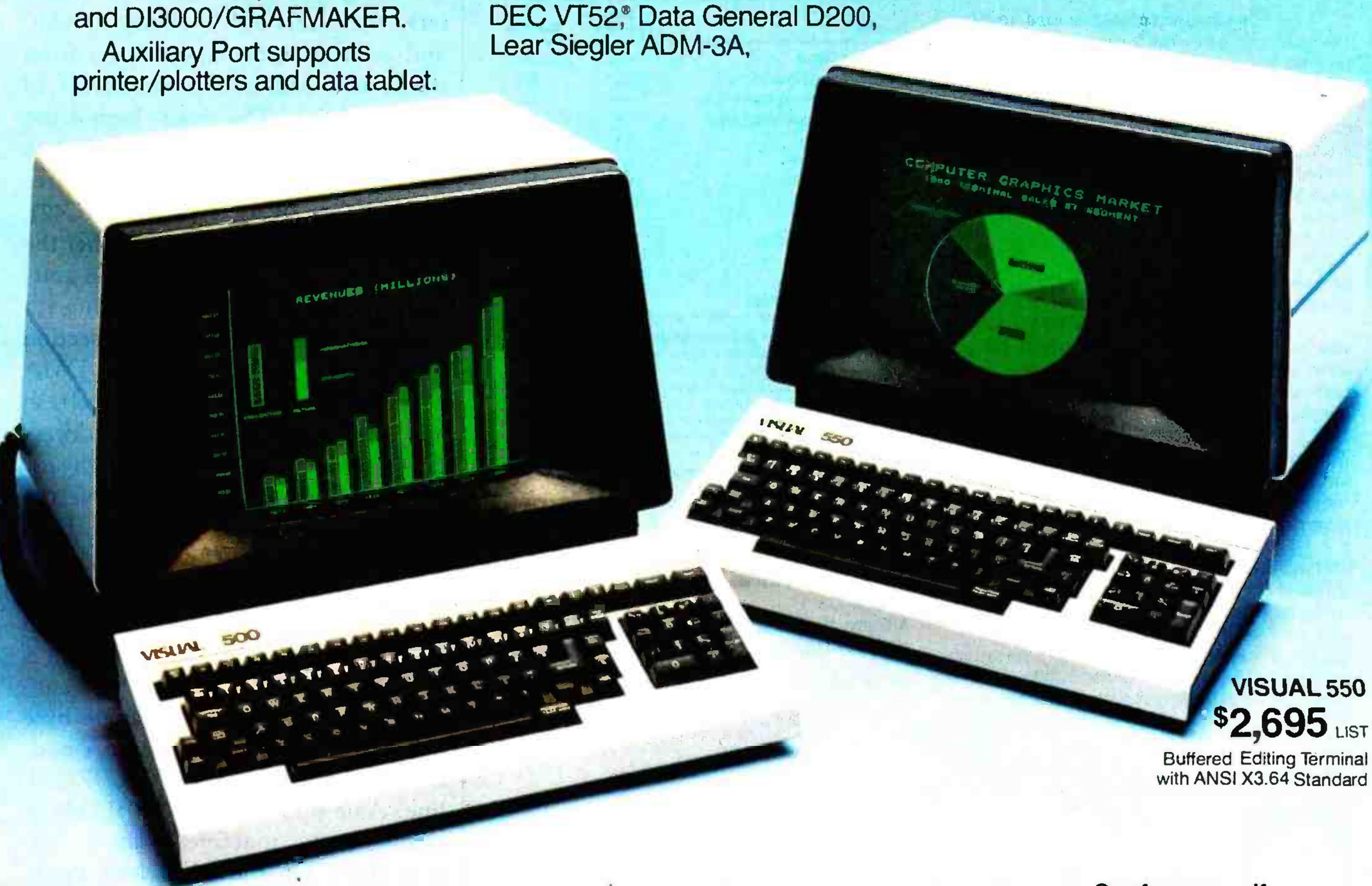

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grammed for a memory-read cycle; it automatically increments the row-address counter for memory after each refresh cycle.

When no DMA requests are pending, the DMA controller is in an idle state (S1) and can be programmed by the CPU. If a DMA channel requests service for a peripheral device and that channel has been enabled by the system software, the DMA controller sends the signal DMAHLDRQST (DMA hold request) to the system-bus-arbitration circuit and enters the active state S0. The 8237 remains in the S0 state until it has received the signal DMAHLDACK (DMA hold acknowledge) from the bus-arbitration circuit, indicating that it has been granted control of the system bus.

At this time the system-bus-arbitration circuit isolates the local bus from the system bus by activating the control signal 88AEN. When this signal becomes inactive again, the 8288 bus controller (IC51) places the system-bus command-line buffers into a high-impedance state and disables the 74LS245 data transceiver IC43. In addition, the 88AEN signal places the system-bus-address latches, IC50, IC38, and IC44, into a high-impedance state so that the local-bus master can drive the local bus during a DMA cycle without affecting operations on the system bus.

After one system-clock cycle following the arrival of the hold-acknowledge signal, the AENDMA control signal from IC24 enables the DMA bus-interface components. One of the 74LS373 latches, IC43, drives system address lines SYSA8 through SYSA15. The eight low-order address lines, SYSA0 through SYSA7, are driven by lines A0 through A7 on the 8237 through a 74LS245 transceiver, IC49 (shown in figure 3a on page 89). The data-flow-direction input of IC49 is controlled by the AENDMA signal such that data flow is from IC49 *to* the system address bus when a DMA transfer is in progress.

During processor memory transfers, the AENDMA signal is high, and address information flows *from* the system address bus through IC49 to the 8237. The four high-order system-bus-address lines, SYSA16 through SYSA19, are driven by three 4-bit latches (IC40, IC41, and IC42). These latches are loaded by either the operating system or application software and allow each DMA channel to operate in a separate 64K-byte section of memory if desired. Since DMA channel 0 is used for memory refresh and only the eight low-order address lines are significant, the latch for DMA channel 1 is used to drive the upper four address lines for both channels 0 and 1. The three address latches are enabled when both the AENDMA signal is active-low and the appropriate acknowledge signal is active.

Once the transfer of a single byte has been completed, the DMA controller turns off the DMAHLDRQST line. As a result, the DMAHLDACK signal goes inactive almost immediately. On the next clock cycle, the system-bus-interface components and 8288 bus controller are reactivated by a low state on the 88AEN

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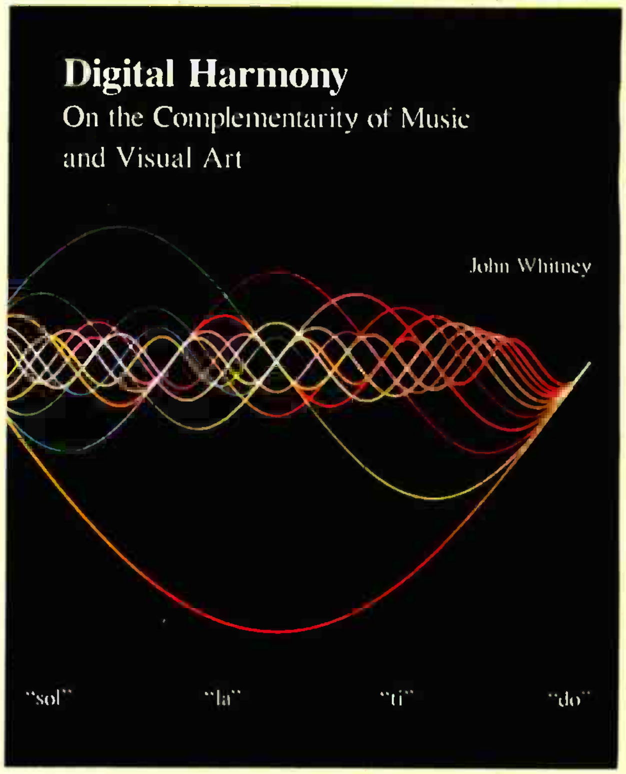

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line, and the DMA bus-interface components are disabled by a high state on the AENDMA line. After the 88AEN signal goes active-low, the 8288 does not drive the control bus until at least 105 ns (nanoseconds) and not more than 275 ns have elapsed, if a local-bus master has a bus cycle pending. A section of the 74LS10 three-input NAND gate IC30 and some flip-flops (in section 2) guarantee this by delaying the 84AEN signal by two clock periods from the time the 88AEN line goes low.

The DMAHLDRQST signal goes inactive after the transfer of each byte, even if the channel requesting service has not dropped the request. This provides at least one machine cycle between successive DMA transfers.

To Be Continued

Since it may take you a month to digest this much information, I'll stop the first installment of this series here. (Besides, I don't want to take up the whole magazine, though I could easily do it in describing this complex project.)

Next Month and Thereafter:

In Part 2, I'll concentrate on the MPX-16's memory section, interrupt logic, and I/O-expansion bus (including a detailed definition of each signal). The third installment will discuss the serial and parallel I/O ports, floppy-disk-drive controller, and operating-system BIOS, plus any other facts needed to summarize the project. ■

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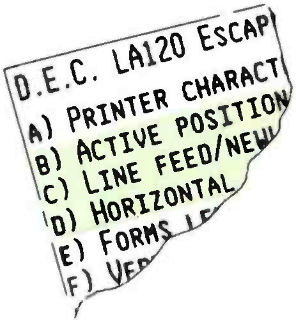

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Problem Solving with Logo

Using Turtle Graphics to Redraw a Design

William Weinreb
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Every computer graphics artist has sat before a console and created a design. This article describes a slightly different experience: *recreating* a design, i.e., solving the riddle of an already existing pattern.

It began when a friend presented me with a pattern (see figure 1) devised by Christopher Keavney for the Massachusetts Institute of Technology's student information-processing board. My friend also furnished the three-page PL/I program that generated it. Thinking that it might be possible to draw the design using turtle graphics instead of PL/I graphics, she challenged me and a colleague, Glenn Forester, to write a Logo program for the design. We accepted the challenge because we too were struck by how similar the design was to pictures we had drawn using turtle graphics. In this article, I recount our attempts, initial failure, and eventual success at writing such a program, which, remarkably, consisted in the end of only seven short Logo procedures that can be run on an Apple II using Apple Logo.

Searching for Clues

Imagine that someone handed you a pattern and a program that draws it and said, "Write a program in another language which will draw this." Where would you begin? I chose to concentrate on understanding the program, hoping this would reveal clues to the structure of the design. Instead of bringing me closer to a solution, however, this approach led me astray. As it turned out, the PL/I program for this design consists of several obscure subroutines, each responsible for calculating a series of Cartesian coordinates that are the endpoints of lines in the design. To me this was very discouraging news: even if I translated the entire program, I would wind up with nothing more helpful than a few point-plotting algorithms written in Logo instead of PL/I. Plotting points in Logo is not much different from plotting points in any other language. What made the project exciting was the prospect of writing a simpler and more elegant program using turtle graphics. Clearly the original program would be no help to me here.

Logo encourages you to solve a problem by breaking it down into smaller pieces, or subproblems, that are more easily grasped.

So I put it aside for good and refocused my attention on the design. Seeking a new approach, I recalled that Logo encourages one to solve a problem by breaking it down into smaller pieces, or subproblems, that are more easily grasped.

A Piece of the Puzzle Is Solved

Applying this technique of breaking down problems to the design led to the first crucial breakthrough. Glenn was certain that the design's border was made up of only one or two patterns repeated many times. Eventually he figured out that the rim of the pattern is merely pentagonal spirals arranged in such a way that

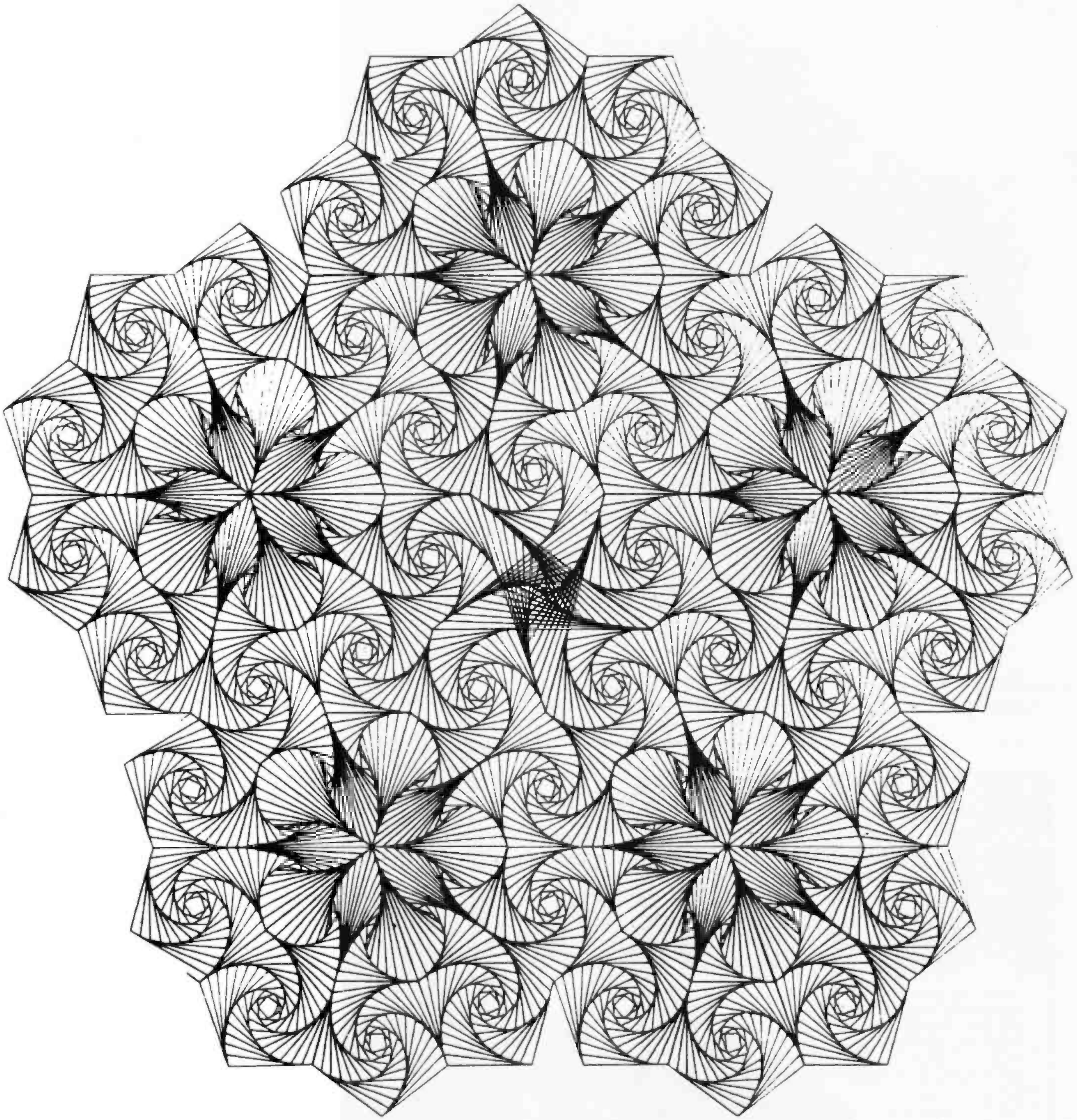

Figure 1: *The challenge was to reproduce this design using Logo. Could this complex design, which was produced by a three-page PL/I program, be redrawn with a simple Logo program?*

their edges blend and are difficult to distinguish (see figure 2). Each spiral fits inside a pentagon. The spiral figure is one that Glenn and I recalled from other turtle drawings; it is a pattern made by a Logo procedure sometimes called POLYSPI.

What is a POLYSPI? As we have worked with Logo turtle graphics, certain procedures and the figures they create have become part of our vocabulary. Two such procedures are familiarly called POLY and POLYSPI (see listing 1). POLY can produce polygons, and figure 3 shows some of the patterns you can produce by giving POLY different inputs. The procedure POLYSPI is like POLY except that in the recursive call, we make the turtle draw a new side that is a little shorter than the last. These ever-shortening sides make the final figure a spiral. Figure 4 shows some figures POLYSPI can draw.

Notice that when POLYSPI is given inputs of 20 and 75, it draws a pentagonal spiral. Now take a close look at the full design (figure 1). The same spiral fills the pentagons that we found in the design. This spiral ap-

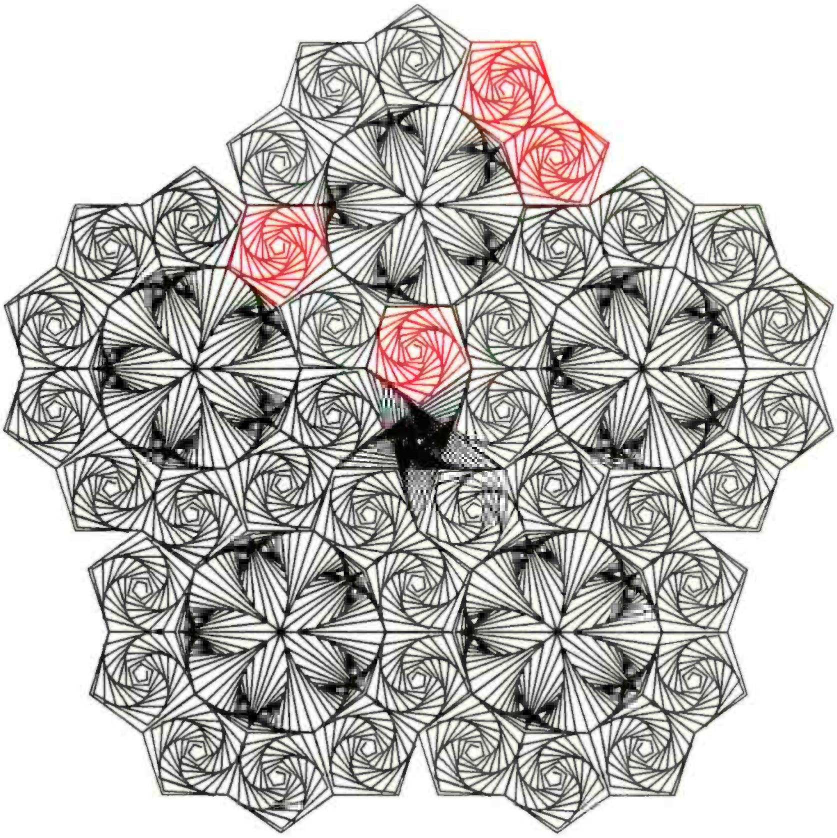

Figure 2: *The design is composed primarily of pentagonal spirals (shown in color), which can be drawn easily using a Logo* POLYSPI *procedure.*

pears 40 times. More accurately, it appears 20 times and its mirror image appears 20 times.

Figure 5 shows the entire design without most of the pentagonal spirals. Looking at it this way, you can see how the design may easily be broken into five identical parts that fit together like pieces in a jigsaw puzzle. One of them is outlined and appears by itself in figure 6. We called this piece a "wheel."

Note that two pentagons are missing from the wheel. This hole provides a space where one wheel can interlock with another. Now if we include the missing pentagons, we have a ring of ten pentagonal spirals surrounding a ten-sided figure (figure 6). What type of figure is this? And could this be broken down as well?

It seemed to Glenn that whatever shapes filled the wheel were arranged in mirrored pairs like the pentagons. So he began to draw lines along the likely edges of these alleged shapes. Figure 7 traces the progression of the lines he drew. As you can see, the


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Listing 1: *The logo procedures* POLY *(left) and* POLYSPI *(right).*

```
TO POLY :SIDE :ANGLE
FD :SIDE
RT :ANGLE
POLY :SIDE :ANGLE
END
```

```
TO POLYSPI :SIDE :ANGLE
FD :SIDE
RT :ANGLE
POLYSPI :SIDE - 1 :ANGLE
END
```

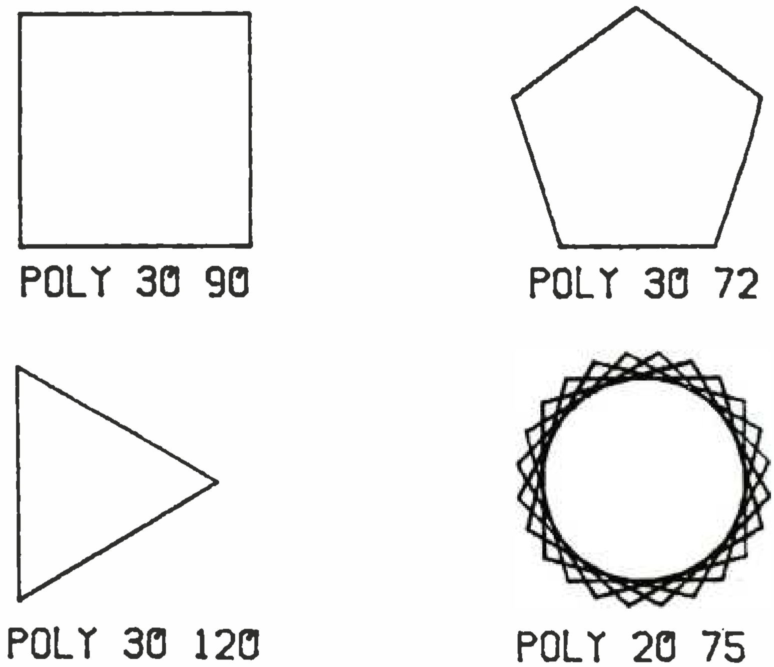

Figure 3: *The result of the* POLY *procedure of Logo. Many different shapes can be produced merely by changing the angle of the "turtle-turn."*

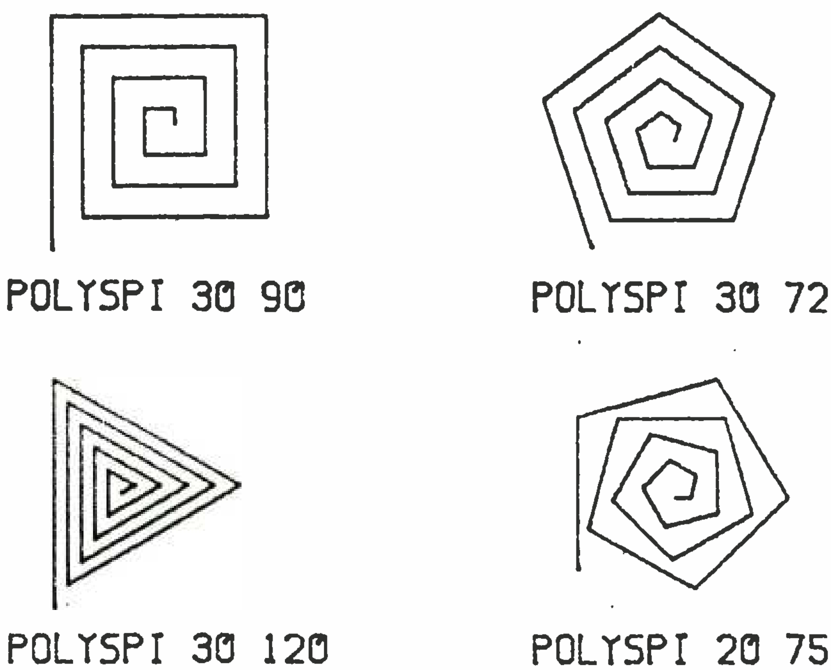

Figure 4: *In the* POLYSPI *procedure, the length of each successive side is shortened by one unit. The result is very similar to a spiral.*

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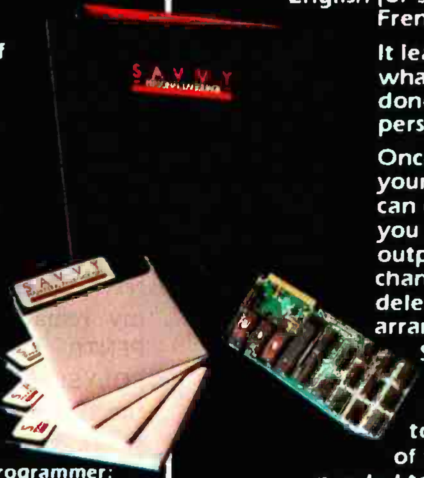

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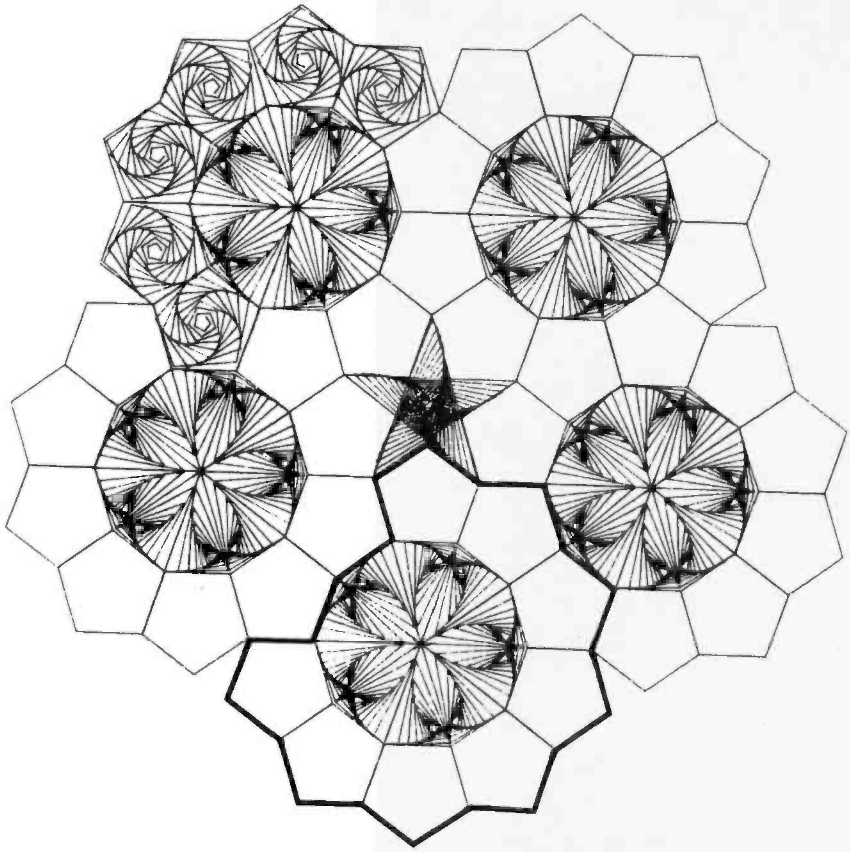


Figure 5: *With most of the spirals removed, you can see that the design can be broken down into five wheels that interlock with each other.*

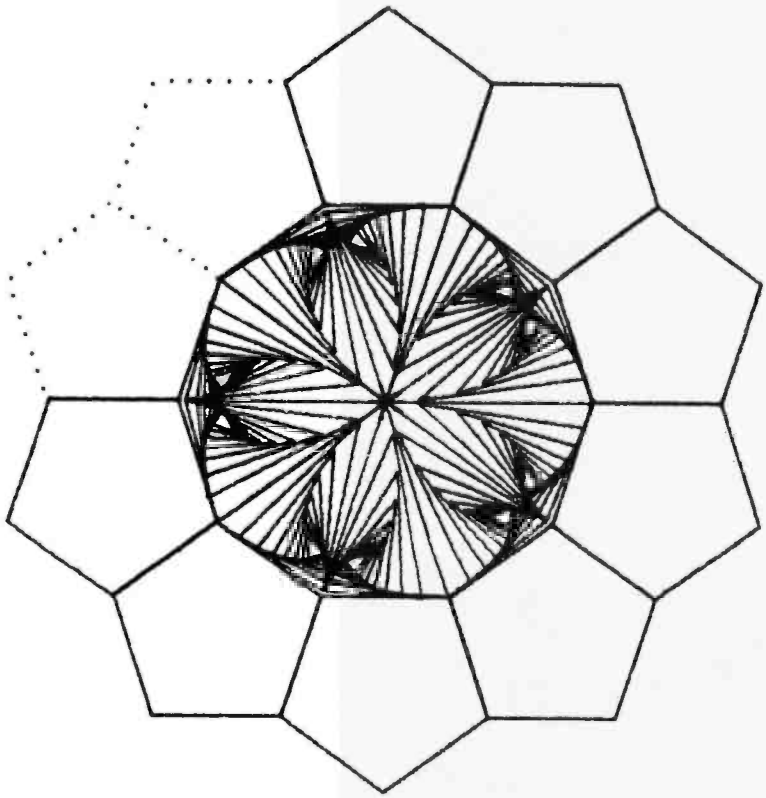


Figure 6: *A close-up of one of the wheels in figure 5. With two pentagonal spirals added, it becomes a complete wheel. The problem now: What is the design in the middle of the wheel?*

shapes revealed by these lines are triangles. They were much harder to recognize than their pentagonal neighbors; they emerged from the dissection of the design visually when lines were drawn.

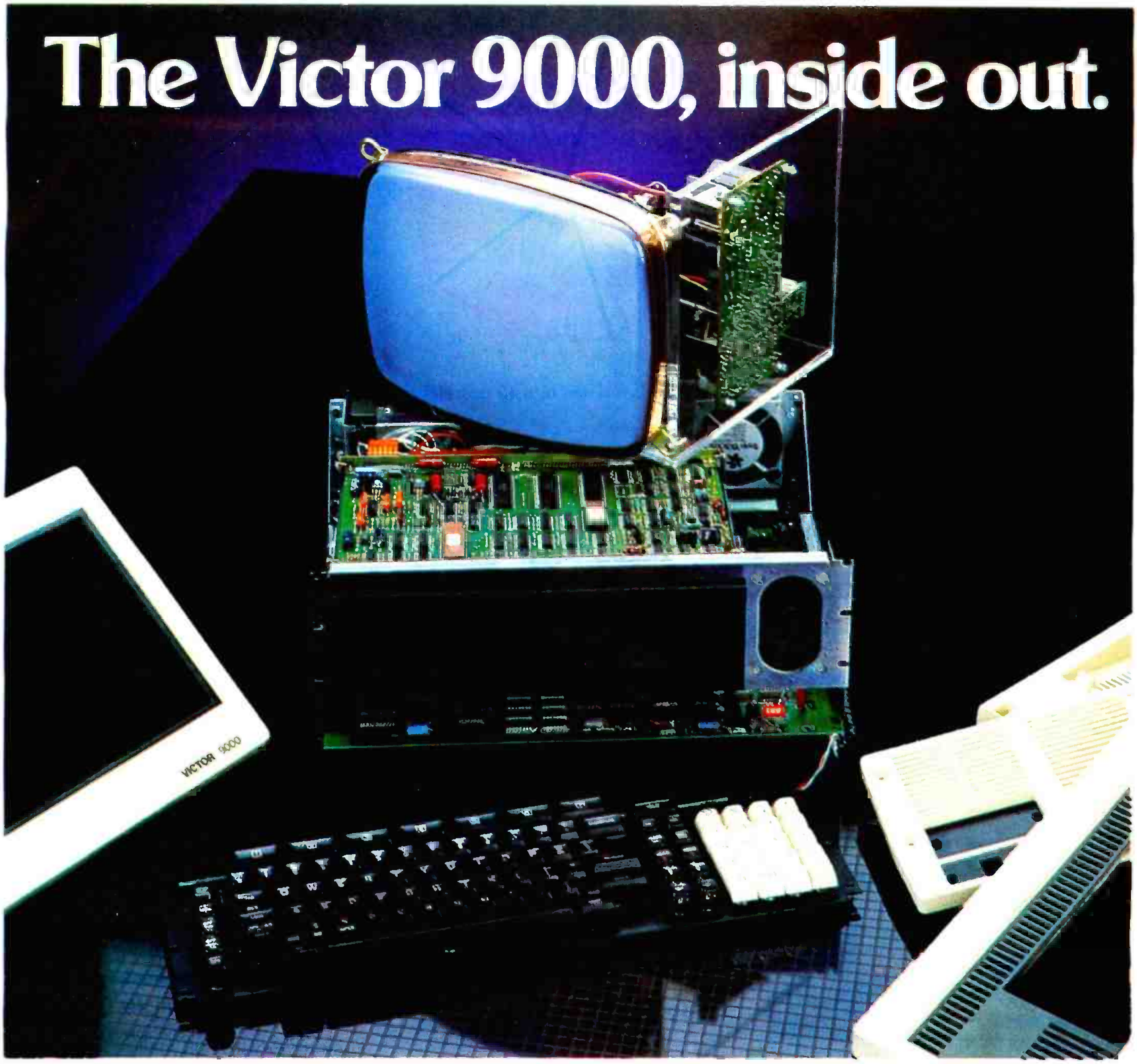
It didn't occur to us at first that the figures inside the triangles might be spirals. However, the figure inside each triangle is a version of our friend POLYSPI, except that the triangles in the design are isosceles, not equilateral. The way a spiral based on an irregular polygon looks is different from what we were used to. The triangular spirals were also hard to identify because their sides get shorter very quickly. Figuring out how to draw these unusual spirals took Glenn a lot of time when we began to write the program. Figure 8 shows a triangular spiral, its mirror image, and both placed back to back. Five such pairs arranged in a circle make up the interior of each ring.

We arranged the five wheels more or less into a ring (figure 9). We were then left with a star-shaped hole in the center, which we filled with a star-shaped spiral (figure 10).

Success: Writing a New Program in Logo

Once we had divided the design into smaller pieces, it was relatively easy to write a program to produce it (see listing 2, page 132). First, we wrote five procedures, one for each version of the design's three basic figures. The procedures PENTR and PENTL draw pentagonal spirals, TRIPOLYR and TRIPOLYL triangular ones, and CENTERPIECE draws the central, star-shaped spiral.

PENTR draws a spiral that curves to the right. PENTL draws its mirror image. (Because this is the only difference between the two, I will limit my remarks to PENTR.) Note that PENTR differs from the procedure POLYSPI mentioned earlier. In PENTR the first instruction is a conditional statement; it stops the procedure when the value of SIDE gets smaller than 2. TRIPOLYR, the procedure that draws right-curving triangular spirals, differs from PENTR in three important ways. The lengths of the three sides in the underlying shape of this spiral are



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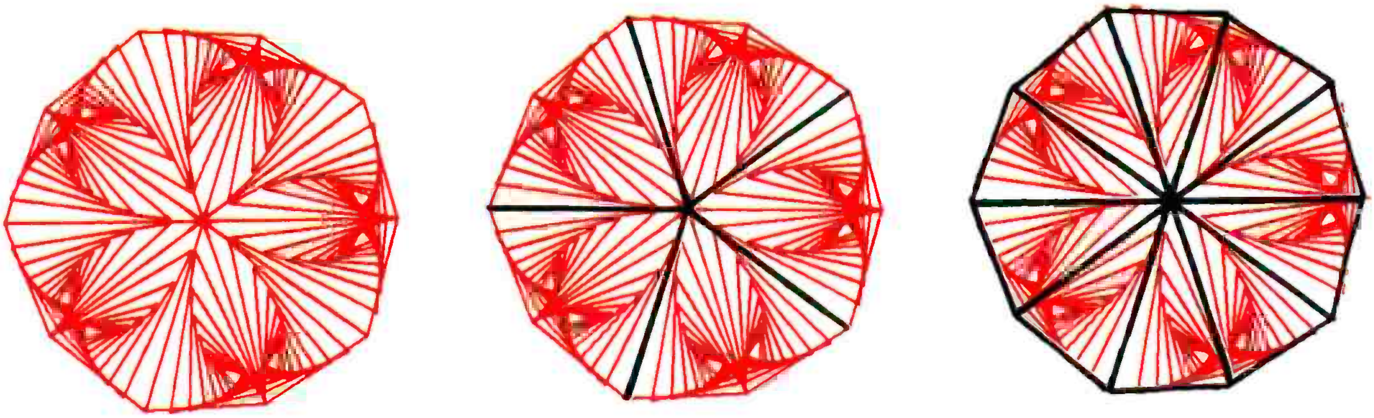

Figure 7: *The center of the wheel in figure 6 can be broken down into 10 isosceles triangles.*

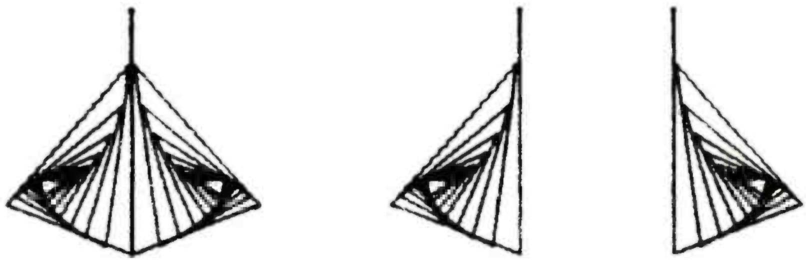

Figure 8: *We discovered that each of the isosceles triangles in figure 7 was a spiral of an irregular polygon.*

not equal. Also, triangles with sides of different lengths must have unequal angles. The "turtle-turn" at two vertices of this triangle is 111 degrees, while the third vertex has a turtle-turn of 146 degrees. The last difference between TRIPOLYR and PENTR is in how SIDE gets shorter each time a side is drawn. In PENTR, you reduce SIDE by subtracting .38 from each previous side. In TRIPOLYR, SIDE is *multiplied* by .75

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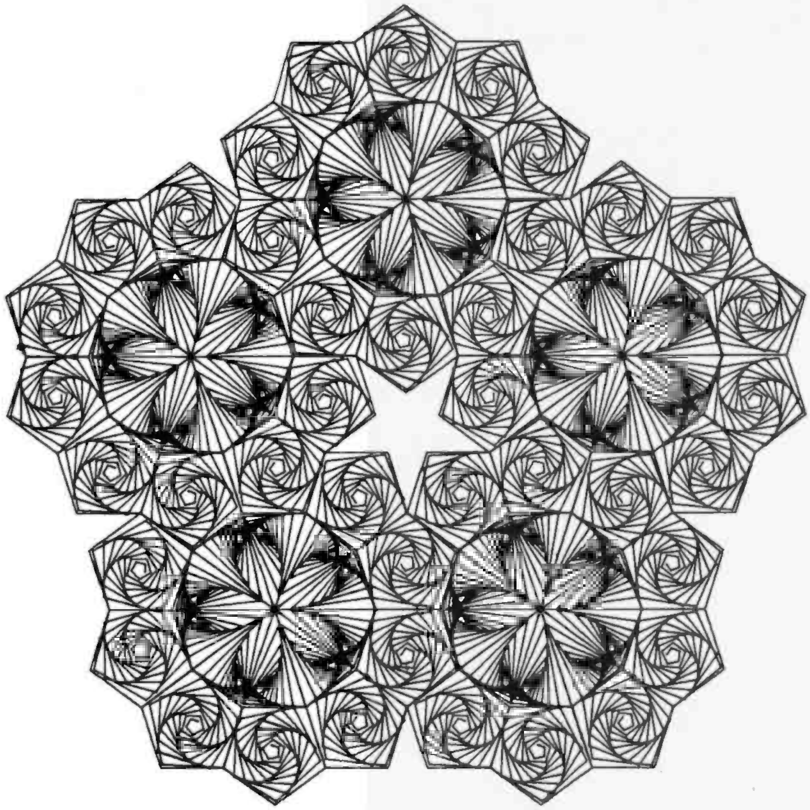

Figure 9: *Our design elements assembled together. The last remaining element is a star-shaped spiral in the center.*

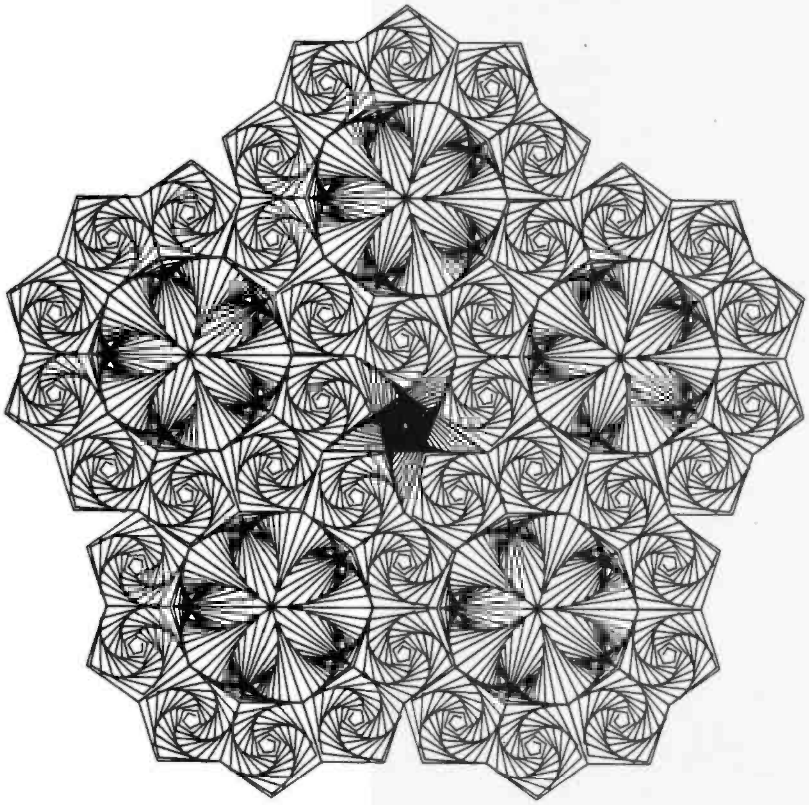

Figure 10: *Our completed Logo design. Using a simple Logo program we have made a good reproduction of a very complex design (figure 1).*

at the end of each three-side cycle; thus, SIDE gets shorter faster.

This precise combination of side lengths and angle measurements and the faster spiraling technique is required to produce the spiral that appears in figure 8. Glenn arrived at the final version of TRIPOLYR after much trial and error. The resulting triangular spiral is a very close approximation to the one in the original design.

Lastly, CENTERPIECE, which draws the central star-shaped spiral, is almost identical to the procedure POLYSPI.

Moving to a Higher Level

The twin procedures PENTRPIECE and TRIPIECE are the next level up in the program; they build bigger chunks of the design by supervising the work of PENTR, PENTL, TRIPOLYR, and TRIPOLYL.

PENTRPIECE's job is to supervise PENTR and PENTL. One PENTRPIECE procedure produces a pair of mirrored pentagonal spirals. Four consecutive PENTRPIECEs make a ring of eight pentagonal spirals. TRIPIECE performs a similar function by supervising TRIPOLYR and TRIPOLYL. Five consecutive calls to TRIPIECE make a ring of five pairs of mirrored triangular spirals.

WHEEL makes one of the five large, identical sections that fit together to form the entire design. The command REPEAT 4 [PENTRPIECE LT 72] makes the rim of one wheel. Then REPEAT 5 [TRIPIECE] fills the newly created wheel with pairs of mirrored, triangular spirals.

It is common to build one procedure in a Logo program that more or less gets the whole thing started. DESIGN supervises the work of WHEEL and makes sure that each of the five wheels interlock. It also has CENTERPIECE fill the central hole with a star-shaped spiral.

Listing 2 shows the complete program for an Apple II using Apple Logo. You can produce the design on the display screen of the Apple, but it will be rather dense. You can get a more interesting, but somewhat cropped, version by multiplying each

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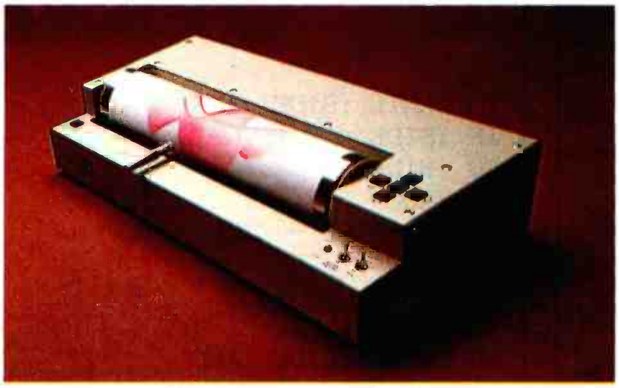

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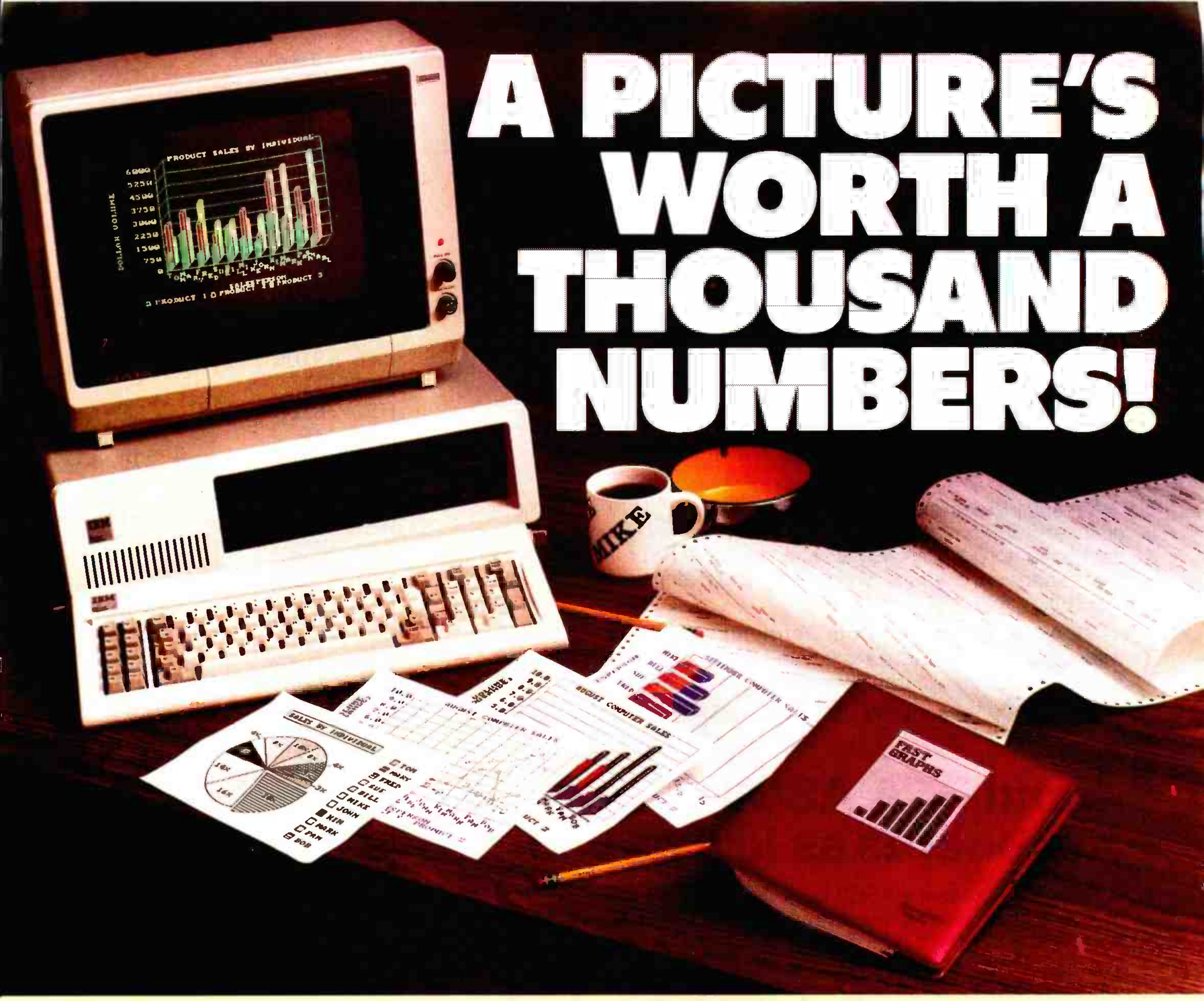
Listing 2: *Our Logo program, entitled* DESIGN, *will redraw the design in figure 1.*

```
TO DESIGN
CS HT PU WINDOW
REPEAT 5 [FD 64.65 PD WHEEL POS PU BK 64.65 RT 72]
PU HOME RT 36 FD 24.5 RT 198 PD
CENTERPIECE 46 143.4
END


TO WHEEL :INITPOS
RT 54 REPEAT 4 [PENTPIECE]
PD LT 36
REPEAT 5 [TRIPIECE]
LT 36
REPEAT 5 [PD RT 72 FD 28 PU BK 28]
LT 54
END


TO TRIPIECE
LOCAL "OLDH MAKE "OLDH HEADING
PD BK 2.5
TRIPOLYR 31.5
PU SETPOS :INITPOS SETH :OLDH
PD BK 2.5
TRIPOLYL 31.5
PU SETPOS :INITPOS SETH :OLDH
LT 72
END


TO PENTPIECE
LOCAL "OLDH MAKE "OLDH HEADING
PU FD 29 PD
REPEAT 5 [FD 18 RT 72]
PENTR 18 75
PU SETPOS :INITPOS SETH :OLDH
FD 29 PD
REPEAT 5 [FD 18 LT 72]
PENTL 18 75
PU SETPOS :INITPOS SETH :OLDH
LT 72
END


TO PENTL :SIDE :ANG
IF :SIDE < 2 [STOP]
FD :SIDE
LT :ANG
PENTL :SIDE - .38  :ANG
END


TO PENTR :SIDE :ANG
IF :SIDE < 2 [STOP]
```

Listing 2 continued on page 134



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Listing 2 continued:

```
FD :SIDE
RT :ANG
PENTR :SIDE - .38 :ANG
END


TO TRIPOLYR :SIDE
IF :SIDE < 4 [STOP]
FD :SIDE
RT 111
FD :SIDE / 1.78
RT 111
FD :SIDE / 1.3
RT 146
TRIPOLYR :SIDE * .75
END


TO TRIPOLYL :SIDE
IF :SIDE < 4 [STOP]
FD :SIDE
LT 111
FD :SIDE / 1.78
LT 111
FD :SIDE / 1.3
LT 146
TRIPOLYL :SIDE * .75
END


TO CENTERPIECE :S :A
FD :S LT :A
IF :S < 7.5 [STOP]
CENTERPIECE :S - 1.2 :A
END
```

of the inputs to the FD and BK commands by two.

We produced our completed design on a Houston Instrument Hiplot plotter using a plotter-interface procedure written by Peter Cann. You can obtain these instructions from Logo Computer Systems (368 Congress St., Boston, MA 02210). Unfortunately, this interface procedure will work only with Apple Logo.

As you can see from figure 10, our design compares pretty well with the original. The important point of this exercise is that a complex design can be broken down into simpler components. And this approach, which is part of the basic philosophy behind Logo, can be used to solve practically any problem. ■

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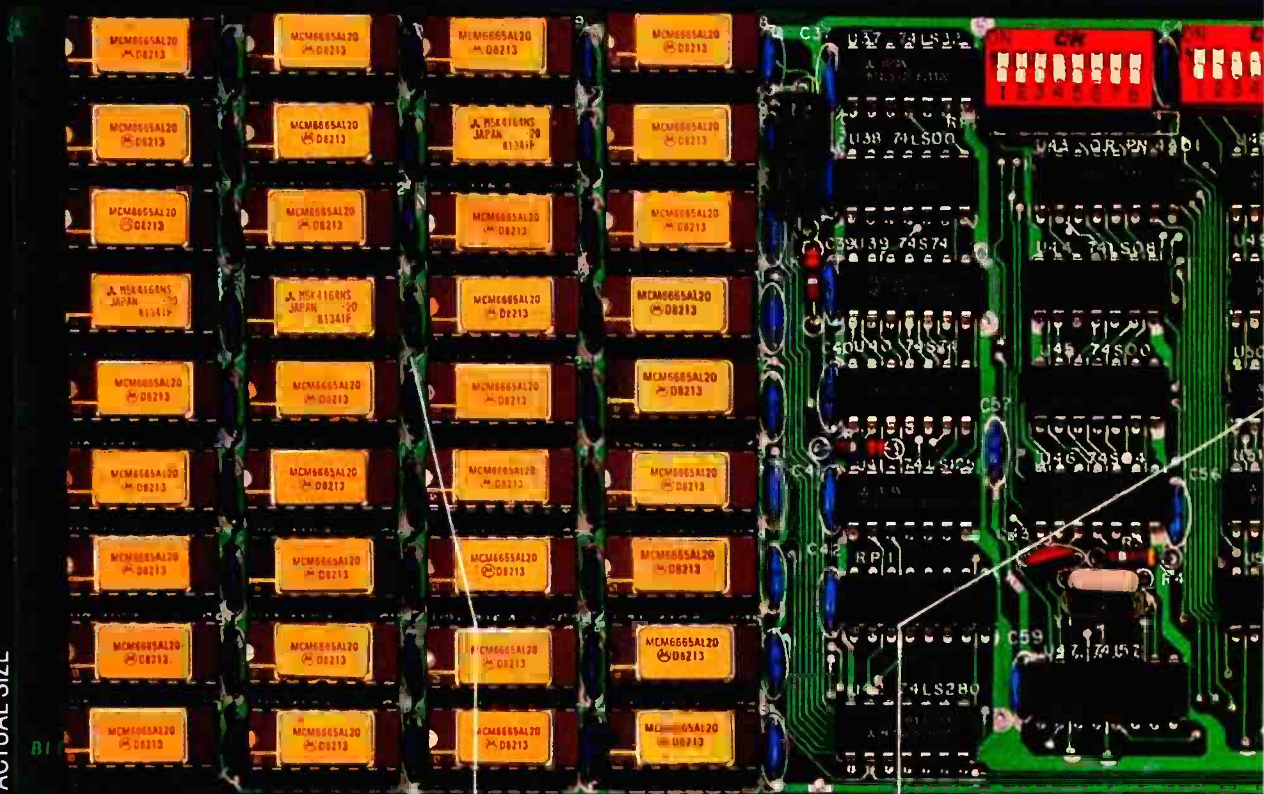

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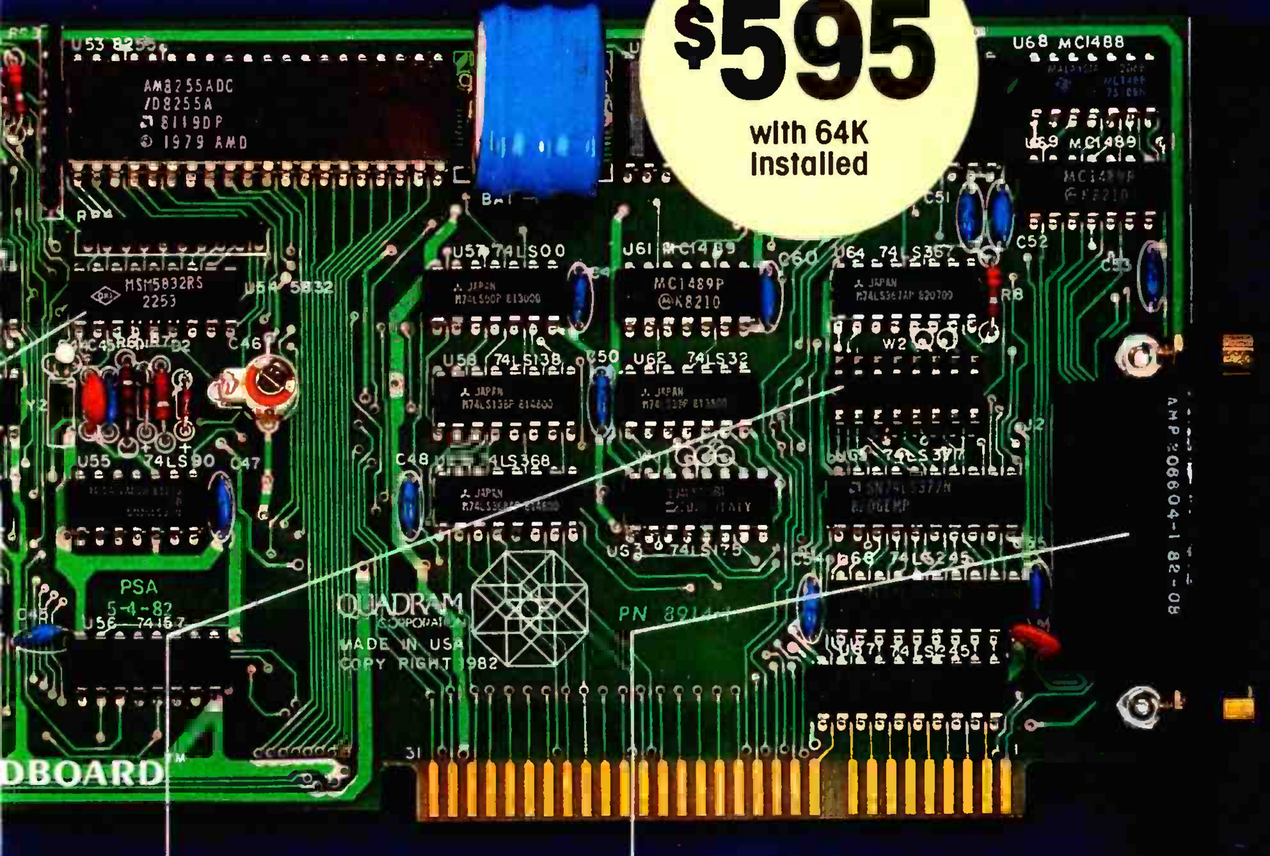

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The Graphics Magician

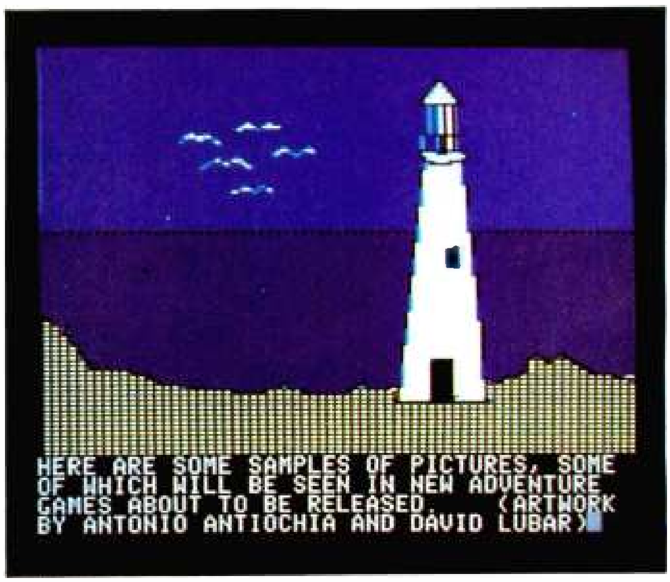
Easy Animation with the Apple II

Pete Callamaras
AFIT/LS
Wright-Patterson AFB, OH 45433

Suddenly, the lifeless blob grew legs! And then slowly it rose and made its way across the room. It paused as if seeking something and then, with a heart-stopping lurch, turned and came straight for me! The creature grew taller, opened a mouth that wasn't there just a moment ago, and charged. . . .

Wow! I had just finished the test run on my first little adventure with an animated character on my Apple II, and it worked. Now, don't get the idea I'm a great graphics programmer—no way! And I didn't create this animated character the old tedious way with graph paper, pencil, and a shape table. I was using a program from Penguin Software, which is aptly titled The Graphics Magician.

The Graphics Magician is a graphics-generating system that allows both the rank novice and the advanced professional programmer to produce professional graphics images on the Apple II or Apple II Plus. In fact, Penguin Software claims that it was used to produce the games Congo and Goldrush (by Sentient Software). Basically, The Graphics Magician is an extension of other Penguin products, namely, The Complete Graphics System and Special Effects. Sections of these two programs have been included in The Graphics Magician, albeit in modified



Photos 1 and 2: *Two examples of pictures that can be created with the Picture/Object Editor of The Graphics Magician software package. Hundreds of these pictures can be stored in compressed form on one disk.*

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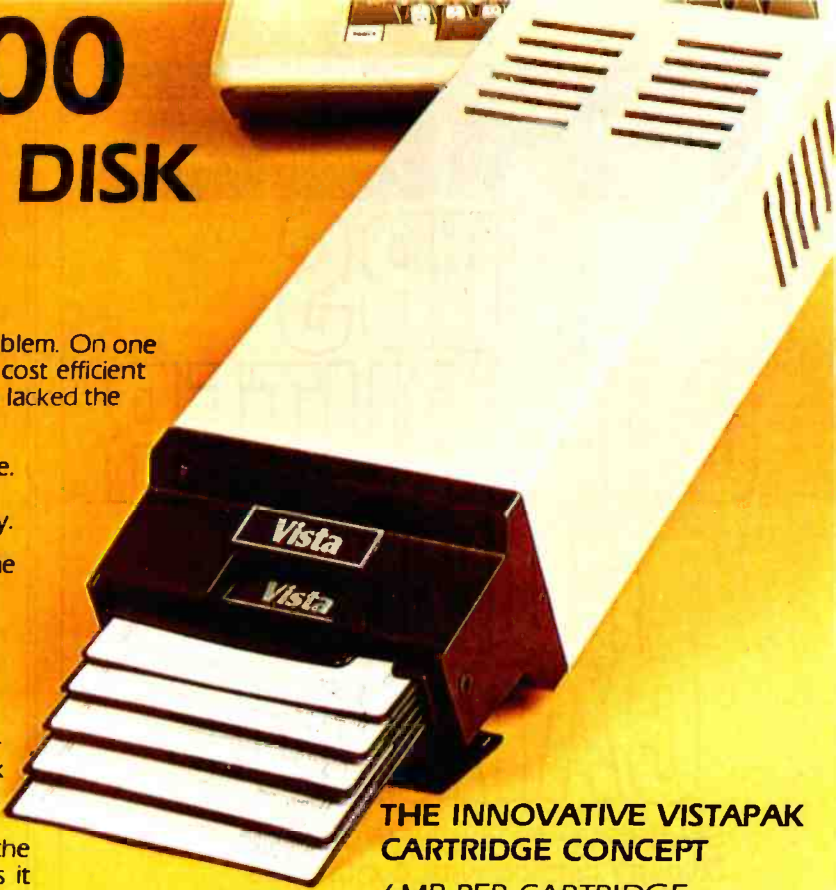

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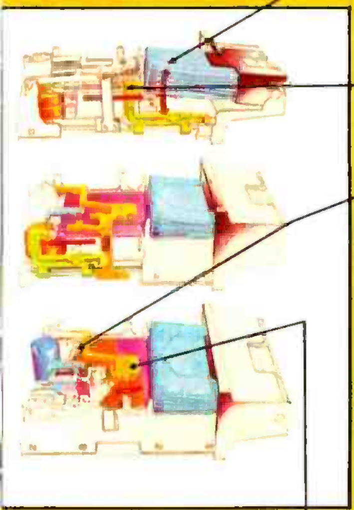

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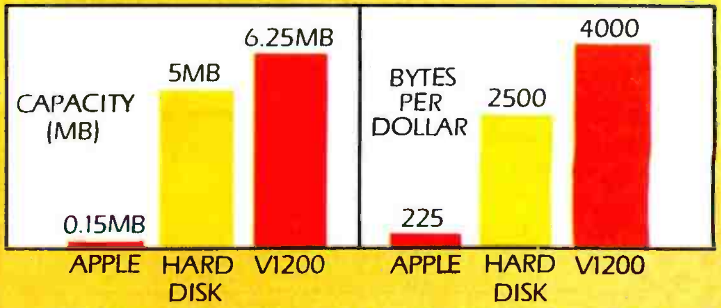

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At a Glance

Name
The Graphics Magician

Type
Graphics-generation system

Manufacturer
Penguin Software
830 4th Ave.
Geneva, IL 60134
(312) 232-1984

Price
\$59.95

Authors
Mark Pelczarski, David Lubar, and Chris Jochumson

Format
5¼-inch floppy disk

Language
6502 machine language

Computer
Apple II with Applesoft or Apple II Plus, 48K bytes of memory and one disk drive

Documentation
32-page manual

Audience
Novice or experienced user with an interest in graphics

form. The result is a very nice package for the Apple.

Many personal computer owners purchase the Apple II because it gives high-resolution graphics and color capability. But learning to use the Apple graphics capability well is not easy, and reading the necessary documentation is quite a time investment. This is why a program like The Graphics Magician is like manna from above. You don't have to go through a lot of agony to start putting animated graphics into your programs. Now, using The Graphics Magician is not a substitute for a good understanding of how the Apple puts those super images on the screen, nor will it take the place of good homework. But it will coax you into learning more because you can start producing high-quality images almost immediately.

The Graphics Magician has three major features:

- The Animation system, which you use to draw a picture, move the resulting image around the screen, and give the image its screen animation characteristics.
- The Picture/Object Editor, which allows you to store many other pictures on a single disk and easily add colors to them.
- The Super Shape Editor, which you use to control the size, scale, and rotation of the shapes you have previously designed and stored in the Apple shape tables.

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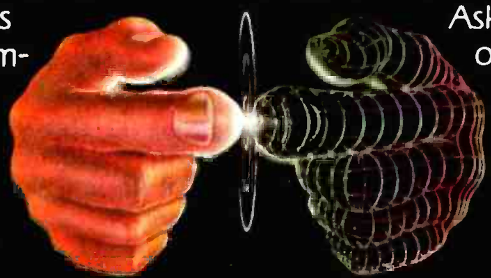

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Personal Computer Division

Nippon Electric Co., Ltd., Tokyo, Japan

There are also some additional utilities on the disk that will come in very handy during your sojourn into the world of graphics design and display. A binary transfer routine will be particularly useful to you.

Animation

Basically, the four steps you will want to take in animation are to draw something, make it change its shape in some pattern, make this changing shape move across the screen, and have the movement performed as smoothly as possible.

Now let's look at these operations and see what The Graphics Magician can do for you. The first two operations are handled by a module called the Shape Editor. The third operation is performed by a Path Editor. And an Animation Editor takes care of the fourth operation.

The Shape Editor. First, you actually draw a desired shape. It's rather simple; you move the cursors around the screen via the familiar I, J, K, and M keys. What's not familiar is that there are seven cursors on the screen, and each one can be controlled individually or in any combination of the seven. You use these to produce what are called *preshifted shapes*. This means that you can draw seven slightly different shapes to give your creation the illusion of movement, and later you can move this set of shapes around the screen using another module called the Path Editor.

A good example of the illusion of movement is a game called Threshold (from On-Line Systems). In the game, the first screen is filled with birds that not only move around but flap their wings at the same time. The flapping movement is created by using the preshifted shapes, and the birds' basic flight pattern is handled by the Path Editor.

I found it easiest to draw the basic shape with all seven cursors, then put the individual differences on each shape one at a time with individual cursors. This keeps all seven shapes in precise relation to each other.

I should also mention that there are two methods of making a shape: the point method, through which you draw the image point by point, and the block method, which uses large groups of points called blocks. You can choose whichever is applicable to your new creation.

Once all of your drawing is done, you naturally will want to save the image. But first you must compile it. To do this, hit one key (C) and enter the height and width of your shape by following the prompts. After the shape is compiled, you can test run it to be sure it looks the way you want it to. Then you can save it. On the first attempt, it may seem a bit awkward, but after about 10 minutes you will get the hang of it.

The Path Editor. This is a relatively simple module. Once you have drawn your figure, you use the Path Editor to tell it how to move across the screen. This includes horizontal, vertical, and diagonal movement, both across the screen and "wrapping around" at the edges if you wish. You specify a starting point for a reference and then simply trace the path it will follow. You can choose the number of directional units the figure will move in and can "mix and match" as you desire. Several hints are also offered in the manual on how to save memory by making small paths and then combining the small paths into larger ones.

The Animation Editor. This editor puts zip into the graphics. As you know, animation is achieved on a video screen by quickly drawing new images. The Graphics Magician gives you four methods for doing this. The simplest to grasp is to draw a figure in one place, then completely erase and draw it again in a different place. This results in a somewhat jerky movement. In another method, only that part of the figure that needs to be erased is erased. The result is a smoother movement. The two remaining methods are concerned with background, and each of the four has its own advantages and disadvantages depending on the type of graphics you are doing. You have to make trade-offs between speed, storage requirements, flicker (presence or absence), shape restrictions, and finally whether or not you need to detect collisions (such as your shape getting shot). Again, the manual covers these requirements in understandable detail.

Using the Animation Editor is relatively simple. You enter the animation method you want to use, the shape and its path, and other data you desire. Once you have

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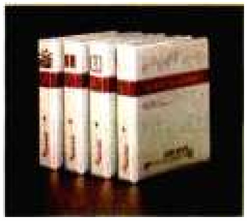

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saved these animation instructions, all that's left is to run it. This can be done with a very simple four-line BASIC program.

The possibilities are very aptly demonstrated by Space Invader-type games in which you have several different shapes, which are all moving across and down and being deleted when a collision is detected (i.e., you hit one), and yet they keep coming. Then when one set of invaders has been eliminated, another set is drawn lower on the screen, and they start their parade of destruction again.

I found myself doing all sorts of interesting things with the program after playing around for only about an hour. You really will be pleased at the amount of control you have over the entire action on the screen.

The Picture/Object Editor

In addition to these animation capabilities, you have two other modules at your disposal. The Picture/Object system allows you to draw several nonanimated images that can be "compressed" for efficient disk storage. An Apple normally requires 34 sectors of disk space per picture, but you can reduce this to 2 or 3 sectors per picture (although extremely complex images might take 5). Thus, you can save hundreds of pictures on one disk in compressed form. You can imagine just how useful this can be when you use graphics in an educational environment or in an adventure game. There are very few limits to worry about. You can put objects anywhere on the screen, have them moving all around, and call on a remarkably large group of pictures for display. The manual gets somewhat technical on this point, but the authors make it as easy as they can for you.

The Picture/Object Editor also has fairly powerful color capabilities. Penguin has included 8 paint brushes and 108 colors along with an improved color-fill routine from its other packages (The Complete Graphics System and Special Effects). The combination of these features makes coloring your pictures very easy.

The Super Shape Editor

The last major feature, the Super Shape Editor, is actually an extension of the Apple's shape tables. Using this function, you can change color and scale of graphics images stored in Apple shape tables. You can put a large number of shapes into memory, and each shape's scale and rotation can be individually controlled. Of course, because you're working in Applesoft with the Super Shape Editor, things are slowed down somewhat. Think of the Super Shape Editor as an interface between the normal shape table and the screen. (Applesoft routines are interpreted by the Super Shape Editor, and the final result is then sent on for display, much the same way as commands are screened by DOS before being acted on by the Apple.)

Other Features

Now that I've covered all the major systems and their subsystems, it's time to talk about some nice extras thrown in. These consist of a demonstration of The Graphics Magician showing how the various features all play together, an animated alphabet ready to be used immediately in your endeavors (or modified if you wish), and finally a binary transfer utility that not only moves your binary files between different disks but also gives you the starting address and length of your binary program. This one utility will probably come in handy in any of your other programming efforts.

I should also mention the somewhat refreshing and unusual attitude of Penguin Software regarding The Graphics Magician and other products: the disk is unprotected! You can make as many backup copies as you need. This also means you will have access to the source code. I would like to congratulate the people at Penguin for looking ahead and thinking about the user. For a change, a program is not hard to work with or fragile due to some esoteric protection scheme. I also think this action led to the relatively low price of this program. When you've used it for a while, you will really appreciate its cost/usefulness ratio.

The manual is nicely written, although I did find it targeted a little more toward the advanced user. The information will make even the novice fairly proficient, but you will want to supplement the manual with outside information on the Apple and its high-resolution color graphics system.

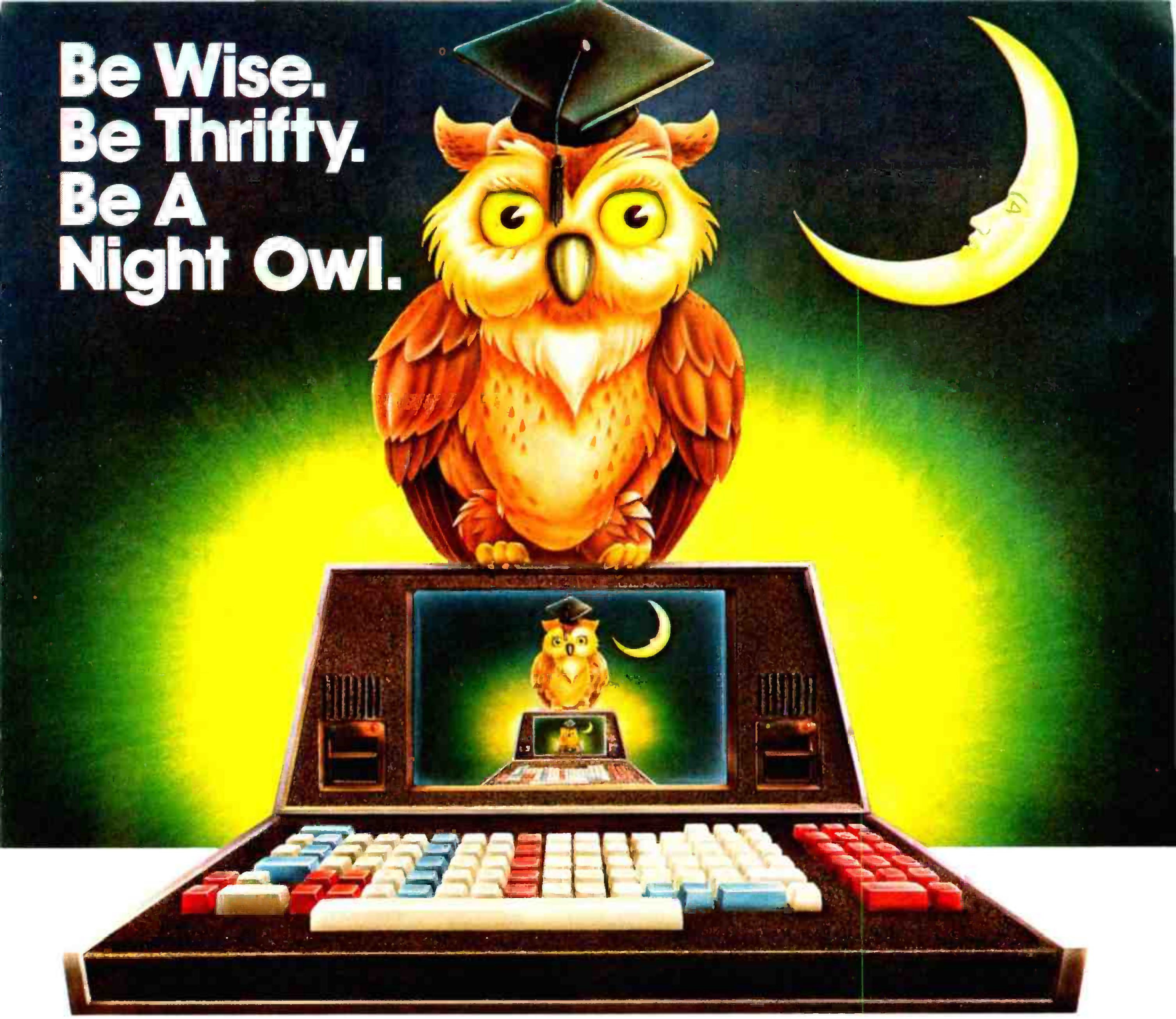
I do have a complaint about the manual, and it applies to the majority of manuals I have seen. Sometimes the most basic information is not included under the assumption that it is too basic. I had a problem the first few times I tried to get from one module of the program to another. It seemed to me it took a long time to ferret out that sort of basic information. I also would have liked a reference card or at least a single page with the different commands and their abbreviations. That would have made the program a little easier to use.

Conclusion

The Graphics Magician from Penguin Software is a superbly done graphics system that greatly simplifies putting high-resolution graphics into your own Apple program. It is a fairly simple-to-use program that should appeal to both the novice and advanced Apple user. You can use the resulting graphics in any level program you wish.

The first application that comes to mind is games, but the simplicity of the program makes it even more attractive for educational purposes. The ability to store many different images, each with different movement patterns and all on a single disk, makes this program even more valuable.

Overall, I would recommend The Graphics Magician to anyone wanting to work with the Apple's high-resolution graphics for whatever purpose, even if it's only to play games. The program's smoothness, simplified animation, and flexibility give credence to the name "magician." This is definitely a program Apple users should have in their software library.■



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Cambridge Development Lab's High-Resolution Video Graphics System

James R. DeKock
University of Wisconsin
Nuclear Engineering Department
1500 Johnson Dr.
Madison, WI 53706

Cambridge Development Laboratory of Watertown, Massachusetts, markets a high-resolution graphics system that enables S-100 computer owners to access some of the sophisticated graphics software used in many mainframe and large minicomputer installations. Used together, the Massachusetts firm's GGEN software and HR series video-graphics board have the unique capacity to emulate many of the attributes possessed by Tektronix series 4010 terminals.

Probably the most striking feature of the HR-X/GGEN system is its ability to create graphics displays from the command codes produced by Tektronix PLOT-10 software. This article will briefly introduce the hardware and software products which form the foundation of the CDL (Cambridge Development Laboratory) high-resolution graphics-terminal emulator system.

Acknowledgments

All work described in this report was performed in the laboratories of the University of Iowa's Department of Physics and Astronomy, Iowa City, Iowa. The author wishes to thank Randy L. Goettsch for his suggestions and technical assistance. This work was supported in part by an agency of the United States Government.

Disclaimer

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The HR-X Graphics Interfaces

CDL's model HR-1 monochrome, raster-scan graphics interface represents the entry level of a multitiered hardware-product line; it can easily be expanded to the top-of-the-line model HR-4C, an interface capable of producing 4096 colors. (Of this number, a user-selectable subset of 16 colors may be displayed at any given time.) Intermediate products produce fewer colors (or gray-scale levels on black-and-white monitors).

Containing 327,680 bits of programmable memory, all HR-X interfaces produce displays with a minimum resolution of 640 horizontal by 482 vertical pixels (picture elements) cells. Vertical resolution can be increased, depending on video-monitor characteristics, up to 507 pixels with one HR-X modification.

The HR-1 is composed of three S-100 boards: the first controls the interface to the host computer, the second controls the display memory and its refresh circuitry, and the third contains output logic and 40K bytes of programmable memory for storing the displayed image.

Expansion beyond the monochrome HR-1 level is accomplished by installing up to three additional copies of the output logic and memory board. Each memory board stores 1 bit of information per pixel. An HR-1 graphics interface, with its single memory card, can control only whether each pixel is on or off. Color or shading capabilities require an interface that stores 2 or more bits per pixel.

With the 4 bits per pixel stored by the HR-4C color interface, the programmer can specify any of 16 possible *logical colors* for each pixel in the display. Each logical

At a Glance

HARDWARE

Name
HR series, high-resolution graphics interface: The Dynamic Blackboard

Use
Production of raster-scan video displays using any combination of text, special characters, or graphics

Manufacturer
Cambridge Development Laboratory
36 Pleasant St.
Watertown, MA 02172
(617) 926-0869

Price
HR-1 (black-and-white): $1200, HR-4C (4096 colors): $3175; intermediate products available

Dimensions
3 to 6 standard-size S-100 boards

Features
High-resolution 640- by 482-pixel displays; HR-1 system can be upgraded by adding additional display memory; HR-X hardware can produce displays at the rate of nearly one-half million pixels per second; includes CGEN software to produce hard copies (see Documentation below)

Hardware required
S-100 computer and video monitor (black-and-white monitors must have composite video, RS-170, input; color monitors may optionally have the timing signal input separate from the display signal); minimum 12-MHz bandwidth

Software required
User-written programs and/or CDL routines (supplied on 8-inch CP/M-format floppy disk with the purchase of HR interface)

Hardware options
Light pen: $100

Software options
GRASIC: $225; GGEN (see summary below): $300; Graphpac (a plotting program): $300; 3D Package by Sublogic: $200

Documentation
122-page manual includes schematic diagrams, theory of operation, and utility programs written in assembly language. A CDL technical note describes a hardware modification to increase the vertical-display resolution to as high as 507 pixels, depending on the type of video monitor used. A 46-page service guide: $25; diagnostic disk (12 programs on an 8-inch CP/M-format floppy disk): $15; newsletter: free of charge

SOFTWARE

Name
GGEN, graphics terminal emulator

Type
Utility; used with HR series of graphics boards

Manufacturer
Cambridge Development Laboratory
36 Pleasant St.
Watertown, MA 02172
(617) 926-0869

Price
$300

Format
8-inch floppy disk, CP/M format

Language
GGEN is supplied in page-relocatable format; converted to executable form by support programs supplied on the GGEN disk

Hardware required
Any S-100 computer with Z80 processor using CP/M (or CP/M-like) operating system. CDL's HR-X graphics interface is required; a modem may be needed to link with a remote mainframe computer running PLOT-10 and to maximize GGEN usefulness

Documentation
25-page manual

Audience
Anyone who wishes to use Tektronix PLOT-10 applications software or other software that can drive Tektronix 4010 series terminals

color points to a corresponding color-intensity level. This level is found in a user-programmable translation table located on each memory board. The intensity level selected from the table is fed to the DAC (digital-to-analog converter) located on that same board. The DAC subsequently drives one of the electron guns found in a color monitor, thus creating a *physical color*. Each logical color is made of three different intensity levels, through not necessarily the same level, for each of the red, green, and blue electron guns.

The model HR-4C can simultaneously drive one color and one black-and-white video monitor. The HR-4 interface, which also uses a total of 4 memory boards, displays 16 shades of gray and can be upgraded to a HR-4C color system if desired. The manual accompanying the graphics boards includes about 20 pages devoted to schematic diagrams, parts lists, and theory of operation. The HR-1 interface is shown in photo 1.

Controlling the Interfaces

The graphics memory of the HR-X interface is not connected to the S-100 bus's address lines. Instead, access to the graphics interface is through eight contiguous, user-selectable input and output ports.

An internal 19-bit register, the *cursor*, contains the address of one screen location. This HR-X register is set by sending the desired cursor address to the appropriate ports. The current cursor location can be determined at any time by reading the same ports.

A second internal register is 4 bits long and is called the *cursor-data register*. The value placed in this register by the user's program is written to the screen memory address specified by the cursor, with each of the register's 4 bits directed to a different memory plane (i.e., the memory boards). If fewer than four memory boards are installed, the corresponding bits of the register are ignored. Expanding the system to include more colors or gray-

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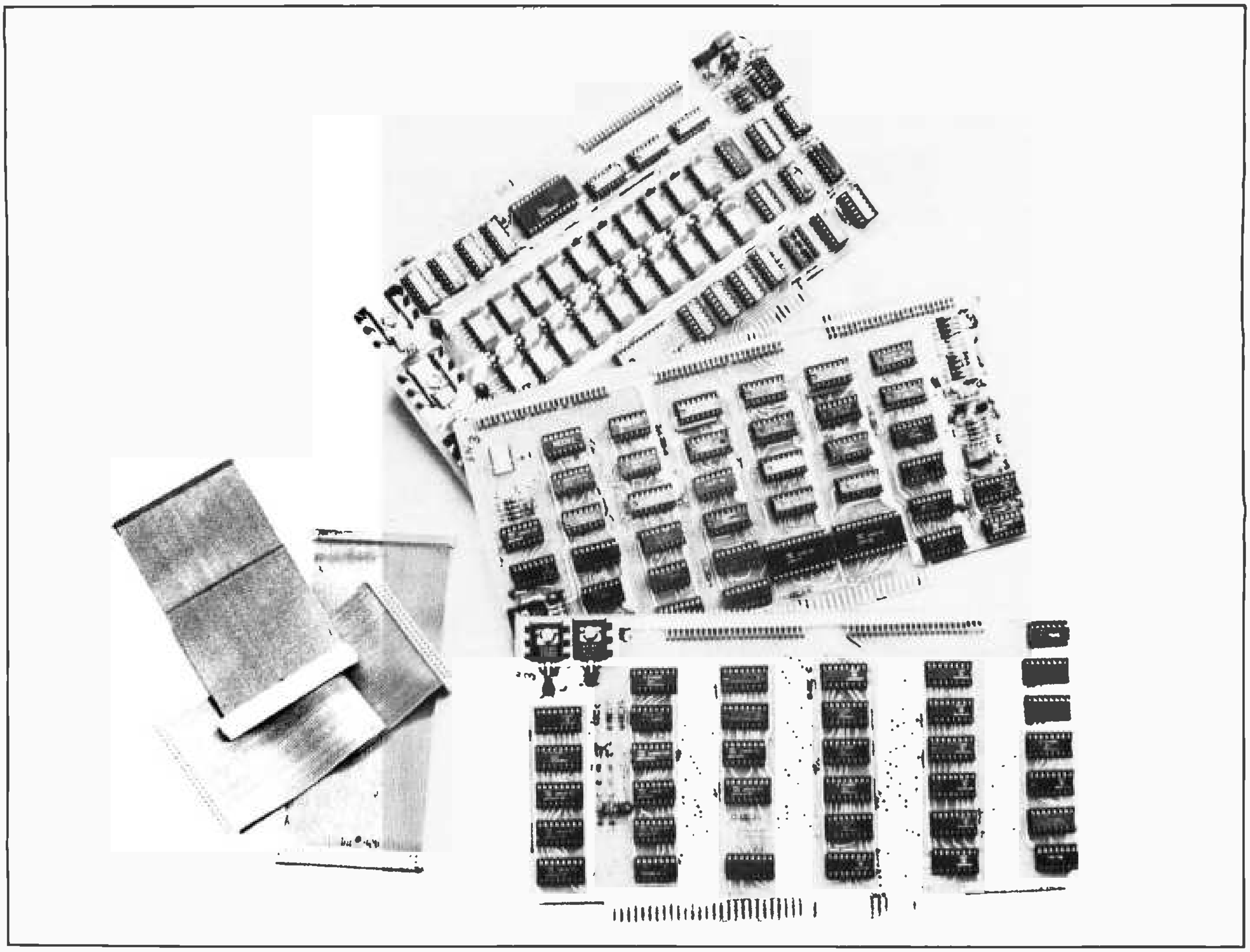

Photo 1: *Cambridge Development Laboratory's HR series of raster-scan video graphics boards. These boards produce high-resolution (640 by 482 pixels) video graphics. The user has software access to a 640- by 512-pixel graphics memory, and the S-100 system is capable of plotting at a rate of nearly 500,000 pixels per second. The HR-1 monochrome interface, pictured here, is composed of three S-100 boards. If the user later requires gray-scale or color capabilities, additional memory boards may be added. CDL has named its HR-series product line The Dynamic Blackboard. (Photograph by CDL.)*

scale levels does not affect the operational speed of the interface, and software commands are designed to adapt readily to the hardware actually present.

The 8-bit *crawl* command, the basic instruction for reading from and writing to the screen memory, causes three distinct operations. First, the contents of memory at the present cursor location are read; the computer may optionally determine what was on the screen before the instruction is completed. Next, the 4-bit contents of the cursor-data register can be written to screen memory. Finally, the cursor is moved one step in any of eight directions.

The *write-byte* command permits eight consecutive crawl commands in the same direction to be performed. The write byte instruction consists of 0s and 1s that have control over whether or not the contents of the cursor-data register are to be written to the eight successive screen memory locations.

The *cursor adjust* command may be used to move the cursor 1 to 16 steps in any of the 8 compass directions. The *auxiliary* command is used to clear or set the display to a desired state, scroll the screen up or down, or reset a light-pen flag.

Using the commands described above is as simple as sending a byte to the port associated with each command. The HR-X manual provides assembly-language source listings for a variety of routines, including one that draws vectors on the screen. A hardware service guide is also available.

HR-X Software

Several software packages are provided with the HR-X graphics interface. CGEN, a character-display program written by CDL, lets you access three character sets and can be incorporated into a CP/M disk operating system.

Characters are usually displayed in an 8- by 16-pixel format. They are created with CDL's character editor, and another program, LOADC, installs the character file into memory. The DUMPSCRN routine will print the contents of screen memory on an IDS (Integral Data Sys-

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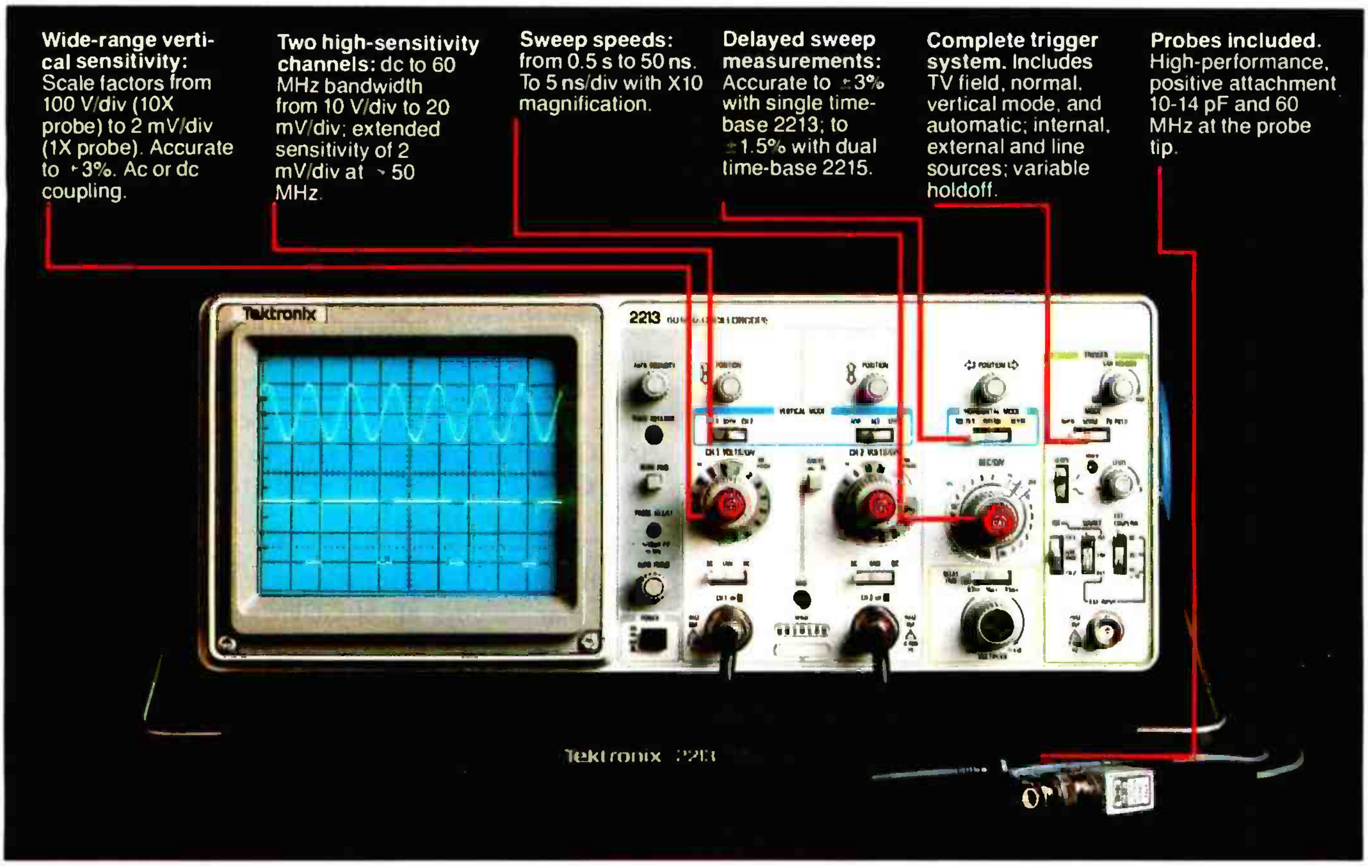

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What Is PLOT-10?

Since the late 1960s, Tektronix Inc. has developed a series of text and graphics terminals primarily for large and minicomputer systems. These terminals display incoming data as either text or high-resolution vector graphics (drawn on a storage-type cathode-ray tube). PLOT-10 is Tektronix's package of utility programs that function as the user interface to the terminal.

The earliest versions of PLOT-10 allowed FORTRAN programmers to create graphics through a series of calls to the PLOT-10 library. Numerical data, frequently the endpoints of vectors, are converted by PLOT-10 into command sequences that are passed to the display device. This frees the programmer from writing the complex subroutines necessary to control the display.

In the past decade, Tektronix has extended PLOT-10 to the point that it accepts English-like statements and produces highly complex images. It is presently used by a large number of educators, industries, and commerical organizations.

tems) Paper Tiger printer. The editor, LOADC, CGEN, and DUMPSCRN programs, written in assembly language, are included with the purchase or any HR-X interface. Optionally available is GRASIC, a graphics-oriented BASIC built on Processor Technology's BASIC/5 and expanded by CDL to drive the HR-X interface. GRASIC also has the ability to call DUMPSCRN.

GGEN

CDL's new GGEN software is a highly versatile program that includes all of CGEN's functions and, additionally, provides high-resolution graphics capabilities not previously available to S-100 computer owners. GGEN can translate Tektronix PLOT-10 terminal-control sequences into commands that can be directly executed by CDL hardware. This allows you to emulate many of the functions of a Tektronix series 4010 terminal with an S-100 computer, the HR-X graphics interface, and a monochrome or color video monitor.

CDL's software can optionally scale incoming data to compensate for the differing resolutions of the Tektronix display and the HR-X. GGEN has Tektronix-like Alpha (character display) and Graph modes, and each mode can access a menu of functions. Some of the available functions follow:

Alpha (text) mode menu selections:

1. select one of up to three character sets for current use
2. character overstrike enable/disable
3. set or clear tab at current cursor position
4. direct cursor to any screen location
5. produce a copy of the display on a graphics printer
6. generate a half linefeed on the screen
7. clear screen and reset the cursor to "home" position

Graphics mode menu selections:

1. select vector type to be solid, dotted, dot-dash, short dash, or long dash

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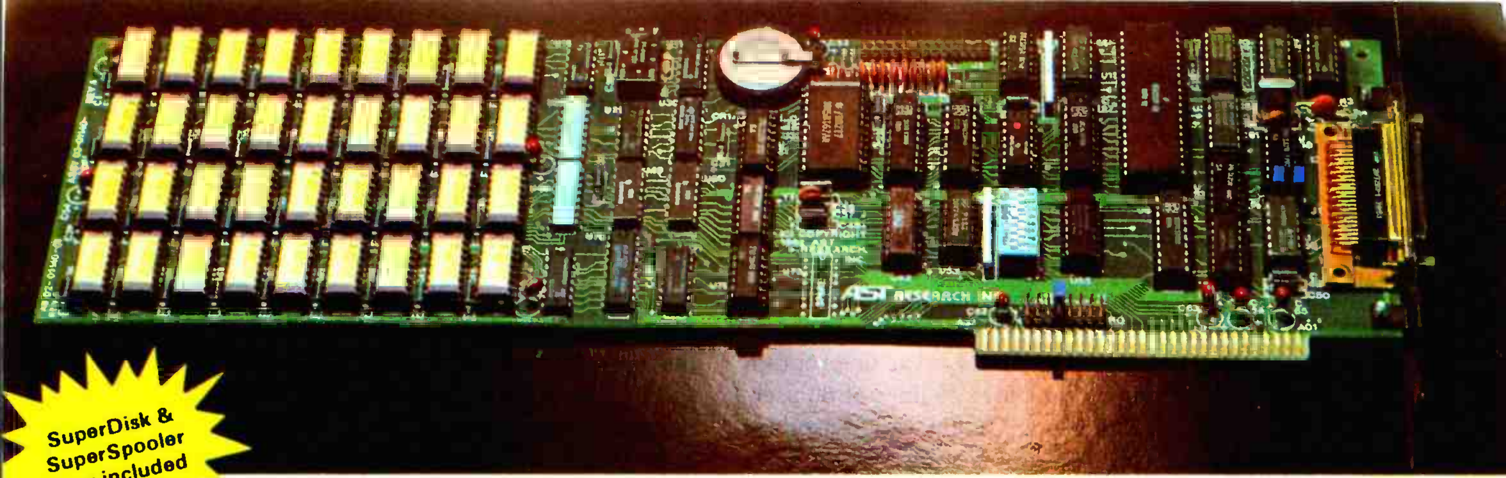

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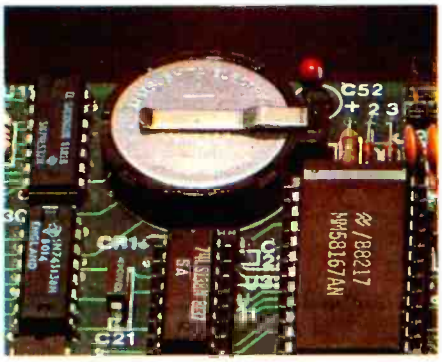

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Alpha/Graphics menu selections:

1. select color intensity or gray-scale level
2. select CRT gun (red, blue, or green) and set with intensity level specified in Step 1
3. scale Tektronix coordinates to CDL coordinates

GGEN defaults to the menu selections that most closely match the characteristics of a Tektronix series 4010 terminal. GGEN can also serve to display text or program listings. The HR-X memory can store 26 lines of 80 user-defined characters. In addition, GGEN can reproduce any screen image of text and graphics on Florida Data Corporation's model BNY high-resolution dot-matrix graphics printer.

GGEN is one of eight CP/M-format files on the distribution disk supplied by CDL. The contents of the GGEN package and the function of each file are

GEN.IMG - a page-relocatable file of GGEN code
EDIT.COM - a program to edit and define character sets
DEFAULT.CHR - an example of EDIT output
DEFAULT.IMG - default page-relocatable character set
CHR2IMG.COM - converts a .CHR file created by EDIT into an .IMG file
BUILD.COM - creates a page-relocatable file from two Intel-format .HEX files produced by the user's assembler
MERGE.COM - joins various page-relocatable files into one .IMG file
LOADING.COM - transforms an .IMG file into a .COM file with all addresses correctly located

Some of the programs are used in succession to produce an executable binary image of GGEN together with the user-defined character sets. The programmer may specify the starting address for GGEN to be any page boundary in memory (i.e., hexadecimal 0100, 0200, etc.).

A typical configuration with one character set will require approximately 4.6K bytes of memory. GGEN may be installed as either a part of the operating system, functioning as the CP/M-console output device, or as standalone code that may be linked to any high-level language program capable of calling assembly-language subroutines.

The four or five steps required to customize GGEN and its default character set to the desired starting address can be completed in about 20 minutes. Although CDL provides some guidance, integrating GGEN into CP/M will require a little time; a working knowledge of CP/M's structure and 8080 or Z80 assembly language is highly recommended. A significant number of PLOT-10 users can be found in many educational, industrial, and commercial organizations; thus, the range of potential ap-

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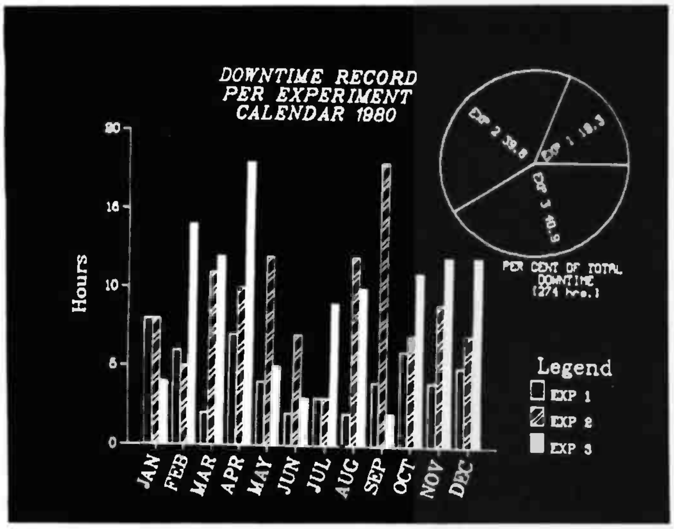

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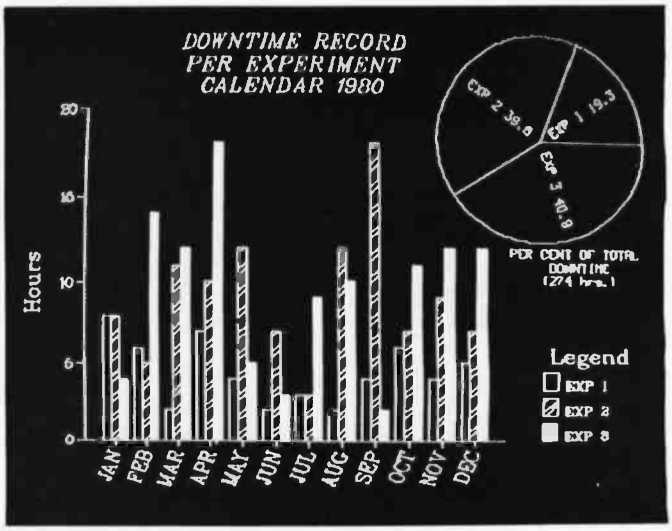


Photo 2: *Comparison of the CDL raster display and the Tektronix vector terminal. Photo 2a's graph was created on a Tektronix 4012 terminal by software running on an IBM 370/168 computer; the "image" was transmitted in PLOT-10 format. Photo 2b's graph was done on CDL's HR-1 interface and GGEN graphics-terminal emulator software; the video monitor is a Video 100 by Leedex. The same command codes for photo 2a were translated and scaled by GGEN for display by the HR-1. (The image is somewhat compressed vertically due to the format restrictions of the camera used to produce the photograph.)*

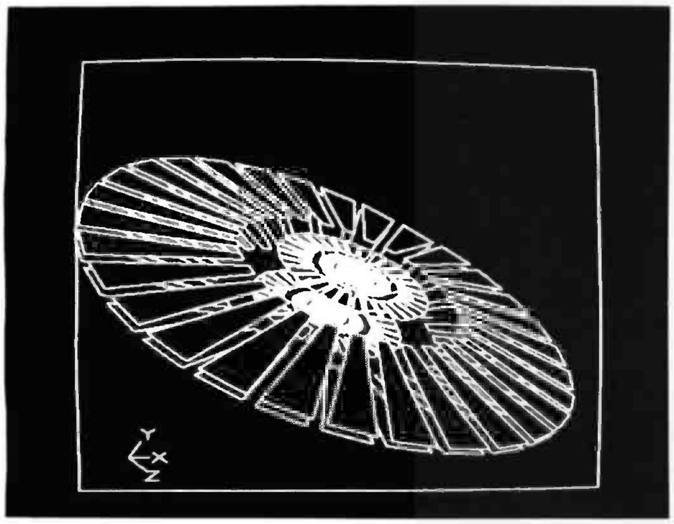
plications for the GGEN/HR-X system is quite large.

Application Example

The Iowa Plasma Physics Laboratory at the University of Iowa's Department of Physics and Astronomy has incorporated the HR-1 graphics boards and GGEN software as part of a microcomputer system that collects and processes data produced by various research experiments. The HR-1/GGEN interface duplicates many of the functions of a Tektronix model 4012 terminal at about 20 percent of a new 4012's cost. This price comparison, however, does not include the cost of the microcomputer.

Data is collected from experiments and transmitted to the university's IBM 370/168 and Prime 750 computers by a Cromemco Z-2 system. After returning numerical results, the large computers calculate graphic representations of the data and transmit the "image" in PLOT-10 command format. A short Z-2 routine intercepts the codes and sends them to GGEN for translation and subsequent display on a video monitor.

Photo 2 represents a comparison of images produced by Tektronix and CDL graphics systems. Photos 3a and 3b are examples of other displays produced at the University of Iowa with the HR-1/GGEN graphics interface. Listing 1 is the hard-copy representation of photo 2b, created by a GGEN routine on Florida Data's model BNY



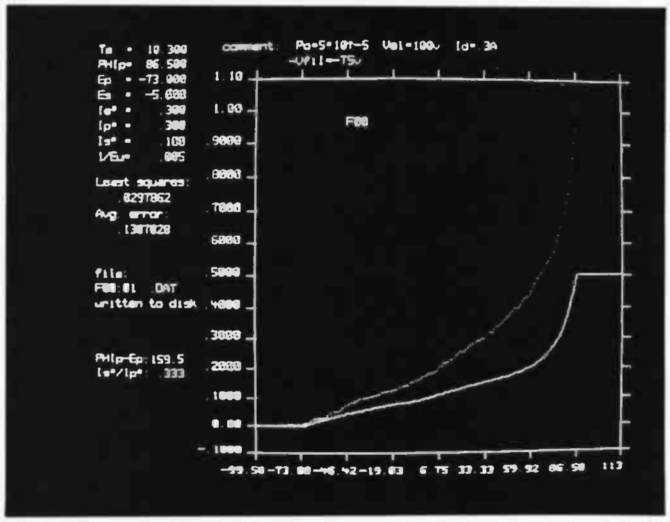


Photo 3: *Other displays produced on the CDL system. CDL's HR-X/GGEN system allows S-100 computer owners to produce highly complex displays in a simple and straightforward manner with Tektronix PLOT-10 software.*

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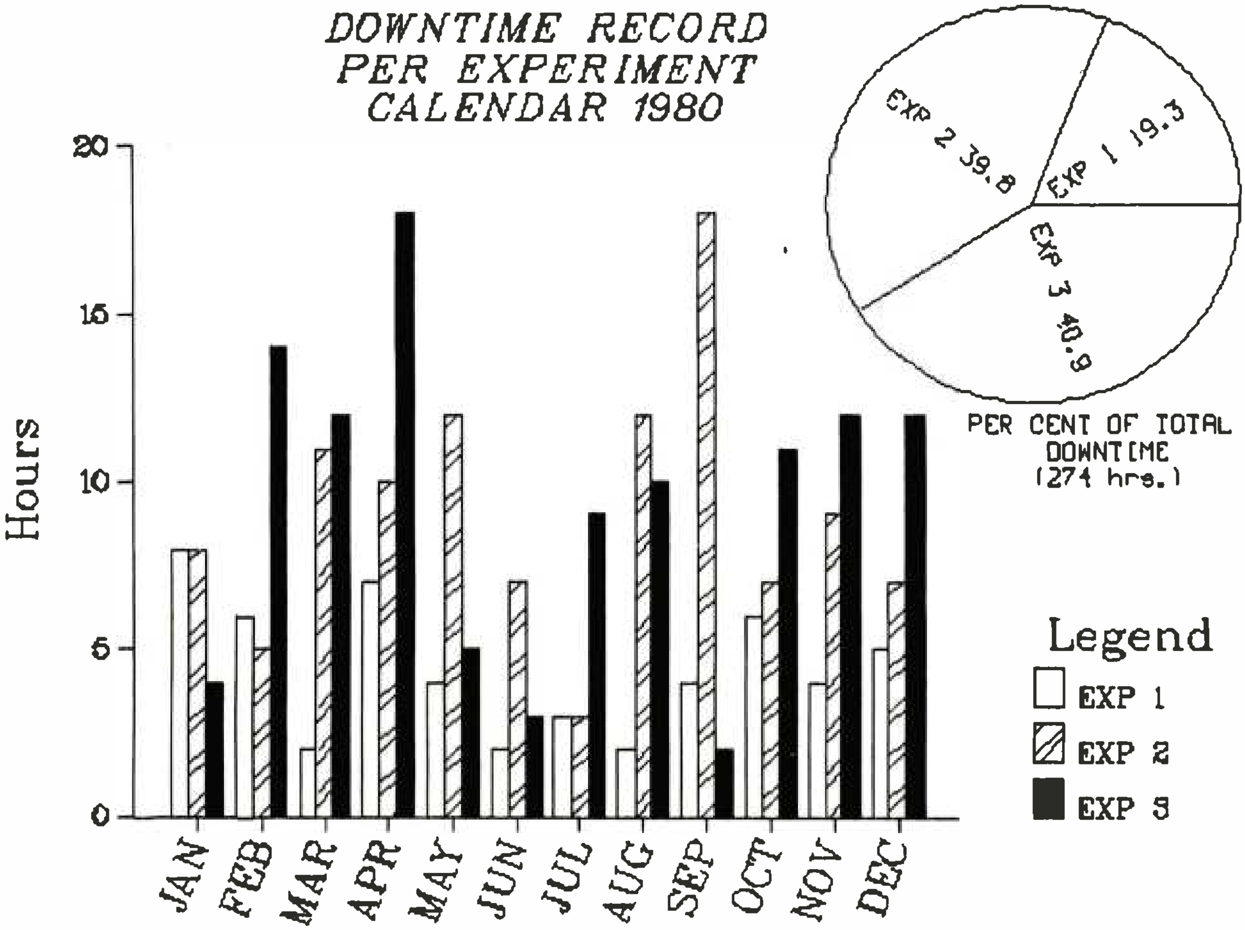

Listing 1: *Hard-copy representation of photo 2b. This listing was produced by GGEN on Florida Data Corporation's model BNY high-resolution dot-matrix printer. GGEN must be installed in a CP/M-compatible operating system environment. CDL's latest release of GGEN lets you merge your own custom hard-copy software with the GGEN code. Thus hard copies may be generated on a wide range of peripheral devices, including multicolor plotters. GGEN responds to a Make Copy command in the PLOT-10 language transmitted by a remote computer.*

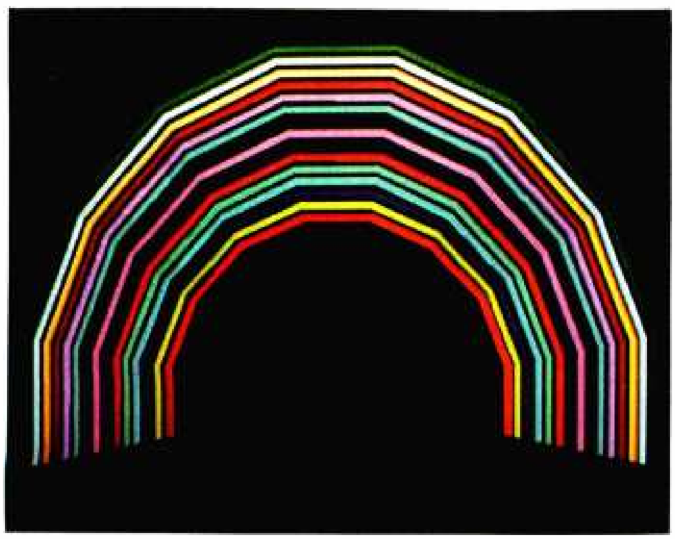

Photo 4: *This display was produced by a CDL model HR-4C color interface. The six-board HR-4C allows the programmer to select 16 colors for use at a given time from a 4096-color "spectrum." GGEN menu selections include color options. (Photo provided by Cambridge Development Laboratory.)*

printer. Photo 4, produced by CDL, shows a display generated by the HR-4C color interface.

Conclusions

CDL's HR series of S-100 graphics boards is designed to expand in concert with your requirements. The graphics boards are thoroughly documented, although the manual could be improved by including a few more programming examples to highlight the commands for controlling the interface. The light pen, optionally available with the HR-X, is somewhat insensitive. Video monitors must be adjusted for maximum brightness to compensate for the problem.

GGEN automatically scales PLOT-10 command sequences to fit the HR-X video-display format, a feature that the user can disable. A routine, which is included, can produce hard copies of any video display on a graphics printer.

Finally, GGEN has been marketed for a while; consequently, the few errors in the first version have already been fixed. GGEN's overall performance is highly satisfactory, and the software is easy to use. Note, though, that GGEN requires a Z80 microprocessor for execution. ■

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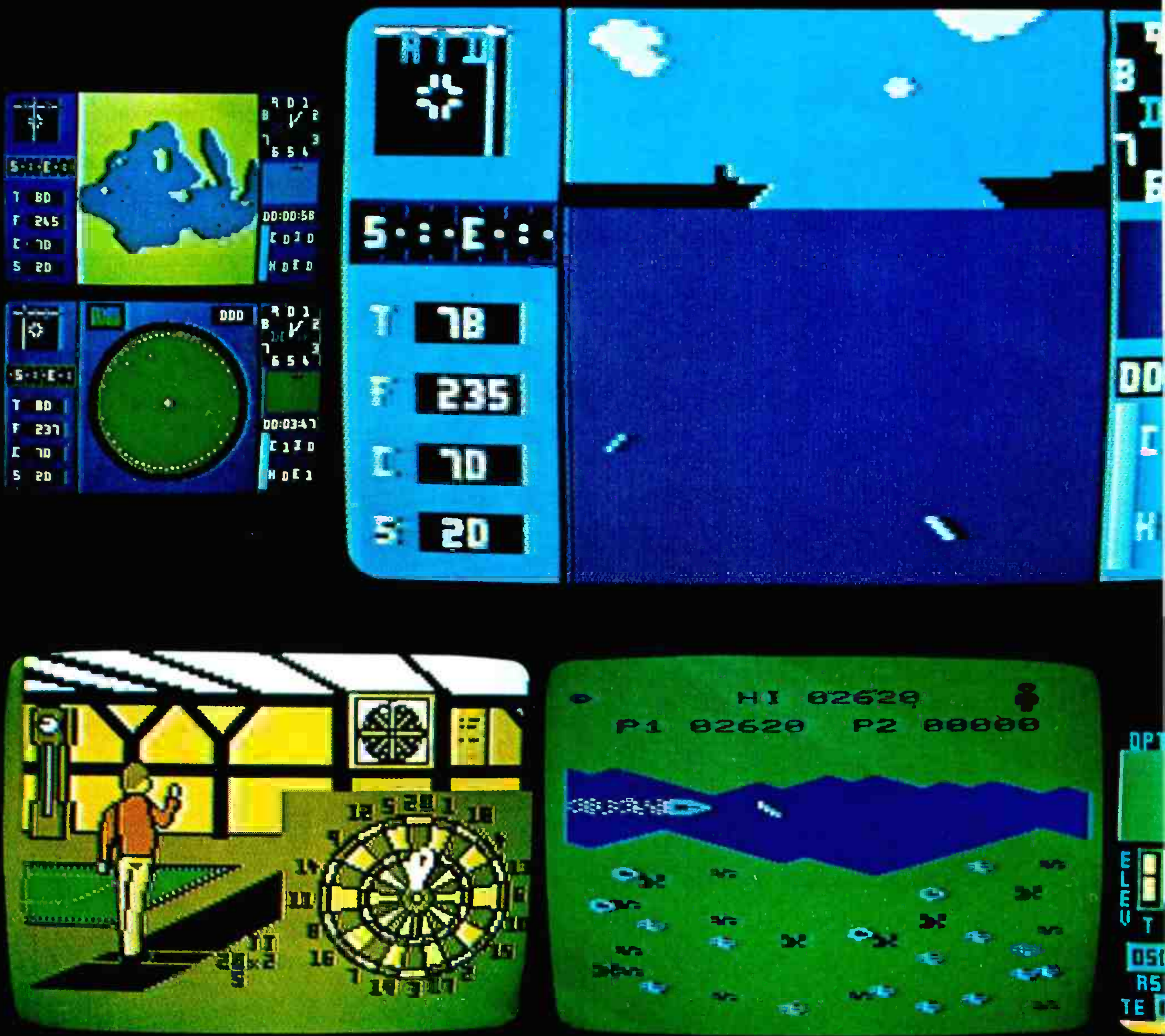

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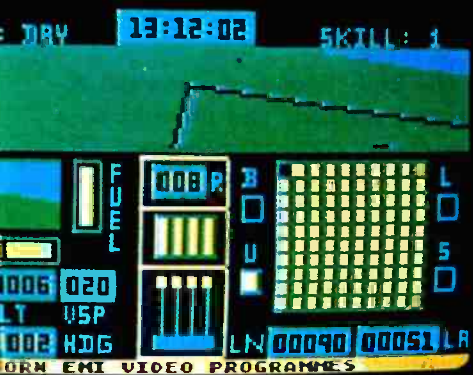

With 21 exciting games to choose from, THORN EMI offers a game for every member of the family. There are super realistic simulator games, like Submarine Commander and Jumbo Jet Pilot, sports games with lots of fast action, nursery rhyme puzzles, even a financial management game. All have different levels of challenge, so you can make them as challenging as you want, and they can be played on the Atari® 400 and 800 and the VIC® 20. Whatever your favorite pastime–playing pool or darts, soccer or driving a power boat, composing music or doing the Cube, THORN EMI has a game just for you.

THORN EMI VIDEO

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Executive Briefing System
A Color Graphics Development System for the Apple II

Peter Callamaras
AFIT/LS
Wright-Patterson AFB, OH 45433

It takes a lot of time and effort—not to mention visual material—to plan, rehearse, and prepare an effective slide presentation. Ordinarily, you jot down your ideas, gather supporting material, and have the company graphics department produce graphs, charts, and other visual aids to support your presentation. Depending on the material, you use bar and pie charts, progress charts, time-line charts, exams, or anything you can think of to get a message across. Most of the time you wind up with a flip chart and velum transparencies of graphs for a projector.

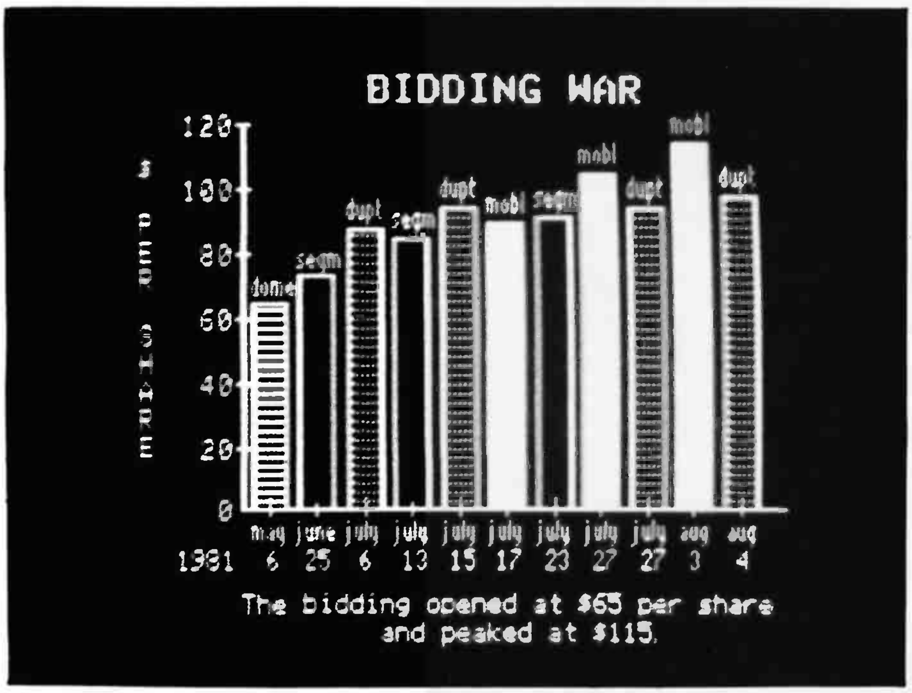

Photo 1: *This sample slide included with the Executive Briefing System charts the bidding war between Du Pont and Seagram for a controlling interest in the Continental Oil Company (Conoco). You can modify it and other slides as you learn to use the system.*

The Executive Briefing System (EBS), a computerized version of these old-fashioned methods, is a faster, more flexible, and more professional alternative. Mitch Kapor and the wizards at Lotus Development Corporation have pulled off a great feat with this slick program. For $199, you can prepare the greatest presentations of your career in short order. The EBS lets you make your own graphics presentations with an Apple II computer, a color or black-and-white monitor, and a printer. And that's not all—the system is even easy to use.

The EBS consists of a manual explaining methods and procedures, a master disk containing the basic EBS program as well as its attendant editor and utility programs, and a sample slide-type show disk called *The Great Conoco Auction*, which depicts the acquisition of the Continental Oil Company (Conoco) by Du Pont (see photo 1).

Your adventure in graphics begins with a sample slide show on the Auction disk. Once you have a feel for what the EBS can do, you take the Conoco show and modify it, using

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Figure 1: *A printout of fonts (lettering styles) from an Epson MX-100, using the Executive Briefing System. Three other disks containing different font sets are available.*

the editor on the master disk. When you have finished, you will have assembled your own slide show by changing existing slides and preparing your own. The EBS gives you the tools to prepare your own graphics, then lets you use those tools to fit your specific needs. Making your own displays is exciting when you realize how tailored they are to your needs. Instead of handing your materials over to an outside department, you can prepare attractive supporting graphics on your own.

Producing Graphics

To create your own presentation you use the initialization module on the main program and initialize a blank disk. You then have the option of creating your own graphics or "slides" from scratch or starting with an existing high-resolution picture from another disk. To prepare your own slide, you can use the editor function to draw borders by using the draw module. Two methods of drawing are available to you: one is based on the particular size of font you have loaded, and the other uses a microcursor, a one-dot pixel that draws fine lines. You can draw elaborate or plain borders as you wish. Once you've placed a border or other rules inside the slide, you add your text by simply typing in whatever you wish. You may include several different styles of lettering (see figure 1) as well; you can change fonts at any time. You can choose any combination of normal or inverse text with color or black-and-white letters.

The other method of creating graphics involves transferring an existing slide onto your disk and then modifying it as you wish. You can use the draw function to modify the visual effects, change, add, or delete text. This is a real advantage if you have to use the same slides for different groups—all you need to do is change titles or other identifying data to tailor the slides to each particular group. That may be sneaky, but it's effective and saves time as well.

One of the most valuable aspects of EBS is the way it interfaces with other business programs like the Visicorp series. You can use the charts from Visiplot and incorporate the slides directly or modify them to suit your needs. Because many of us already collect our data on some sort of a

At a Glance

Name
Executive Briefing System

Type
Graphics presentation system

Manufacturer
Lotus Development Corporation
180 Franklin St.
Cambridge, MA 02139
(617) 492-7100

Price
$199

Author
Mitchell Kapor

Language
6502 machine language and modified Applesoft BASIC

Format
Two 5¼-inch floppy disks. Three other optional color font disks are available

Computer
Apple II or II Plus with 48K bytes of memory, one or two floppy-disk drives, and DOS 3.3

Documentation
Extensive three-part manual and one sample slide show

Audience
Professionals or others who need to present visual information to groups

"Visi" program, most of the difficult work is already done by the time we want to show it to someone. Of course, as I mentioned earlier, any high-resolution screen you can save on the Apple can serve as a source for slides; in other words, you can use a graphics tablet, a digitizer, or both as an input device.

The entire process of creating a slide from scratch took me roughly 40 minutes the first time and less as I became more familiar with the program. After an evening with the program, I found myself turning out slides from scratch in less then 10 minutes!

After all your slides are on the disk, you add the effects you want for the actual show. You can fade from one slide to another, make a spiral unwrap, move a curtain up or down, or make the display dissolve. You can use one specific effect or any combination of them. You can control the time between slides when you select the automatic slide show. Naturally, you have manual control over the show and can move forward or backward or halt as you desire. If you want to control the show manually, you can use either the Apple keyboard or a game paddle. The game paddle enables you to walk around during a presentation if you like. No other accessories are necessary.

Hard Copy

Once you've finished your slide show and you've saved it to the disk with the desired control and effect commands, you're done, right? Well, almost. Usually, the group wants a hard copy of the presentation for future reference. Once again, this poses no problem. The EBS has a set of printer drivers built in to accommodate most of the popular printers capable of reproducing the Apple graphics. You can also get color hard copy if you have an Integral Data Systems Prism Printer. You might want to keep your own hard copy as a reference library of slides, grouped by application, as well. The EBS is a real time-saver: you only need to spend time putting together a sophisticated slide show once. You can then reuse slides as the need arises and mix and match your set of stock slides.

For best results, you'll want to use a color display for your presentations. I have viewed various slide shows on ordinary color TVs, color monitors, and the newer RGB (red-green-blue) color monitors, and all are fine for the job. If I had a preference it would be to use the EBS with one of the wide-screen color sets (imagine a slide 7 feet wide!). You can modify both the size of the screen and the content of the presentation on the basis of the size of your audience and the material you are presenting.

Documentation

The EBS manual is somewhat different from the ones I'm used to. Basically, the first section is a tutorial containing several lessons. It starts with how to turn on the Apple Computer and finishes with how to polish your slide show. All of this is covered in the first 90-plus pages. It's important to pay attention to where information is located, because the tutorial is building-block style; you must go through A, B, and C before you can go to D. Making notes as you go will help, especially when you're first learning to use the program.

The next 50-odd pages contain a reference section that covers various aspects of the EBS and its use. The dictionary includes all the commands you will be using. The last section contains the appendixes. Appendix C is a quick reference guide to the control keys.

The only drawback to the manual is that it lacks a standard index. Whenever I ran into a moment of forgetfulness, I had to ferret out the information I needed. The table of contents will have to suffice, so look there first. Using a colored pen to mark key pages can be a real time saver.

The philosophy ostensibly behind the EBS manual is interesting. It gives you the information to do a job, takes you through a short apprenticeship, and finally sends you off on your own. For a change, you decide the best form for your application, an idea I find refreshing. If your job requires you to pass information on to a group of people, then you already know enough to use EBS to make your efforts pay the biggest dividends.

I spent several evenings just playing around drawing my own slides and modifying other existing Apple high-resolution graphics files, and I had a great time. The fact that you can have fun while using EBS makes it even more valuable. You don't have to fight to get the job done.

Conclusion

The Executive Briefing System is an outstanding new program for Apple computer users who need to present information to a group in the most ef-

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FIRST IN SOFTWARE TECHNOLOGY P.O.Box 1628 Champaign, IL 61820 (217) 359-2112 Telex 270365 fective manner. It can be used as a visual aid or on its own.

The program lets you prepare slides from scratch or modify existing slides, which can come from a variety of sources. You may transfer slides from disk to disk as you like.

You can load an automatic set of operation files that will run the slide presentation automatically—without operator intervention—or manually, by using the Apple keyboard or game paddle. In addition, you can manually override the automatic slide show.

Several sets of fonts give you great latitude in tailoring the emphasis of your slide show. A choice of color or black-and-white slides adds another element of variety. A set of decorative fonts is available for special applications.

The hardware you need is minimal: an Apple computer, a color or black-and-white display, and one disk drive. You can also use several drives and disks to chain together a long slide show using a multidisk option. Because the first slide follows the last and will run until it's interrupted, the show can be set to run in an "endless" loop configuration.

The EBS documentation is tutorial in nature; it begins with turning on the computer and then leads you into the entire range of options available. The table of contents serves as the index for locating specific information.

One of the program's advantages is that it can interact with a large variety of existing programs like the Visicorp series. You will immediately notice menu prompts in the same style as those Mitch Kapor developed for the Visi-family of programs.

The EBS program belongs in your library of Apple programs. Children can use it for their own schoolwork to produce reports and presentations. Businesses, too, shouldn't be without the EBS. It has tremendous potential for improving sales, productivity, and the transmission of information.

Other uses for the EBS are practically limitless; I find a new one every time I sit down with it. I suspect the Executive Briefing System will soon be to graphic presentations what Visicalc has been to numerical manipulation on microcomputers. ■

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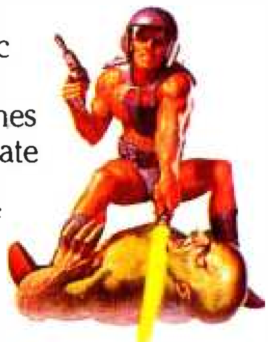

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Michael Keryan
713 Locust Dr.
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Using a personal computer to capture and store a television image is not as difficult as you might think. In this article, I will describe a $50 interface that will allow you to connect your TV receiver to your computer and digitize any video signal—whether from a broadcast, cable, video-cassette recorder, videodisc player, or even the video image from another computer. Any medium-resolution picture can be digitized and reproduced with three intensity levels, and the process takes about half a second.

In a nutshell, the interface lets the TV receiver separate the video information from the rest of an RF (radio-frequency) signal. By providing special timing information, the interface allows the computer to sample the video signal at regular intervals. The interface decides which of the three intensity levels the sampled pixel (picture element) represents, and the information is passed on to the computer for storage. Thus, anything that can be put on the TV screen can be transferred to a computer for processing.

Some Facts

The typical low-cost personal computer of today has about 6K bytes of bit-mapped graphics memory. In the highest-resolution mode, this gives a density of somewhat less than 300 pixels horizontally and 200 pixels vertically—each with two possible intensity levels: black or white (see photo 1).

The digitizer provides good resolution but allows only three intensity levels: black, gray, and white.

Independent gray levels for each pixel are not possible with this limited amount of memory; in fact, the graphics-display circuits of most personal computers have no provision for gray levels. Gray levels can be simulated, however, by intermixing black and white pixels in a region. While a large number of gray levels can be simulated by varying the black-to-white ratio (see photo 2), too many levels sacrifice resolution. For this reason, the digitizer presented here will provide resolution at least as good as the average personal computer, but will allow only three intensity levels: black, gray, and white.

It would seem appropriate to transfer one full video frame of data to the computer just as it appears, in 1/60 second; to achieve a horizontal resolution of 256 pixels, however, we would have to transfer 32 bytes in the time it takes to display one video line: 64 microseconds (μs). This high data-transfer rate is not possible with common microprocessors without resorting to DMA (direct memory access). Fortunately, successive video frames are usually very much alike. Therefore, the refresh rate need only be fast enough to transfer data before

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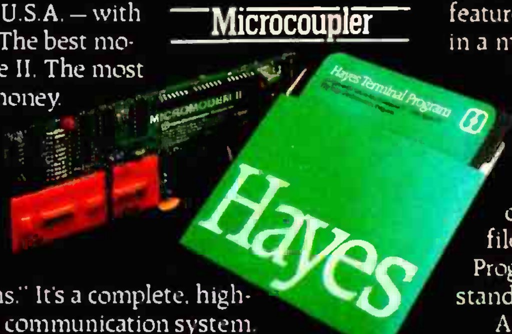

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Photo 1: *A series of images captured from a broadcast using only black and white levels.*

the picture changes drastically. For most broadcast material, a half second would do nicely.

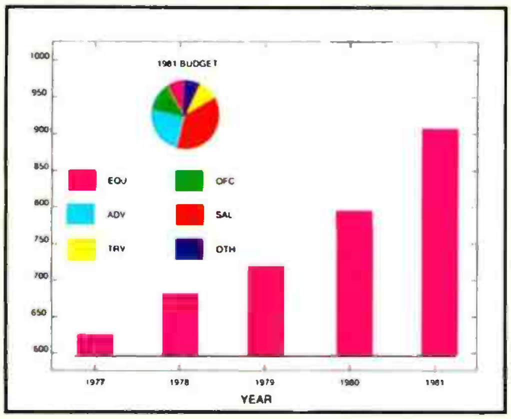
The Circuit

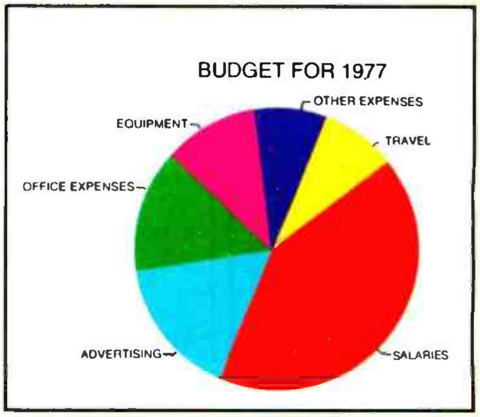
The interface connects between a normal TV receiver and a computer. The computer sends a vertical and horizontal address to the interface, and when the video information at that location is broadcast, the interface captures the next eight pixels. To capture a complete picture, the computer next requests the eight pixels in the same horizontal position, but on the line just below. Thus, it takes 1/60 second to digitize an eight-pixel-wide column the height of the screen. When this is done, another column next to the first is digitized, and so on until the whole frame is finished—for a 256-pixel-wide screen, this takes 32/60 second.

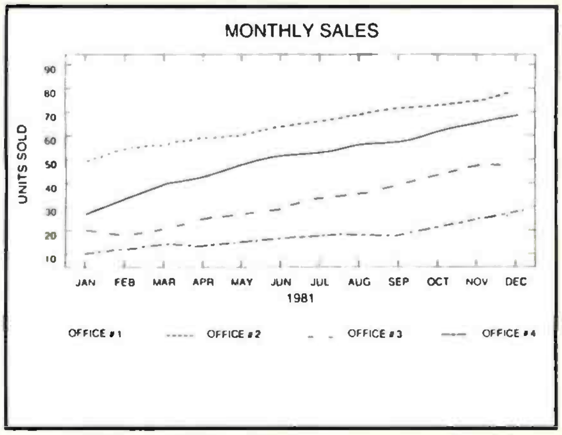
As shown in figure 1, the device can be thought of in two parts: one containing the analog circuitry, the other the digital circuitry. It is connected to the TV receiver to obtain horizontal and vertical synchronization, as well as the video data.

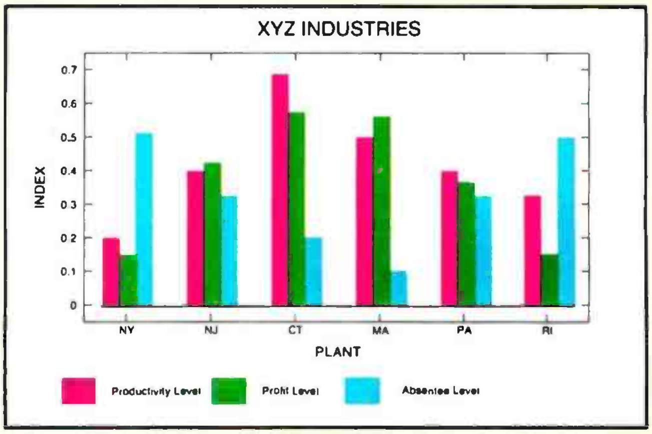
In the analog portion of the circuit, the horizontal-synchronization signal is passed through an RC (resistor/capacitor) network to trigger a pulse on the rising waveform. The horizontal-synchronization signal is buffered and inverted by a section of IC1, a CMOS (complementary metal-oxide semiconductor)-to-TTL (transistor-transistor logic)-level converter. The falling portion of the vertical-synchronization signal is likewise buffered and inverted by another section of IC1.

The composite video signal is added to a bias voltage that is adjusted by a 5-kilohm (kΩ) potentiometer, which sets the brightness or white level. This signal is amplified by IC2 and "squared" by two sections of IC1. Two LEDs (light-emitting diodes) are









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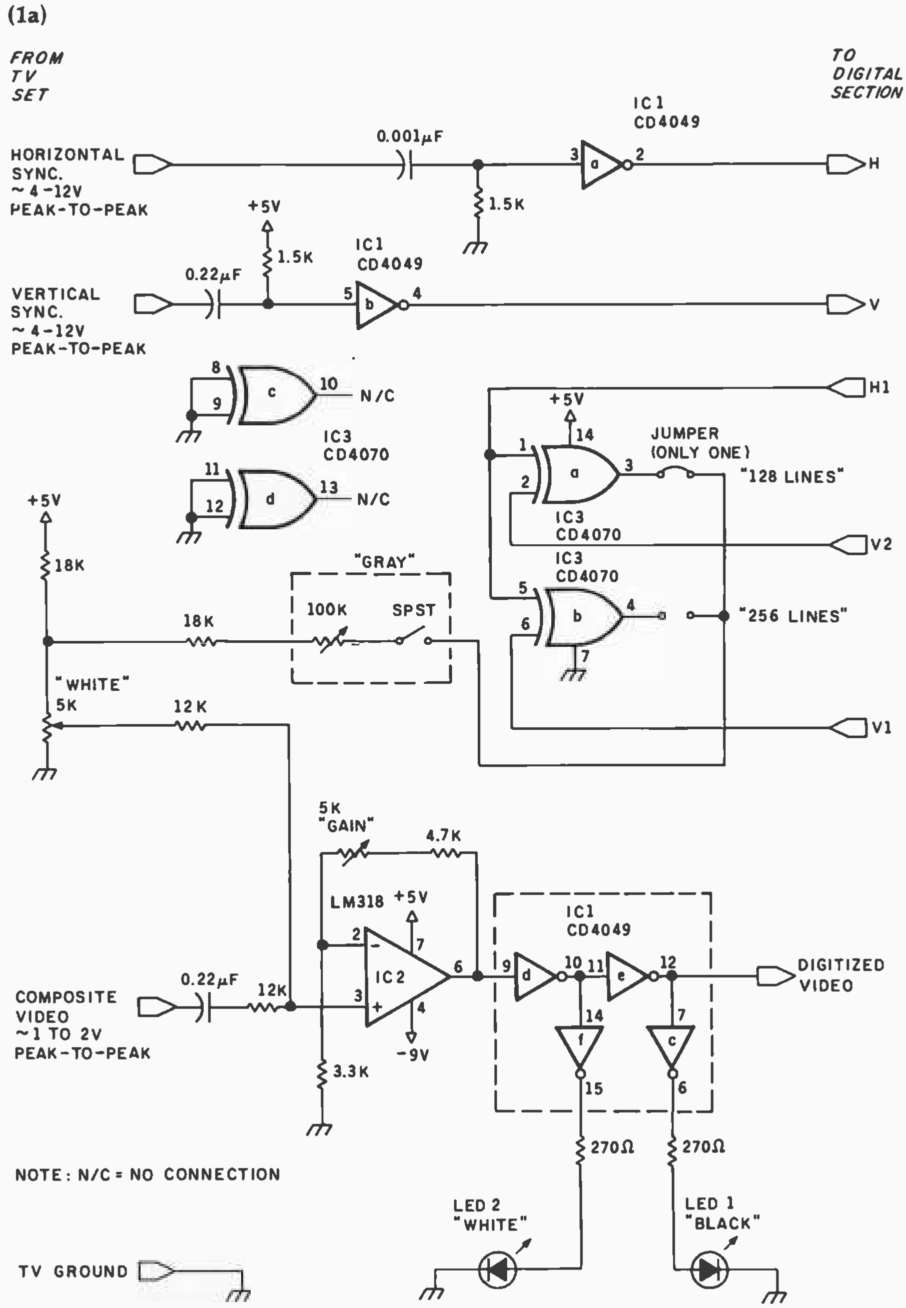
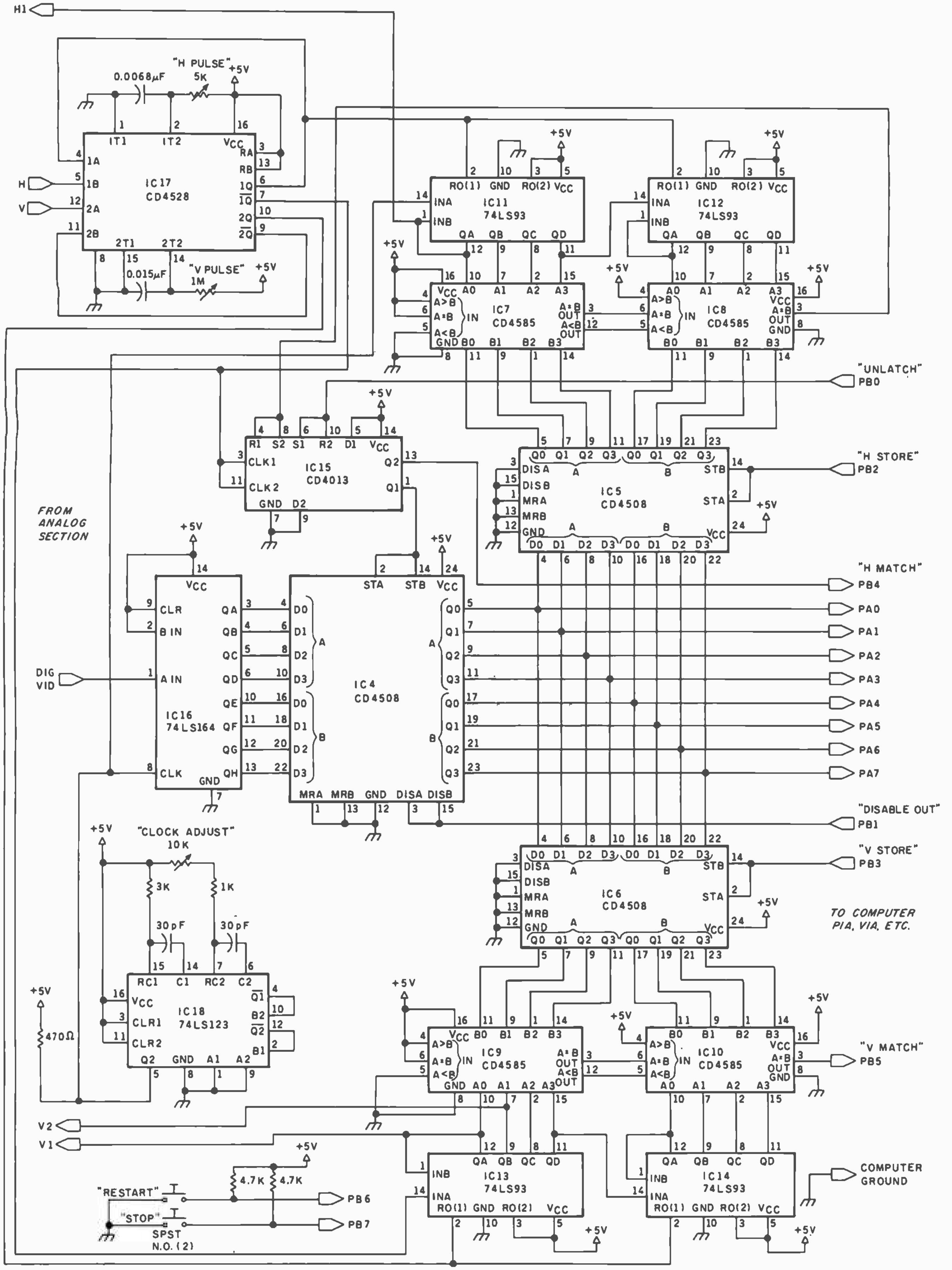


Figure 1: *Schematic diagram of the video digitizer. The analog section of the interface (shown in figure 1a) converts signals from a normal television receiver into timing and data signals to be used by the computer. Figure 1b shows the interface's digital section.*

driven by inverter sections of IC1 to provide a visual indication that a signal is present. One of these will light when the digitized video is at the white level; the other one will light at the black level. (When the brightness of these LEDs is about equal, the digitized picture consists of approximately equal levels of black and white.)

Gray level has been made possible by IC3, an exclusive-OR gate. The inputs of this gate are chosen to give an alternating pattern of 1s and 0s to generate a fine checkerboard grid across and down the screen. This grid, when viewed at a distance, appears gray (relative to an all-white or all-black area). The voltage level of the checkerboard signal is reduced by a 100-kΩ potentiometer. This signal is also added to the composite video signal. Therefore, three visually distinct intensity levels are generated, depending on the voltage level of the composite video signal, as illustrated in figure 2. A switch mounted on the rear of the 100-kΩ potentiometer can

(1b)



H1
"H PULSE"
0.0068µF
5K
+5V
IC17
CD4528
H
V
"V PULSE"
0.015µF
1M
IC11
74LS93
IC12
74LS93
IC7
CD4585
IC8
CD4585
"UNLATCH"
PB0
IC15
CD4013
IC5
CD4508
"H STORE"
PB2
FROM
ANALOG
SECTION
"H MATCH"
PB4
PA0
PA1
PA2
PA3
PA4
PA5
PA6
PA7
DIG
VID
IC16
74LS164
IC4
CD4508
"DISABLE OUT"
PB1
"CLOCK ADJUST"
10K
3K
1K
30pF
30pF
IC6
CD4508
"V STORE"
PB3
TO COMPUTER
PIA, VIA, ETC.
IC18
74LS123
470Ω
IC9
CD4585
IC10
CD4585
"V MATCH"
PB5
V2
V1
IC13
74LS93
IC14
74LS93
COMPUTER
GROUND
4.7K
4.7K
"RESTART"
"STOP"
PB6
PB7
SPST
N.O. (2)

Photo 2: *This series of photos was captured from a broadcast using gray-level simulation.*

be used to eliminate the gray levels for high contrast.

Figure 1b shows the digital portion of the interface circuit. IC17, a dual monostable multivibrator, generates horizontal-synchronization and vertical-synchronization pulses, which are used by the rest of the circuit (see figure 3); the pulse widths are adjusted by the 5-kΩ and 1-megohm (MΩ) trimmers. IC18 is wired as an astable multivibrator; the 10-kΩ trimmer adjusts it to clock frequencies between about 2 MHz and 5 MHz. This allows you to set the pixel-display rate for the desired horizontal resolution.

The clock is divided by IC11 and IC12 (they are wired as an 8-bit binary counter whose outputs count from 0 to 255). If the horizontal resolution is greater than 256 pixels, the counters will recycle through 0 to 255 a second time; the software used must take this into account. These counters are reset to 0 by the horizontal-synchronization pulse, so

The zero horizontal position starts at the same point on each line.

that the zero horizontal position always starts at the same point on each line.

A serial-in, parallel-out shift register (IC16) steps the digitized video signal bit by bit from the first output to the eighth output after eight clock steps from IC18. This allows 8 sequential bits of video-input data to appear simultaneously as 1 byte of output data. As shown in the schematic, the leftmost of the eight dots corresponds to the highest bit of the byte.

IC13 and IC14 form an 8-bit counter whose output corresponds to the vertical position. The count of 0 is the first horizontal line (top of the screen), while 255 is near the bottom. This binary counter is clocked by the horizontal-synchronization pulses and reset to 0 by the vertical-synchronization pulse.

ICs 4, 5, and 6 are 8-bit three-state latches that are wired together as a bus comprising three registers. The eight common lines may be connected to an 8-bit bidirectional I/O (input/output) port on a computer (such as one port of a peripheral interface adapter; its other port may be used

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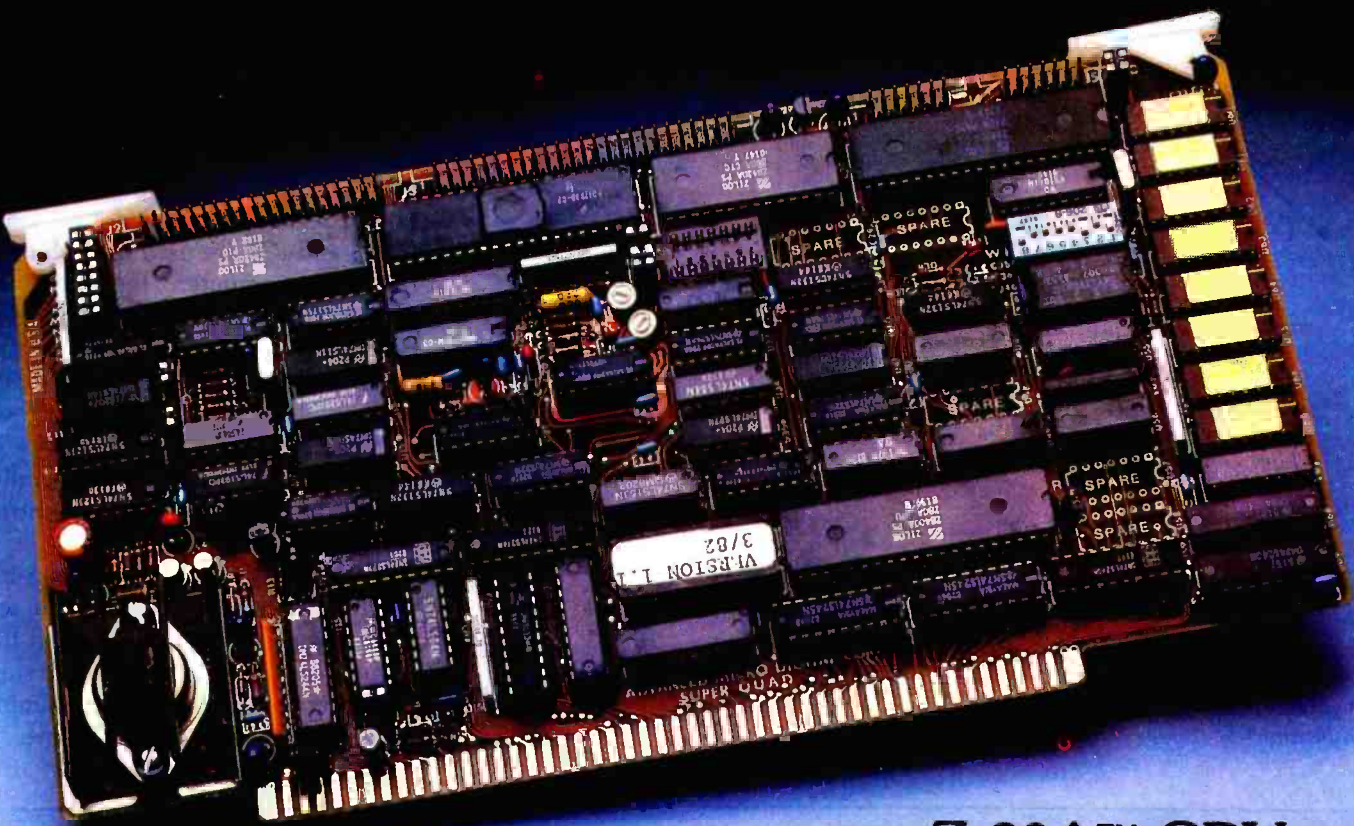

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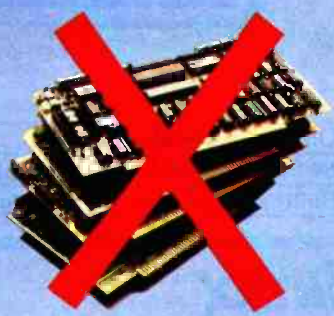

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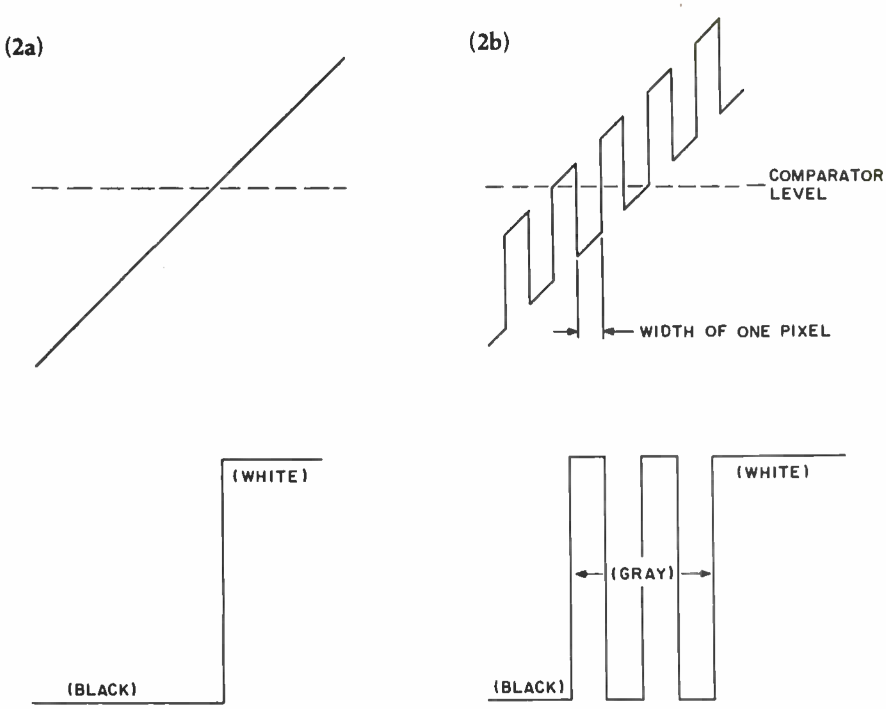

Figure 2: *Effect of a digital comparator on analog signals. Figure 2a shows a simple analog "ramp" and how the comparator interprets it as a black-to-white transition. In figure 2b, an analog signal with "dot modulation" becomes a black-to-gray-to-white transition.*

for control, with bits 0 through 3 being outputs to the interface circuit and bits 4 through 7 being inputs to the computer). Control bit 1 is used to enable or disable the output from IC4. When bit 1 is brought low, the 8 bits of data latched from the shift register appear on the bus to be read by the computer. When the computer sets bit 1 of the control port high, this output register is disabled.

IC5 and IC6 are used to latch data from the computer: the computer produces a count for the horizontal position. A high-to-low transition in bit 2 of the control port causes this horizontal-count data to be latched into IC5, while a similar sequence is used to load vertical-count data into IC6 by bringing bit 3 of the control port low, momentarily.

IC9 and IC10 are wired as an 8-bit magnitude comparator, used to tell the computer when the TV is on the correct scan line. For example, suppose the computer wants to sample data on the sixteenth scan line. It

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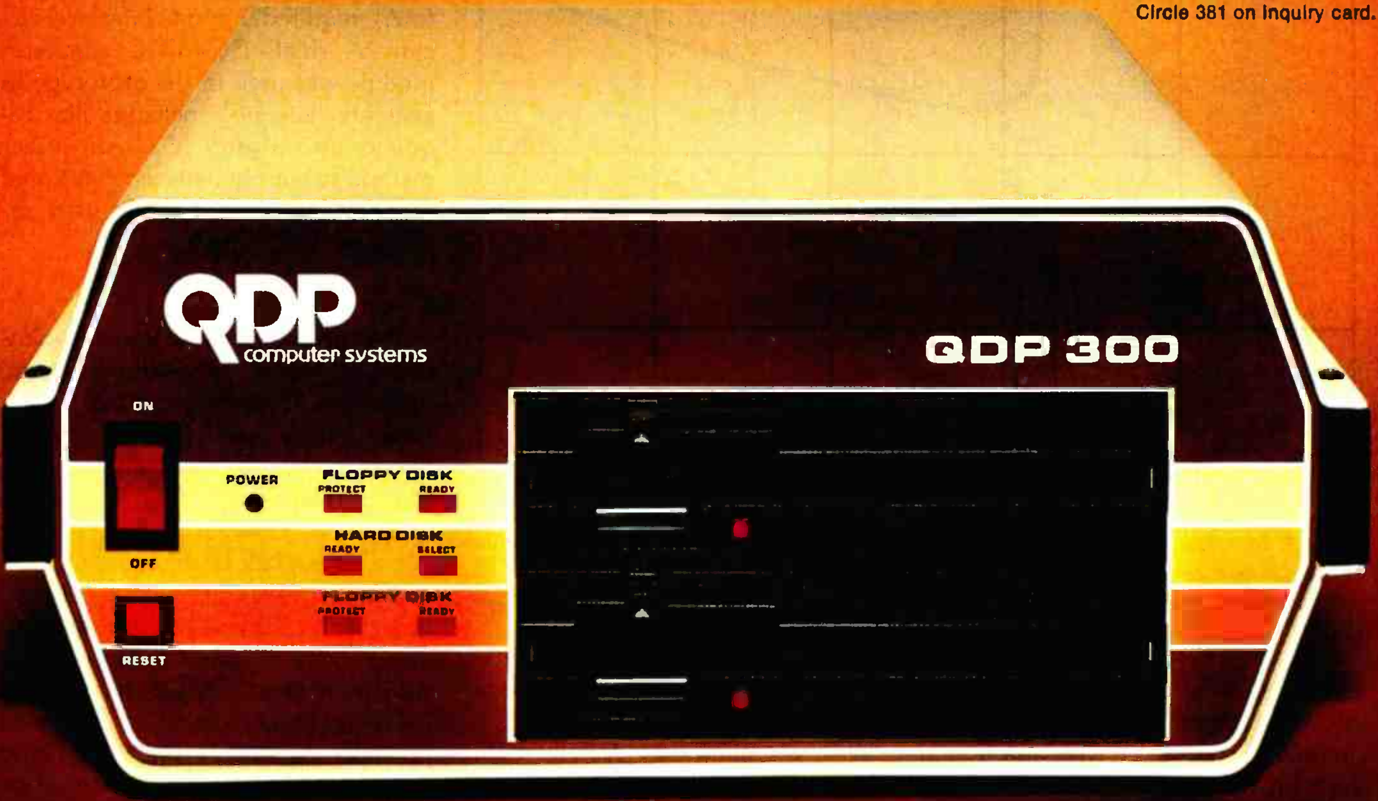

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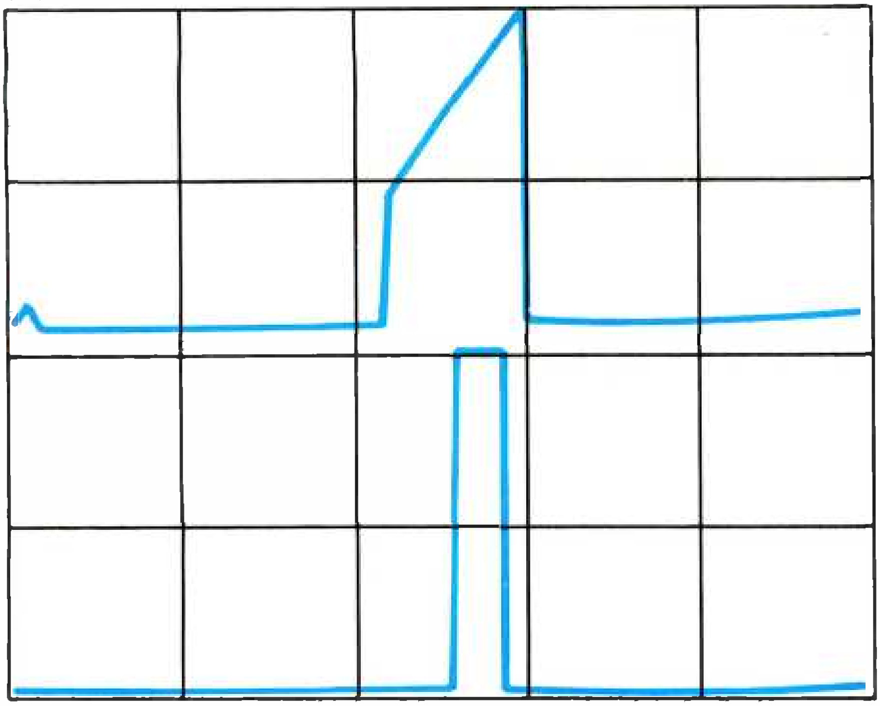
(3a)



(3b)

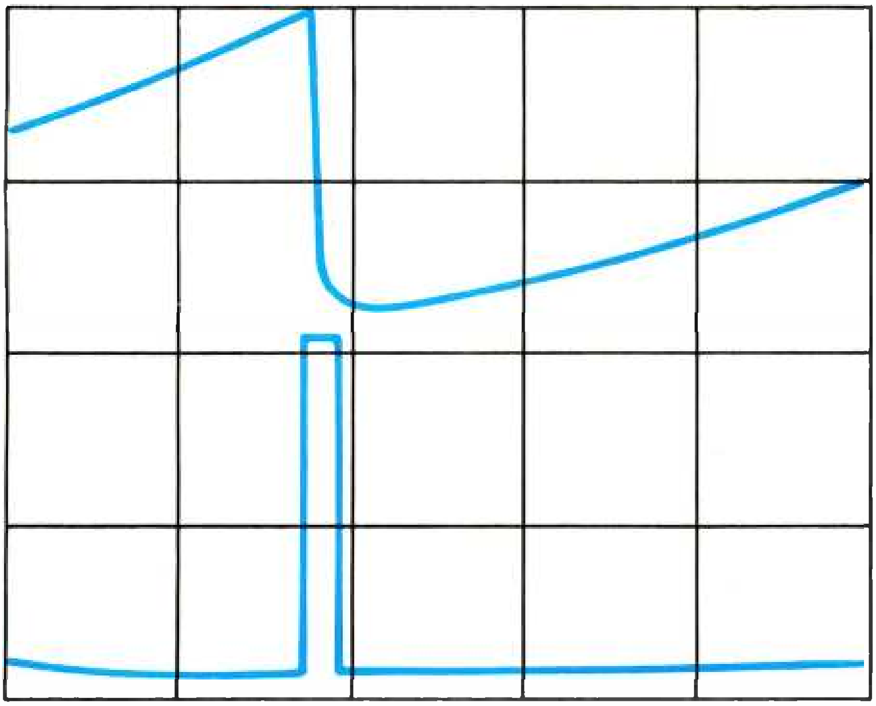


Figure 3: *Important timing signals. In figure 3a, we see the horizontal-synchronization signal (upper trace) and the resulting pulse from pin 6 of IC17; in figure 3b, we see the vertical-synchronization signal (upper trace) and the resulting pulse from pin 10 of IC17.*

loads a count of 15 (binary 00001111) into IC6. When IC13 and IC14 have counted to 00001111, the output of the 8-bit comparator goes high. This signal is monitored by the computer by reading the control port and waiting for a high level on bit 5. IC7 and IC8 do exactly the same as IC9 and IC10, except the current *horizontal* position is compared to the count loaded into IC5.

With the circuit as described this far, the computer can load prescribed counts into the horizontal and vertical registers, wait for the coincidence of the counters and the loaded values, and then read the register containing 8 consecutive digitized bits of video data. Because the horizontal-coincidence pulse is only about 2 μs wide, both the horizontal-coincidence signal and the video data are latched to allow the computer more time to read them.

When the horizontal count is equal to the preset horizontal position, pin 3 of IC8 goes high, causing the flip-flop's output (pin 13) to also go high; this is connected to bit 4 of the control port. It will remain unchanged until either the computer unlatches it (by generating a high level on bit 0 of the control port), or a new horizontal line comes along (which clocks the flip-flop). These same signals cause the video data from the shift register to be latched and unlatched in IC4.

The two switches marked Stop and Restart are connected directly to control-port bits 7 and 6. These switches allow human communication to the computer through the interface circuit.

The power supply is shown in figure 4. The +5-volt (V) portion is fairly straightforward and generates approximately 200 milliamperes (mA) required by the interface circuit. A small DC-to-DC converter module was used in the prototype to generate the −9-V negative bias required by op amp IC2. Any other method to supply between −6 V and −9 V at low current can be used, including a 9-V battery.

Construction

The prototype was wired "point-to-point" using wire-wrapping and prototype boards available from Radio Shack (see photo 3). It was placed in a Global Specialties Benchtopper case. The prototype used two SCL4404 CMOS 8-bit binary counters in place of the four 74LS93s. The 4404s are difficult to obtain, however, and also limit the pixel-display rate to about 5 MHz. Don't substitute other CMOS ICs for the 74LS93s because most of them will typically operate to only 2 MHz at 5-V operation. The LM318 could be replaced by an LF357 or similar high-speed op amp; however, don't use a 741 type—its low speed will give poor resolution.

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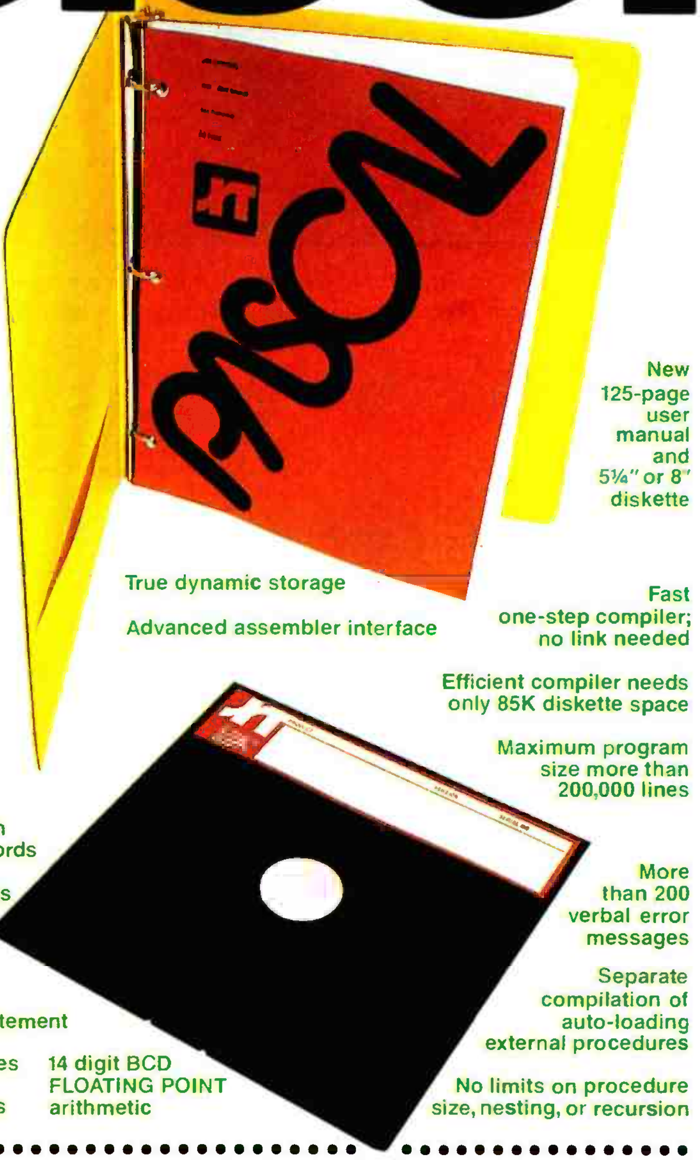

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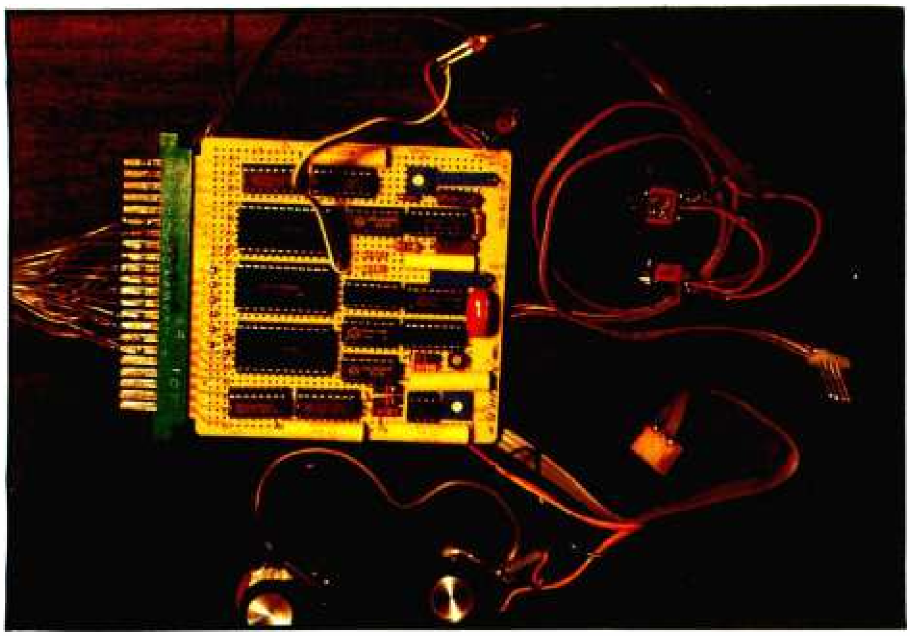

Photo 3: *The author's prototype, which was wire-wrapped on a Radio Shack circuit board with a 44-pin edge connector; the power supply is on a separate board.*

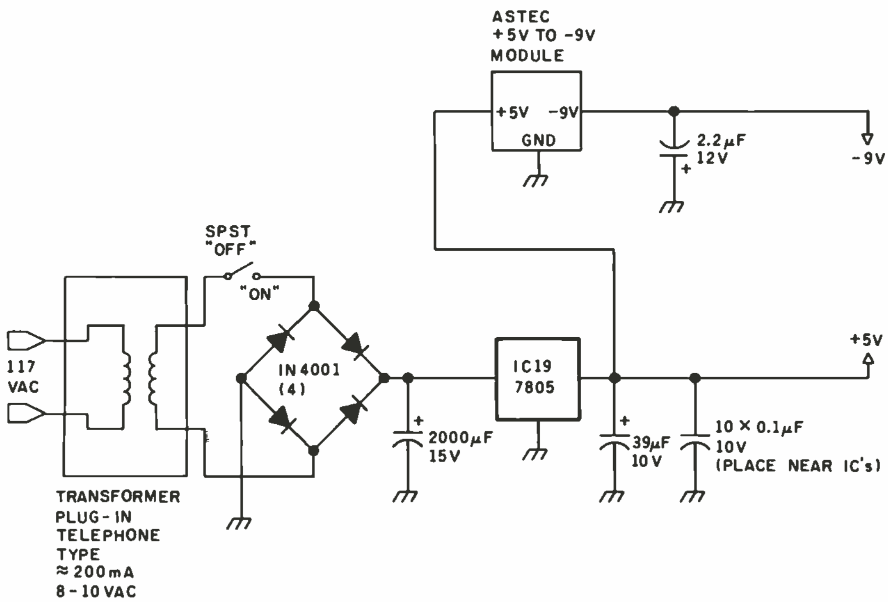

Figure 4: *Simple power supply for the video digitizer. This circuit is capable of supplying +5 V at 250 mA and −9 V at less than 25 mA.*

nect the interface to the TV and the computer. Limit cable lengths to 3 feet to avoid noise. A jack (such as a DIN-type connector) should be installed on the TV set's back panel to allow easy interconnection. Do not attempt to use a TV with a hot (ungrounded) chassis unless you plan on frying your computer and possibly yourself; use a TV that is transformer isolated.

Obtain a schematic of the TV and tap off the horizontal- and vertical-synchronization signals at the points that their amplitude is between 4 V and 12 V peak-to-peak. The composite video signal should be between 1 V to 2 V peak-to-peak, with negative-going synchronization. Try to use signals of low impedance, i.e., tap them off at the outputs of transistor stages, rather than at the inputs. Signals of opposite polarity from that used in the prototype are usable, but the circuit will require minor changes. Figure 5 shows a typical transistorized portable TV and the tap-off points used.

Using the Circuit

An oscilloscope is extremely useful when setting up and testing the circuit. Adjust the clock speed to give the approximate desired horizontal pulse count in the active scan area. The horizontal and vertical pulse widths are adjusted so that the pulses end when the active scan area starts (top and left side of the screen). The gain of the op amp and the white- and gray-level potentiometers are adjusted by monitoring the two LEDs.

A machine-language routine is required to sample the data, format it to graphic mode, and store it. Listing 1 can be used as a starting point for those of you with a 6502-based computer that uses a VIA (versatile interface adapter). For other systems, a program with the same logical sequence can be used.

The VIDEO routine is called to activate the interface. By pressing the Stop button, the scanning will stop and a picture will freeze on the computer monitor; Restart will resume the scan. Pressing both buttons together will stop the scan, save the currently displayed picture, and exit to the calling program. User-supplied routines are required for graphic screen clear, alpha- and graphic-mode configuration, and screen save.

The graphic resolution of the computer used with the prototype was 256 horizontal by 128 vertical; therefore, only *every other* scan line is sampled. All photos shown are at this resolution. From listing 1, the time required to loop through the program is about 70 μs, using a 1-MHz processor clock signal. If more than 128 vertical lines were desired, this loop time would have to be reduced to less than 64 μs, either by use of a more efficient program or a faster processor clock.

When starting out, use only the central portion of the screen and revise the parameters to make it wider and taller. These parameters

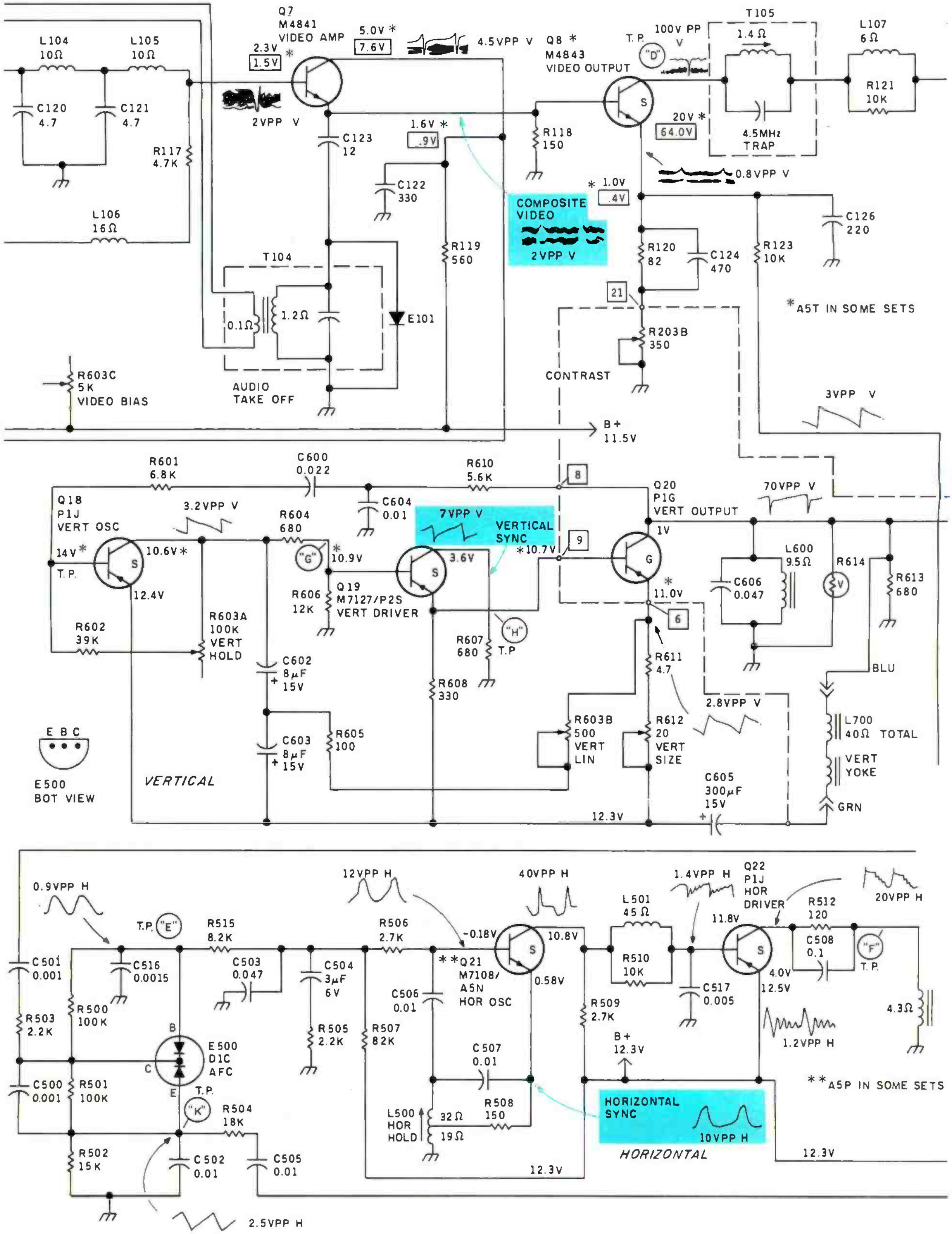

Figure 5: *The three connections made to a typical TV receiver. The horizontal, vertical, and video data may be brought to a connector on the back of the set. Since no circuit modifications need be made, the set can be used for normal viewing at any time.*

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Listing 1: *A sample digitizer-control program written in machine language for the 6502 microprocessor. Machine language is employed because of the high data rates involved; most high-level languages would be too slow. This program assumes that the I/O port is controlled by a 6522 VIA (versatile interface adapter). Users can add their own subroutines to handle text and graphics, image processing, and functions such as clearing the screen and saving images on disk.*

```
                   ;* Video Driver Routine
                   ;*
                   ;*     by M. J. Keryan
                   ;*
                   PNTR     EQU $00F0    ;Pointer to Video Memory
                   VIADB    EQU $FA00    ;VIA B I/O
                   VIADDB   EQU $FA02    ;VIA B Data Direction
                   VIADDA   EQU $FA03    ;VIA A Data Direction
                   VIAACR   EQU $FA0B    ;VIA Aux. Control Reg.
                   VIAPCR   EQU $FA0C    ;VIA Per. Control Reg.
                   VIADA    EQU $FA0F    ;VIA A I/O
                   SETGRF   EQU $XX00    ;Graphics Set-up
                   CLRGRF   EQU $XXXX    ;Clear Graphic Screen
                   SETALF   EQU $XXYY    ;Alpha Set-up
                   SAVVID   EQU $XXZZ    ;Save Video Screen
                   ;
                            ORG $3F00

                   ;
3F00  20 00 XX     VIDEO    JSR SETGRF   ;Configure graphics
3F03  20 XX XX              JSR CLRGRF   ;Clear screen
3F06  A9 00                 LDA #$0      ;Reset
3F08  8D 0C FA              STA VIAPCR   ;   control
3F0B  8D 0B FA              STA VIAACR   ;   registers
3F0E  8D 03 FA              STA VIADDA   ;A port=input
3F11  A9 0F                 LDA #$0F     ;%00001111
3F13  8D 02 FA              STA VIADDB   ;Bits 0-3:out, 4-7:in
3F16  A9 0E                 LDA #$0E     ;%XXXX1110
3F18  8D 00 FA              STA VIADB    ;   disable output
3F1B  2C 00 FA     LOOP1    BIT VIADB    ;Is stop pressed?
3F1E  10 06                 BPL STOP     ;   yes, branch
3F20  20 80 3F     TOSCAN   JSR SCAN     ;   no, then scan
3F23  18                    CLC          ;Branch always
3F24  90 F5                 BCC LOOP1    ;   (continue)
3F26  2C 00 FA     STOP     BIT VIADB    ;Is start also pressed?
3F29  50 07                 BVC TOALPH   ;   yes, branch
3F2B  2C 00 FA     LOOP2    BIT VIADB    ;Is start pressed now?
3F2E  50 EB                 BVC LOOP1    ;   yes, then check stop
3F30  70 F9                 BVS LOOP2    ;   no, wait
3F32  20 ZZ XX     TOALPH   JSR SAVVID   ;Save the screen
3F35  20 YY XX              JSR SETALF   ;Configure alpha mode
3F38  60                    RTS          ;Return to caller
3F80  A0 00        SCAN     LDY #$00     ;Initial horiz. byte
3F82  A2 08        LOOPY    LDX #$08     ;Initial vertical byte
3F84  A9 81                 LDA #$ 81    ;Margin 3 dots on left
3F86  85 F0                 STA PNTR     ;       4 dots on top
3F88  A9 D0                 LDA #$D0     ;
3F8A  85 F1                 STA PNTR+1   ;Pointer=$D081
3F8C  A9 06                 LDA #$06     ;Output %XXXX0110
3F8E  8D 00 FA              STA VIADB    ;   follow H
3F91  A9 FF                 LDA #$FF     ;Set A port as
3F93  8D 03 FA              STA VIADDA   ;   output
3F96  98                    TYA          ;
3F97  0A                    ASL A        ;Multiply
3F98  0A                    ASL A        ;   byte number by 8
3F99  0A                    ASL A        ;   for bit number
3F9A  8D 0F FA              STA VIADA    ;Output bit no. for H
3F9D  A9 02                 LDA #$02     ;Output %XXXX0010
3F9F  8D 00 FA              STA VIADB    ;   latch H
3FA2  A9 0B        LOOPV    LDA #$0B     ;Output %XXXX1011
3FA4  8D 00 FA              STA VIADB    ;   follow V, unlatch video
3FA7  A9 FF                 LDA #$FF     ;%11111111
3FA9  8D 03 FA              STA VIADDA   ;A port=output
3FAC  8E 0F FA              STX VIADA    ;Output line no. for V
3FAF  A9 02                 LDA #$02     ;Output %XXXX0010
3FB1  8D 00 FA              STA VIADB    ;   latch V
3FB4  A9 00                 LDA #$00     ;%00000000
3FB6  8D 03 FA              STA VIADDA   ;A port=input
3FB9  8D 00 FA              STA VIADB    ;Enable output
3FBC  AD 00 FA     CHKV     LDA VIADB    ;Sample status
3FBF  29 20                 AND #$20     ;Is line=V?
```

Listing 1 continued on page 192

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	12	180	180	—	—	120
	12.5	—	—	150	150	—
	13.3	200	200	—	—	—
	15	—	—	180	180	150
	16.4	—	—	200	200	164
Enhanced	10	—	—	—	—	100
Expanded Print (Double Width)		Yes	Yes	Yes	Yes	Yes
Dot Addressable Graphics (Dot/In., H/V)		60/72	60/72	75/72	75/72	72/72
Max. Line Width (In.)		8.0	13.2	8.0	13.2	13.2
Audible Alarm		Opt.	Opt.	Opt.	Opt.	Yes
Out-of-Paper Sense		Yes	Yes	Yes	Yes	Yes
Ribbon, Continuous Loop Cartridge (Yds)		30	30	30	30	30
Interfacing: Parallel Cent. Comp.		Yes	Yes	Yes	Yes	Yes
RS-232-C Serial		Yes	Yes	Yes	Yes	Yes

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Circle 26 on inquiry card.

Listing 1 continued:

```
3FC1   F0 F9              BEQ CHKV     ;   no, loop and wait
3FC3   AD 00 FA   CHKH    LDA VIADB    ;Sample status
3FC6   29 10              AND #$10     ;Is bit=1?
3FC8   F0 F9              BEQ CHKH     ;   no, loop and wait
3FCA   AD 0F FA           LDA VIADA    ;Read byte of video
3FCD   91 F0              STA (PNTR),Y ;Output to screen memory
3FCF   E8                 INX          ;Move down
3FD0   E8                 INX          ;   2 lines
3FD1   E0 FC              CPX #$FC     ;Bottom reached?
3FD3   B0 0E              BCS BOTTOM   ;   yes, branch
3FD5   18                 CLC          ;   no
3FD6   A5 F0              LDA PNTR     ;Update pointer
3FD8   69 20              ADC #$20     ;   2 lines down
3FDA   85 F0              STA PNTR     ;
3FDC   90 02              BCC SAMPAG   ;
3FDE   E6 F1              INC PNTR+1   ;Bump high byte
3FE0   18         SAMPAG  CLC          ;Branch always
3FE1   90 BF              BCC LOOPV    ;   until bottom
3FE3   C8         BOTTOM  INY          ;Move right 1 byte
3FE4   C0 1F              CPY #$1F     ;Right byte margin
3FE6   B0 02              BCS DONE     ;   reached yet?
3FE8   90 98              BCC LOOPY    ;   no, then continue
3FEA   60         DONE    RTS          ;Return to VIDEO
```

are located at hexadecimal 3F81, 3F83, 3FD2, and 3FE5 in listing 1. Some adjustments in the trimmers may be required to sample the entire screen. If more than 128 lines are sampled, change one of the INX commands (at hexadecimal 3FCF and 3FD0) to an NOP, and wire the jumper associated with IC3 to the 256th scan-line position. Note that if your computer can't keep up with the desired lines, it must wait until the corresponding byte appears in the following field to obtain a data sample. Instead of a sampling rate of approximately 64 μs, the rate will be about 16 milliseconds (ms), slowing the refresh rate from about a half second to about 30 seconds.

Applications

Since the interface is wired to a normal TV set, anything appearing on the TV can be stored in your computer. This includes pictures broadcast normally and cable TV signals, as well as signals from anything that can be connected to a TV with an RF modulator: TV camera, video-tape recorder, videodisc player, video game, and another personal computer (have you ever wanted to transfer an Atari graphics image to an Apple II?). Images can be merely displayed on your computer's screen, saved on tape or disk, enhanced or otherwise modified by software, and dumped to a graphics (dot-matrix) printer.

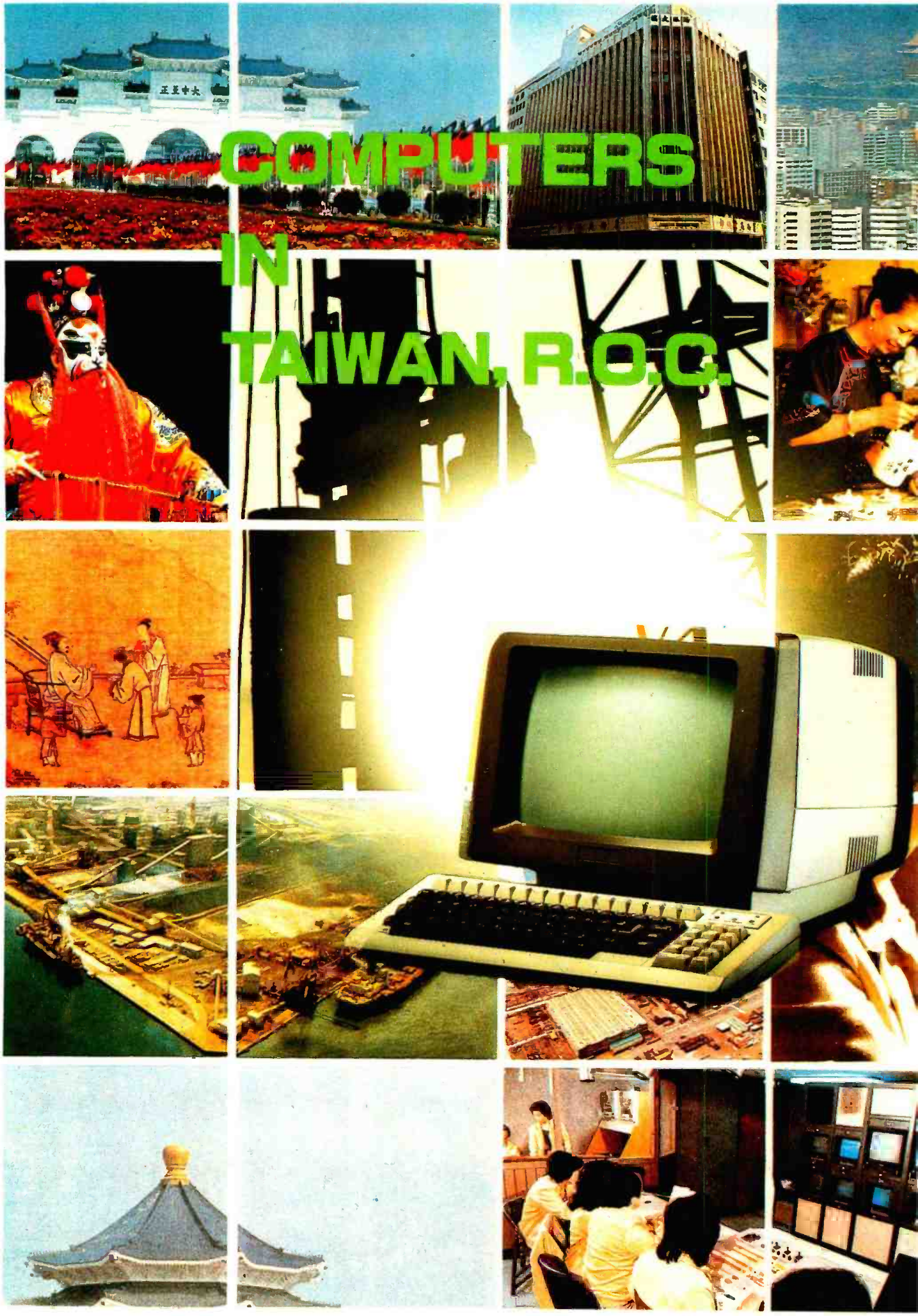
Applications include the obvious: computer-generated portraits and computer security and surveillance. For computer-recognition systems, you may want to simplify the images by using low resolution and only black and white intensity levels. The interface will make it very easy to get relatively sophisticated graphics images into your computer for use in games, education, or other programs. For example, a few pictures grabbed from Johnny Carson's monologue and a $150 speech-synthesizer board might turn your computer into a computerized joke teller. Or can you imagine President Reagan teaching your children arithmetic?

Although the interface circuit was designed to be simple, it could be upgraded. The op-amp, shift-register, and output-register circuits could be duplicated several times to provide more than 1 byte of information. Since the extra time for a computer to read three or four more registers is minimal, the scan rate would probably not be degraded.

Additional intensity levels can be created by setting slightly different bias levels on the op amps. True primary colors can be obtained by sampling the voltages at the three color-output transistors in a normal color TV. Cartoons are especially suited to color digitization. Most cartoons have several vivid color zones that differ little in gray scale, making a black and white system rather poor in distinguishing the different areas.

Another possible application is computerized TV commercial recognition. Detecting a commercial, your computer can switch off the TV's audio and video outputs and replace them with a 60-second computerized monologue. ■

COMPUTERS IN TAIWAN, R.O.C.



TAIWAN: SET ON COMPUTERS

Who hasn't heard of the so-called Taiwan Economic Miracle? From a sleepy, agricultural island of 10 million inhabitants in 1960 to the trade-oriented giant of the 1980's, the island is now among the world's largest suppliers of footwear, textiles, and electronic goods. It is the third largest exporter of goods to the United States, with about 8 billion worth of exports there last year.

Taiwan's planners realized some years ago that the large pool of cheap labor that Taiwan used to have and has contributed greatly to the nation's economic growth wouldn't last forever. They knew that the accent of Taiwan's industry would have to be changed from labor-intensive goods if its economy was to remain viable. They also knew that, because of a number of factors, Taiwan wouldn't be able to compete with economic giants such as Japan and the United States in already-established product lines.

Their solution was a wise one: stress a shift in industrial emphasis to state-of-the-art, capital-and technology-intensive undertakings such as advanced optics, precision machinery, and especially, computers and software.

As more advanced countries in the West have developed highly sophisticated computer technologies, Taiwan, which has not entered this field until mid '70s, is accelerating not only the manufacturing of computer parts and peripherals but also the design and application of software packages.

Taiwan may have a long way to go to become a computer giant, but its potential of developing the computer industry is great. Taiwan's exports of electronic products came to US$ 3.3 billion in 1981, making the nation the seventh largest electronics supplier in the world. Because of its electronics industry, Taiwan has available a large number of technicians and a great variety of electronic parts and components, both of which have made the development of the computer industry much easier.

There are now more than 100 companies specializing in micro- and mini-computer systems. Others are developing specialized devices such as process controllers and communications devices, while still others have begun exports of peripherals such as monitors and terminals.

A visible hand to promote computerization

The manufacture of computer parts and peripherals can best be boosted by the promotion of computerization in private and public sectors. To achieve this purpose, the Institute for Information Industry (III), a non-profit semi-government sponsored organization, was set up three years ago to serve as bridges between the computer industry and its users, education and research institutions, and the government. One of III's major tasks is to vigorously promote the efficient use of computers on all sectors in Taiwan. To achieve this goal III for example developed last year a nationwide banking automation scheme aimed at streamlining and improving the services of all banks on Taiwan.

Furthermore, the III is cooperating with world famous computer companies, such as Wang Lab and Hewlett-Packard, to jointly develop software packages in order to transfer advanced technologies to the island and thus creating export opportunities. Nevertheless, the list of III's endeavours is far from exhausted.

The Industrial Technology Research Institute (ITRI), an autonomous body, constituted by a number of sections including the Electronics Research and Service Organization (ERSO) provides a cutting edge for much advanced research on the island.

ERSO, which began its computer research in 1979, now employs about 200 technical people at its laboratories in Hsinchu. With an annual budget of $5 million, ERSO concentrates on micro-and minicomputer technology, general-purpose microcomputers, software, industrial process controllers, and testing, quality assurance, and product engineering. Its findings and prototypes are made available to any private enterprise interested in mass production of items developed.

Recently, ERSO engineers completed a real-time multi-testing software system, and cross-assemblers and software-simulators for the Intel 8086 microprocessor. They've also develped eight- and 16-bit microcomputer systems based on the Z-80A and 8086 microprocessors, and a data-acquisition system using about 40 microprocessor-based controllers and minicomputers . Erso's findings, in turn, are made available to industry-at-large, which then develops the device's commercial possibilities. By so doing, ERSO has served local manufacturers by offering a design service for microprocessor-based products and system software, as well as providing pilot production and qualification of subcontractors.

Photo 1: *A Taiwan's Terminal Assembly Line*

ERSO looks towards 16-bit design

In the future, ERSO plans to emphasize the design of 16-bit and possibly 32-bit microprocessors. It also plans research into graphics, image processing, real time redundant systems, and the development of more complete testing services. It will cooperate with other ITRI labs in further development of CNC robots, CAD and CAT.

A number of impressive achievement in private segement

Among the private firms, companies such as Mitac Inc, Multitech International Corp, Microtek International Corp, Teco Electric and Machinery Co., Ltd, Disco Electronics Co., Ltd, Pan Asia Electronic Co., Ltd, Compeq Manufacturing Co., Ltd, Joining Instruments and Equipment Co., ATW, Liberty Electronics Co., Ltd, Plus and Plus Co., Ltd, Shinlee Corporation, Lung Hwa Electronics Co., Ltd, Sampo Corp, Cal-Comp, Tea Po Co., haven't been idle either. Although their achievements are modest when compared with the activity taking place in more advanced countries, many Taiwan compaines have jumped eagerly into the automation game and are now taking the first steps in learning the game. Some have won international distinction for their innovative products already. Others have won major export contracts for terminals and monitors designed here. Still others are taking a crack at high-value, specialized lines such as design-and-analysis tools for microprocessors and computerized numerical controllers. Component makers, too, are providing parts in tolerances and specifications that are computer-compatible —— a step up from the consumer-grade devices that served the electronics industry for many years.

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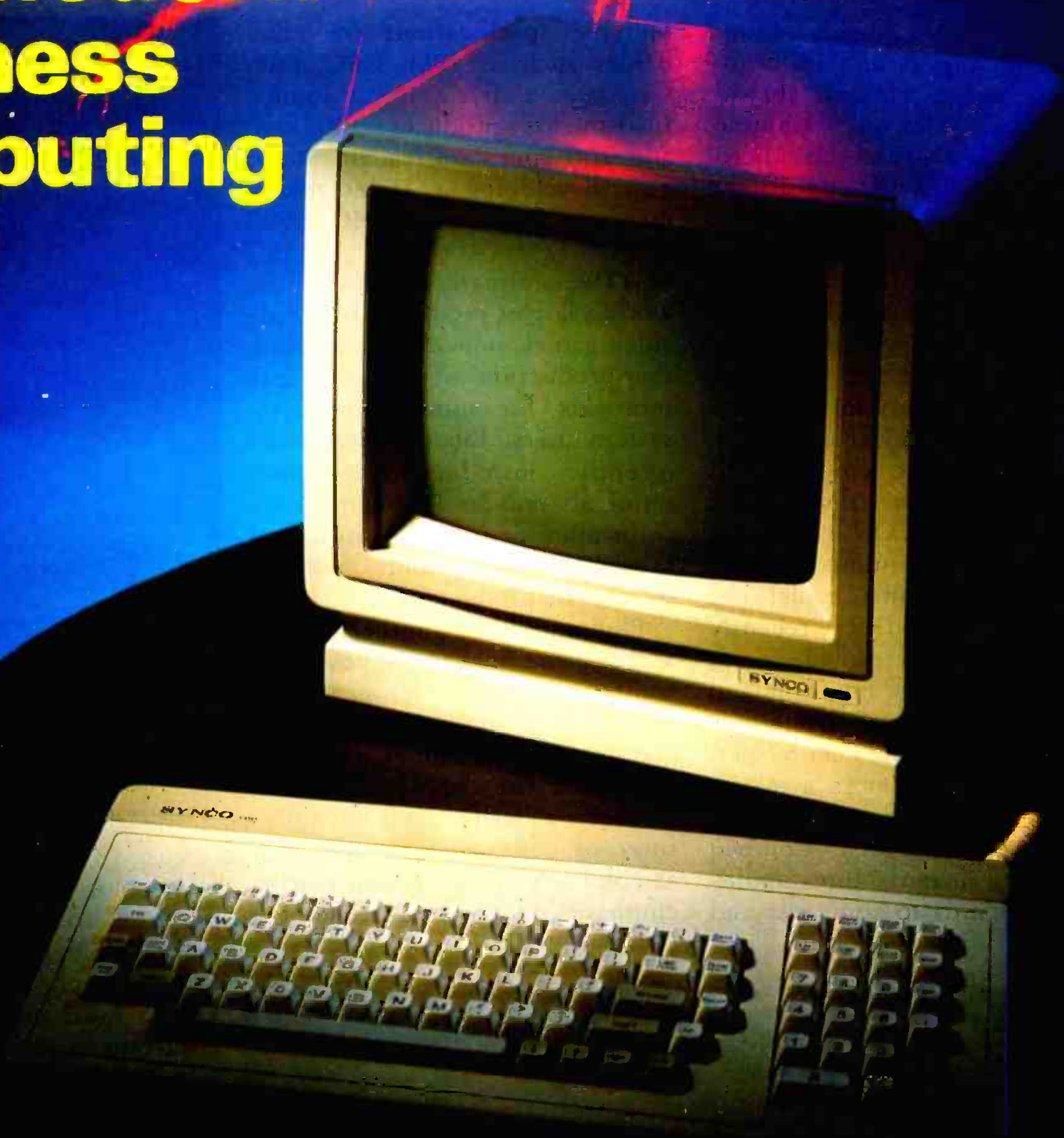

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* *Operating system:CP/M+
* *Communication:2xRS232C 1x16 bits PIO

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Video Display Terminal MODEL:T88

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* *8 transmission speed from 75 to 9600 bps
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* *current cursor position displayed on right upper screen
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on drives have already found markets in Taiwan and are beginning to make inroads abroad. Multitech's "Dragon" Chinese-Language terminal and the "Micro-professor" series of educational home computers have won awards and distinctions in addition to sales at home and abroad. Microtek, a young firm fueled by locally-born engineers with advanced American educations and experience, has already introduced a low-cost design and analysis tool, the micro incircuit emulator (or MICE) which gained the product of award of WESCON 81, as well as computerized numerical controllers for machine tools, last April. Teco and Disco recently won contracts to provide color and black-and-white monitors and terminals for major American vendors Hazeltine and Lear-Siegler. Pan Asia manufacturers a microcomputer series for the domestic and export markets. Compeq designs and manufactures multilayer PC boards to computer and military specifications for companies such as IBM, DEC, Data General, Fuji Xerox. Joining Instruments produces 300 cpm and 700 cpm card readers, and is now developing a 16-bit microcomputer based on an MC-68000 chip.

ATW, formerly one of the world's largest producers of arcade video games, now concentrates on the production of low-cost data terminals for mini- and microsystem users. Liberty Electronics recently introduced a smart terminal and an IBM-compatible color monitor to add to its line of other peripherals and consumer electronics products.

Plus and Plus, another former arcade-game maker, is now concentrating on microprocessor-training kits with EPROM programmers and Chinese-character generators for the Apple II Plus. Shinlee, a well-known manufacturer of consumer products such as color televisions, is now placing emphasis on the marketing of a new color terminal and general purpose computer. Lung Hwa makes linking RF modulators. The Sampo Corporation, another well-known local maker of consumer electronics items such as color televisions, is also entering the personal computer. TeaPo makes all kinds of switching power supplies for both the domestic and export markets. Cal-Comp, with 1981 exports of 15 million calculators, in 1982 began production of smart terminals at a new factory.

These manufacturers by no means comprise the complete list of companies busy in Taiwan engaged in the design and production of computer-related products. But they nevertheless give a rather clear example of how far the industry has come to in just a few short years, and of how fast the industry is prepared to shift its emphasis when conditions demand and new marketing opportunities open up.

Photo 3: *Minister without Portfolio K. T. Li, one of the principal architects of ROC's accelerated economic development program, promotes vigorously the information industry.*

Photo 2: *A Hardware Design House*

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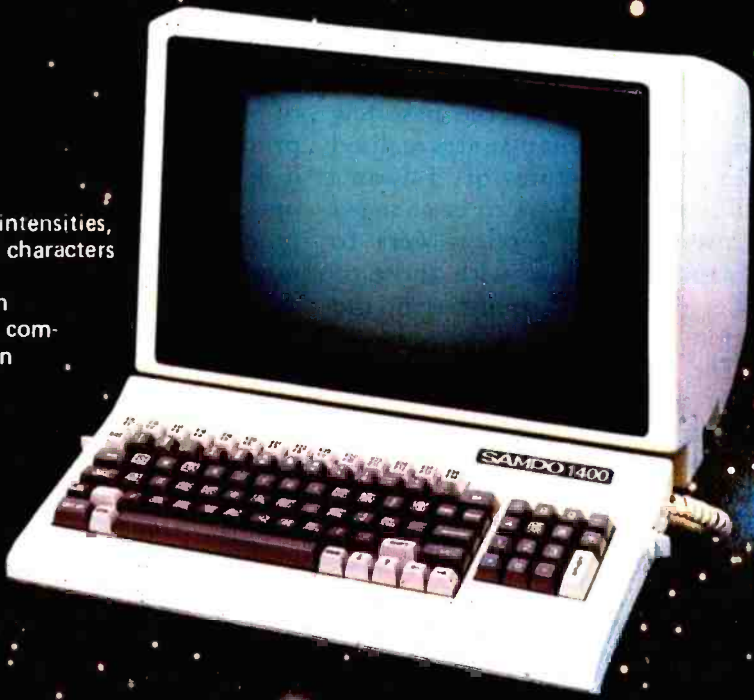

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BEHIND THE ACHIEVEMENTS:

Cooperation Between Government and Industry

As Taiwan gradually ran out of cheap manpower in the past few years, government planners realised that the structure of Taiwan's industry would have to be changed if products and services were to remain competitive with those of other developing countries in the region.

The planners translated their ideas into a "Ten-Year Plan for Industry", which had as its focus a virtual re-structuring of industry from the top down. On the manufacturing side, the government called for more high-value production in areas where exports might not increase dramatically in guantitative turns. Qualitatively, it called for more emphasis on production of high-value, low-labor items such as precision machinery, optics, electronics goods, and computers and peripherals.

Computer and information comprise a significant part of the Ten-Year plan segment dealing with the electronics industry. That segment calls for the development of products such as CRT terminals, printers, raster-scan graphics, fixed disk drives, magnetic tape drives, optical character readers, word processors, and special-purpose minicomputers for business use and process control. Part and parcel of these products is the intention that Taiwan's engineers stop making products designed in other countries. Instead, the planners suggest that as great a percentage of future technological exports from Taiwan be designed on the island as well.

One-stop service

To achieve this end, government has planned a whole new environment for manufacturers and foreign investors. The government also reaslises that foreign entrepreneurs in technical cooperation with local businessmen can give the industry the push it needs to make its mark in the world of technology. Already, there has appeared a loosening of customs and investment regulations for foreign firms on Taiwan. In particular, efforts are being made to minimize or do away with entirely the bureaucratic hassles foreign businessmen have often faced with when dealing with foreign countries.

For instance, Taiwan's Ministry of Economic Affairs on July 1 of this year formally established the Joint Industrial Investment Service Center to provide a "one-stop service" to Overseas Chinese and foreign investors, and to route them around the maze of paperwork that the bureaucracies often generate. The Center will help investors process all administrative procedures ranging from investment applications to the establishment of factories. In another word, the Center plans to put all investment-related services under one roof.

In addition to the establishment of the Center, the government this year decided on a series of steps that will make investing in Taiwan more than $7,500 worth of instance, manufacturers purchasing a more than us $ 7,500 worth of Taiwan-made and imported machinery and equipment before April 18, 1983, can deduct 10 to 15 percent of the machinery cost from their business tax of the year. In addition, companies in the strategic industries -- of which computers and information science are included -- are eligible for long-term, low-interest loans from the government.

Photo 4: *A Typical Software House*

A Growth of the Industry

As little as seven years ago, Taiwan was considered a relatively under-computerized nation. But in the past few years, it has become one of the fastest-growing markets for computers and peripheral equipment in the world. In 1979, for instance, there were 450 in-


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stallations on the island, second only to Hong Kong among nations of comparable size and economic development in the region. As of June, 1981, the number of installations in Taiwan had more than doubled, to 988. In addition, the number of Taiwanese companies involved with computing and information had mushroomed. Today, continued interest in computers and information science is evidenced by the fact that the two areas of top preference among graduating high school students who plan to go on to university are electrical engineering and information science. It is also evidenced by the attendence recorde on numerous and diversified EDP training courses offered by the industry. For example, a III-sponsored intensive EDP training program for a clase of 40 non-DP students usually attracted more than 1000 enthusiatic applicants. These university and college graduates of tomorrow will form the basis of Taiwan's continued development of its higher-level skills.

uP-based Designs Are Everywhere

Most hardware design houses in Taiwan concentrate on microprocessor-based products and their applications, rather than computer systems per se. What computers there are that have emerged from Taiwan's engineering shops have been mostly small micro systems. But in the microprocessor-based range, the island's designers have shown themselves particularly strong.

For instance, various design houses on the island have turned out hardware and applications that end up in products such as microprocessor-based temperature controllers for refrigerators and airconditioners, devices that control various automotive functions, automatic telephone dialers, television games, video terminals, PABX's, industrial process controllers, and microcomputer systems. Some of these products are marketed directly by the companies here, others are sold through brandname manufacturers and distributors in the United States and other foreign countries.

At the same time, the island's hardware designers have undertaken a number of projects at the behest of large Western firms such as IBM and National Semiconductor. Taiwan-made computer boards may grace minicomputers and mainframes marketed by well-known American manufacturers.

A large part of the attraction of Taiwan designs for foreign companies is the low development cost on the island. For instance, the salary of a very experienced hardware designer in Taiwan is only about $ 1,000 a month, compared with a minimum of three times that figure in the United States. Other project costs are also considerably lower than in the United States. Thus, project development costs for a product such as a terminal would be one-third to one-half of what they would be in the United States.

Software Houses Start to Boom

Savings on software design costs are similar. In fact, Taiwan has over 100 software design houses

By 1981, electronic production value in Taiwan reached 5.54 billions, and its export totally reached 3.6 billion, including 45% consumes products and 48% components. The other 7% are professional electronics (mainly in telecommunication products.)

Product's Name	Value (Million US dollars)		
	1981	1985	1989
Personal Computer	0.8	15	135
Small Business Computer	2.2	14	95
OEM Board Module	4.2	32	283
OEM Microcomputer	1.1	8	47
CRT	66.6	440	2900
Point of Sales CRT	4.2	270	183
Word Processor	2.1	14	94
Printer	--	45	400
Teleprinter Terminal	--	45	150
GraphicTerminal	--	80	150
Others	8.8	30	63
Total	90	750	4500

Table 1: *Projected Computer Production Growth in Taiwan* *Source: ITRI*

compared with 50 hardware houses. Most of these software firms have fewer than 20 employees, and their efficiency is high. Again, most firms concerntrate on applications packages.

Other software houses specialize in business-management systems. They provide applications packages to perform such services as accounting, editing, purchasing and point-of-sale. They may also do programming for large foreign systems and do equipment-oriented design for companies such as IBM, Hewlett-Packard, and large Japanese brands.

Nevertheless, the industry expects a bright average educational level of the population, which means that the industry has a relatively larger pool of educated talent on which to draw. It also means the industry will be quicker to learn and begin developing its own packages than ot in the region.

Photo 5: *Computer Stores Are Springing up Everywhere*

AMERICAN COMPUTER FIRMS ENJOY OPERATING IN TAIWAN

IBM

Several large American computer firms also maintain branch offices here. For instance, IBM has maintained a presence on the island for 26 years, and has enjoyed annual sales increases between 20 and 40 percent. It sells and services IBM 3000 and 4300-series mainframes, Systems 23, 34 and 38, and the Display Writer. In addition to its sales and service efforts, IBM Taiwan has in recent years made significant contributions to the advancement of agriculture around the world by providing computing services to the Asian Vegetable Research and Development Center near Tainan, in the southern part of the island.

NCR

National Office Equipment Corp, a National Cash Register's affiliate in Taiwan, is the island's oldest computer firm. The company provides sales of its computer systems and software support to retail stores, supermarkets, department stores, government offices, trading companies, schools and hospitals. It has net profits of $1 million during 1981 on sales of $5 million, and has projected 1982 profits of $1.5 million. It numbers 58 engineers among its 143-member staff.

Digital

Digital Equipment Taiwan Ltd began its ten-year history in Taiwan with a 1972 investment of $300,000 to produce core memories. In 1977, company doubled this investment to $620,000 with the inauguration of facilities to bond and package computer-grade LSIs. During the next five years the firm's investment jumped to $5.64 million with the addition of facilities to produce terminals, keyboards, and monitors. During this time, the company's sales also rose, from $13.5 million in 1977 to a projected $70 million in 1982.

The company's plans for 1983 call for the design of a new generation of terminals and monitors, and further production automation. The company also estimates it will turn out 25,000

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VT-101 terminals, 25,000 VT-100 monitors, 160,500 VR-201 monitors, 25,000 keyboards, and 1.86 million sets of LSI packages during the coming year.

The company's profits during 1981 reached $2.5 million, a 30 percent growth over the previous year.

Qume

Qume Corp of San Jose is the newest addition to Taiwan's growing group of offshore investors. The ITT subsidiary's local affiliate, Qume Corp (Taiwan) Ltd, received approval in July of a $10 million investment to produce daisy-wheel printers and disk drives in the Hsinchu Science-base Industrial Park. Production began in September at a temporary facility, but when a permanent plant is completed in July, 1983, production may rise as high as 200 printers and 1,000 disk drives a day.

Within two years, Qume expects to employ 1,000 people at its plant; within five years, the company expects sales to reach $100 million annually. In addition, taking advantage of the technical talent available in Taiwan, it will conduct research in interface hardware and software.

Wangs

Wang is an old Taiwan hand. In 1967 the company began its presence in Taiwan by opening an affiliate here, Wang Laboratories Taiwan Ltd, to produce various Wang products for export to the United States. It now has about 500 employees here.

Wang's latest venture in Taiwan, Wang Computer Taiwan Ltd, was established about two years ago in the Hsinchu Science-based Industrial Park. In fact, Wang was among the earliest offshore firms to receive investment approval and begin operations in the ambitious about 60 miles souch of Taipei.

Atari

Atari Inc late last year began production in Taiwan of its Video Computer TV games at a plant in Tamshui, on the island's northwest coast. Production from the plant augments video games made for some years by subcontractors on the island, and considerably increases the Atari output from Taiwan. The investment in Tamshui, according to company officials, involves millions of dollars. The plant, which formerly belonged to Sylvania-Philco Taiwan, covers 167,000 square meters; employment there was scheduled to reach 1,500 people by the middle of this year.

Atari set up the video-game plant in Taiwan because of the ease of obtaining materials here. The volume of games atari was already exporting from Taiwan caused the company to seek such a facility.

SEEKING RESEARCH AND DEVELOPMENT

A few years ago, Taiwan's economic and industrial planners were faced with a problem.

The problem was how to attract the knowhow and capital to Taiwan that would help educate local businessmen and manufacturers in the direction of the new high-tech industry, and at the same time make available the technology for these businessmen to use.

They came up with a solution following the example of American entrepreneurs and conceptual pioneers in creating places like the Standford Industrial Park, Silicon Valley, and the North Carolina Research triangle, they decided to set up a place to focus on high-technology development and research, and to offer attractive incentives to those agreeing to invest there.

Thus the Hsin-chu Science-based Industrial Park (HSIP) was born, the first industrial park developed exclusively for high technology industries in Asia. Established in September, 1980, the HSIP has a very aggressive plan to bring in 15 companies every year. Great

Photo 6: *Dr. Ho, Director General of Hsinchu Science-based Industrial Park, Says "Taiwan will become the future technology center of Asia."*

emphasis is placed on development and engineering in addition to production. Park officials plan for a healthy mix of companies in areas such as electronics and information, precision instrument and machinery, high technology material science, energy science, and aeronautical and biological engineering. To date, the major investments have been concentrated in the electronics field.

Taiwan is offering its best tax, duty, financing and investment incentives to accomodate investors in the Park. Various branch offices of governmental agencies are located right in the Park to offer one-stop operation and streamlined bureaucracy. Standard factory buildings are available at very reasonable rental rates so the industries can move in and start operation right away. The Park will also provide international standard educational, recreational and shopping facilities. Moreover, being in the Park is by itself a prestige and pride which lend luster to the brand names.

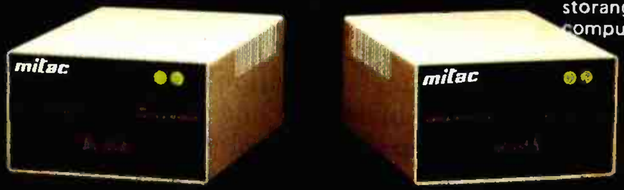
Two years after the grand opening of HSIP, 37 companies have received approval, of which 23 already started operation, and 18 are offering their products on the market. Total approved investment capital amounted to $66 million. Almost half of the people working in the Park now are at least a college graduate. Many of the founders have blossomed into local heroes of sorts. New products are scheduled for announcement continuously. The current list of products include: computer CPU and peripherals, semiconductor devices, integrated circuits, microprocessors, computerized numerical control systems, silicon wafers, crystal resonators, optical and laser components, high pressure water tools, ball bearing screws, optical fibre systems, epoxy resin and reinforced plastic, polymer medical material and ultrasound scanners.

Photo 7: *A View of Hsinchu Science-based Industrial Park*

CCRT – 1640 is the unique versatile bilingual Chinese/English intelligent terminal for your W/P.
- Simplex Input Method
- Programmable Edit, Function Keys
- RS-232C Univeral Interface
- Local Character Generator
- 8086 Single Board Design
- Direct Screen Hardcopy

MIS – 900 Features with a 12-inch non-glare green screen and a detachable capacitive keyboard. It is a user-friendly video terminal.

AppleMate is a low cost but reliable add-on disk storange for your Apple computer.



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QUALITY•RELIABILITY•QUANTITY•ECONOMY

The system products currently on line are **MIS – 5000** and **MIS – 8000** series microcomputer systems. Both series are Z-80A, 64KB, CP/M® based single board computers. There are two RS-232C serial ports and one Centronics parallel port for system I/O interface. DMA function is available on board for easy field installation to the single-sided or double-sided floppy disk system while it is standard for Winchester hard disk system. The major difference in these two series is in the external memory design. The 8000 series uses 8" floppy disk drives, the 5000 series uses 5¼" mini-floppy disk drives.

Located in the tax-bond zone of Hsinchu Science-Based Industrial Park in Taiwan, where only the companies possessed of advanced technology of design and manufacture are motivated to move in ***mitac*** Inc. has enjoyed very successful sales and stable production of the current products available to domestic and international market. ***mitac*** is grouped by a professional engineering team with expertise in the state of the art design, precise manufacturing and prolonged quality controlled burn-in testing in all products. Besides, the strong financial standing of ***mitac*** will back up well to its world-wide marketing capability and mass production capacity. ***mitac*** is respectably playing the leading role of the computer manufacturing industry in Taiwan. Its outstanding computer engineers expert in both hardware and software have worked out some 14 kinds of the products for production and sales. From OEM boards to Chinese Computer Systems, ***mitac*** has proved its formidable workforce as the best in the industry.

mitac is continuously developing several new products. To manufacture the most cost-effective and reliable microcomputer in large quantity is our major goal. 16 bit system, using 8086 CPU and Unix-like operating system is also scheduled to be put on the market soon.

Domestic Dealer/Distributor enquires in the States are welcomed. For more detail information please contact American *mitac* Corp. at P.O. Box D, Santa Clara, CA 95050 Service hot line: (408)988-4427, International Distributor enquires, please contact *mitac* Inc. at 2/F 75 Nanking E. Rd., Sec. 4, Taipei, Taiwan, R.O.C. Telex: 20261 MECTAC. Tel: (02)781-6980.

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"Information Week" and "Youth -of The Future"

When a small island with 18 million inhabitants decides to turn the direction of its industry away from labor-intensive, low-capital assembly operations toward precision, state-of-the-art technologies such as computers and information, it faces a problem over how to implement the change.

In Taiwan's case, the problem was particularly acute, because the island doesn't have a long industrial history. In fact, 30 years ago the only industry of any size here was agriculture . . . But Taiwan's economic planners realised that to maintain the force of the country's drive toward becoming a computer-producing nation, they would have to have a sufficient number of young people willing to enter the sciences as professionals. They also realised that in order to make industry as a whole more productive and efficient, industrialists and small businessmen alike would have to be made aware of the potential of automation in their businesses.

And so the planners embarked on a series of programs of popular education. One major program is an annual event called "Information Week", which was initiated and proposed early in 1980 by Minister K. T. Li, then the chairman of the Institute for Information Industry. Activities in the event consist of exhibitions, movies, lectures, essay and speech competitions, demonstrations by computer users, advertising through mass media, and issuance of special stamps.

When Taiwan's first Information Week was launched two years ago this December as a joint project between government and computer people, it was hoped that the activities would draw enough interested people to justify making the Week an annual event. But few were prepared for the turn-out.

From the first day of the week-long series of lectures, slide presentations, and demonstrations of computing-in-action at the old Taipei International Airport, crowds surged through the exhibition halls. They crowded around the more attractive displays in rows four and five people deep. Outside the exhibition hall, a line of people waiting to enter stretched a quarter of a mile down the street and around the block. It appeared that the media blitz promoting the event had been more than successful.

Nowadays, after two years of

Information Week, it also appears that the planners' strategy is paying off in year-round interest. More and more students are finding their way after school hours into the computer stores, even if it's only to play the video games. Around Taipei, Taiwan's major city, you find more and more people aware of computing and its applications. The "electric brain" — a literal translation of "computer" in Chinese — seems to have found a home.

For the non-professional, Taiwan expects to see an island-wide computer network, similar to the British Post Office's Teletext system, that would allow people at home to tune in. A massive leased-line network already links much of the island, and communications will be further enhanced shortly with the inauguration of a packet-switching system. Dial-up will also be introduced on a limited basis to bring more rural locations into the network. By the end of the decade, the planners expect Taiwan to represent a relatively large domestic market, not only for home-produced computers, but for those of major international vendors as well. At the same time, a populace concerned with computerization will be able to make important contributions to the information industry worldwide.

Photo 8: *By bits and bytes, lots of microkids are finding their way to run the micro computer in Taiwan.*

SOME SPEARHEADING PRODUCTS

HIGH PERFORMANCE/LOW COST MICROCOMPUTER SERIES FROM PAN ASIA — Pan-Asia Electronics Co., Ltd. introduces its new PA-2000 series of Z-80B-based microcomputers for business, management, industrial control, data communications, and other uses. The series offers up to 256 KBytes of RAM and 1.6 MBytes of disk storage, a standard Z-80 bus system, an eight- or 12-slot card cage, and dual minifloppy disk drives. It can support CP/M or MP/M-compatible operations systems and software, as well as high-speed file access on pseudodisk options and many other utility programs for optional I/O expansion modules. Its modular system makes maintenance easy. Price changed depending on model. Contact Pan-Asia Electronics Co., Ltd, 8/F, 325 Chung Hsiao East Road., Section 4, Taipei, Taiwan, ROC. TLX: 10437

MICRO IN-CIRCUIT EMULATOR (MICE) FROM MICROTEK — Microtek ofers this microprocessor programming and analysis tool that can be used with a terminal connected to a host computer or with micro from manufactures such as Apple, Radio Shack, Sharp, NEC, Prime, Zilog, Intel MDS. MICE is the total solution from R/D, production, QA, and field service. It offers Features including a resident assembler/disassembler, down-load and up-load, a built-in logic analyser function, and powerful I/O capabilities.

Available from Microtek International Inc, Hsinchu Science-Based Industrial Park, Hsinchu, Taiwan, ROC. TEL: (035) 772-155, Telex: 32169 MICROTEK. U.S. office: Microtek Lab., Inc, 17221 South Western Avenue, Gardena, California 90247, USA. Tel: (213) 321-2345 Telex: 696334 BENNY GDNA.

The Micro-Professor™ from Multitech recognized worldwide

Multitech Achievements

1. The Micro-Professor microcomputer and the "Dragon" Chinese terminal were cited for their innovative design in April, 1982, at the Hannover Fair, West Germany.

2. The Micro-Professor (MPF-I) is the world's most widely-used Z-80* microprocessor learning tool, with more than 30,000 already in service worldwide.

3. The Micro-Professor II and the "Dragon" Chinese terminal each received the Premier's Award – the most prestigeous award for superior product design in the Republic of China. The terminal received its award in November, 1980; the Micro-Professor, in July, 1982.

4. Multinational firms such as IBM, ITT, and Philips have used the MPF-I microcomputer for in-house training of their engineers. The device has also found wide use in the general educational market.

5. Multitech, which also provides customs design service, has developed over 40 microprocessor-based products such as CRT terminals, PABXs, and computer games.

They Said

Shelly Kroan, vice president of Versadata, an Illinois-based manufacturer of versatile data products: "We have been very successful in selling the Micro-Professor in the United States. We find it to be a very interesting and useful product . . ."

Telexed from a West German company: "We have got first report from Prof. Dr. Niemeyer, professor for Economics and Computer Science of University of Regensburg, and he finds MPF-I 'marvellous, wonderful' . . . ."

Max D. Soffe, Managing Director of Flight Electronics Ltd. of Britain: "The MPF-I should be welcomed by scools and technical colleges because of its reliability, ease of use, and its extra hardware support and its incredibly low price, in fact half the price of its nearest competition . . . and an astounding low rejection rate of 0.4%."

Micro-Professor (MPF-II)

Product Lines

Micro-Professor I (MPF-I) is a low-cost, Z80-based microcomputer that will lead you step-by-step to a thorough knowledge of microprocessor. Not only is MPF-I a superb learning tool for technical students and engineers, it is also an excellent teaching aid for instructors of electrical engineering and computer science. Options such as an EPROM programmer board, a BASIC Interpreter, a speech synthesis board, a sound generation board, and a printer make the MPF-I versatile.

Micro-Professor II (MPF-II) is a full-feature home computer which can be used for education, entertainment, home and business management, and learning programming language. MPF-II provides BASIC Interpreter, compatible with the Apple II*. It can be connected to color TV sets and video displays. With options such as a printer, software cartridges and cassettes, a RS232C network interface board, a remote control box, a Chinese Character Controller, a floppy disk driver, and a speech/sound generation board enable you to expand the system.

Other products available from Multitech are:

1. Dragon Chinese Terminal
2. Universal Development System
3. Small Business Computer System
4. Speech Synthesis Board

Micro-Professor (MPF-I)

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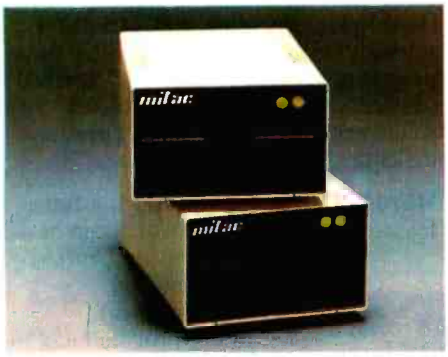
* APPLE II is the trademark of Apple computer INC
* Z 80 is the trademark of Zilog INC

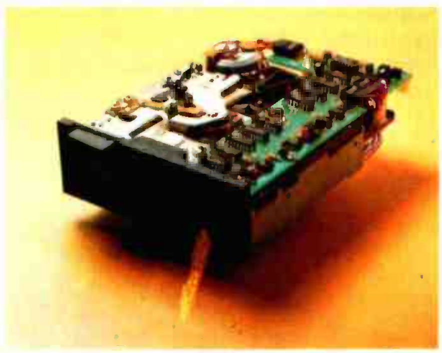
APPLE II COMPATIBLE DISK DRIVE FROM MITAC INC----Mitac's Apple Mate 5¼-inch disk drive offers Apple II compatibility at a low price. Its track format and storage capacity are identical with Apple drives, allowing simultaneous use of Apple Mate and Apple drives. One-year warranty. Price: $ 385 per set, interface card $75 Available by mail from American Mitac Corp, P.O.Box D, Santa Clara, CA 95050 USA. Tel: (408) 988-4427 TLX: (TAIWAN): 20261 MECTAC



CRT TERMINAL FROM CAL-COMP-- Cal-Comp's VCT-1 12-inch CRT offers a 24 x 80 screen format, a 7 x 9 dot matrix, 15 graphics symbols, detachable keyboard with numeric keys, security mode. Operates through standard RS-232 interface or a 20ma current loop. Baud rates 75 through 19,200. Diagnostics: power up RAM and ROM tests, keyboard test, audible bell and LED indicator tests. Size: 395 mm (D) x 369 mm (W) x 331 mm (H). For further information, write Cal-Comp Electronics Inc, 99-109 Nanking E. Road Section 5, Taipei 105, Taiwan, ROC. TLX: 22769

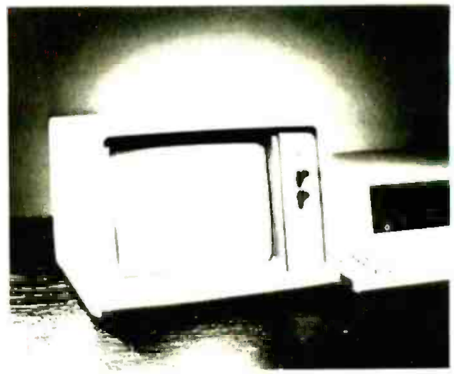
VIDEO DISPLAY TERMINAL FROM SHINLEE CORP -- Shinlee's T88 terminals is microprocessor-based, teletype-compatible model with detachable keyboard capable of displaying the complete ASCII set. The 12-inch screen will accomodate 2,000 characters in an 80 x 25 matrix. The T88 is compatible with most currently-available terminals. Size: 345mm (H) x 370mm (W) x 295mm (D). The Shinlee Corp, 2/F, 372 Lin Sen North Road, Taipei, Taiwan, ROC. TLX: 11154 SHINLEE

MINIFLOPPY DISK DRIVERS FROM LUNG HWA -- LUNG HWA ELECTRONICS' LDD-101 disk driver offers 250K byte of storage caparity and 48 TPI double density. This SLIMtype LDD-101 has 54 mm in height and 40 tracks, its disk locational speed reaches 300 rpm. It will available in Jan., 1983. LUNG HWA Electronic Co., Ltd. 5/F, No. 33, Pao-Hsing Rd., Hsin Tien City, Taipei Country Taiwan, R.O.C. TLX: 31143 LUNG HWA



INTELLIGENT TERMINAL AND COLOR MONITOR FROM LIBERTY CO. -- Liberties' intelligent terminal FREEDOM 100 offers detachable keyboard and tilt screen, 25th status line, video attributes and 15 graphic characters. 128-alphanumeric keys and ASCII set. And it also processes 10 function keys, 8 editing keys and 6 command keys.

Its 12" monitor CM-1200A is the one and only one of high resolution color monitor that can compatable with IBM Personal Computer. It can display 2000 (80 x 25) characters with 8-color-2-intensity by 690 dots high resolution non-glare in-line gun CRT. A 9 pin D shell connector cable is also provided. LI BERTY ELECTRONIC CO., LTD. P. O. BOX 22745 TAIPEI, TAIWAN, R.O.C. TLX: 26063 LIBERCO, TAIPEI



COLOR COMPUTER AND BTC-1400 TERMINAL FROM SAMPO CO. -- SAMPO'S Color Computer is a multifeatured home computer designed for large volume computations, and for education, entertainment and hobbist uses. It has a 6809E uP, uses extended BASIC, and has upper and lower case alphammeric semigraphic display ability in full color.

SAMPO also offers BTC-1400 14" display with two intensities terminal. The BTC-1400 will accomodate 2000 characters in 80 x 25 matrix, and with 7 x 9 dot matrix character structure in 9 x 14 dot windows. The Communication mode has: ENTER, LOCAL, conversation half and full duplex. EIA RS/232C interface etc. SMAPO Corp. 2/F, 217, Nanking E. Rd, Sec. 3, Taipei, Taiwan, R.O.C. TLX (TAIWAN): 21737 SEMCO, TLX (USA) 206837 SAMPO USA ELGR

SWITCHING POWER SUPPLY FROM TEAPO – TEAPO OFFERS TSM-34C switching power supply for terminal and minicomputer. It has 80-135VAC or 180-265VAC input, and has 5V10A, -5V1A, 12V3A, 12V1A output. Its efficiency reaches 75%, and ripple & noise only to 30 mV, and has protection to all output. TEAPO ELECTRONIC CORP., 3 LN89, SEC 3, Chung Yang Rd, Tu-Cheng Hsiang, Taipei Hsien, Taiwan, ROC. TLX: 31223 TEAPOCO

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- 32 CONTROL CHARACTERS SYMBOL
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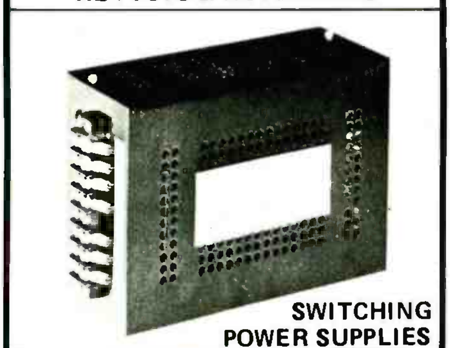
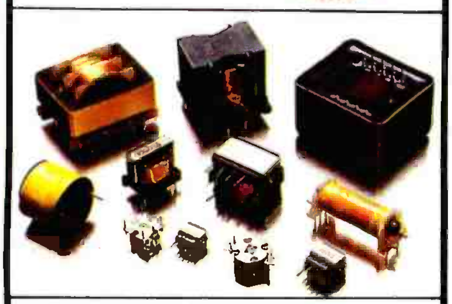


SWITCHING POWER SUPPLIES



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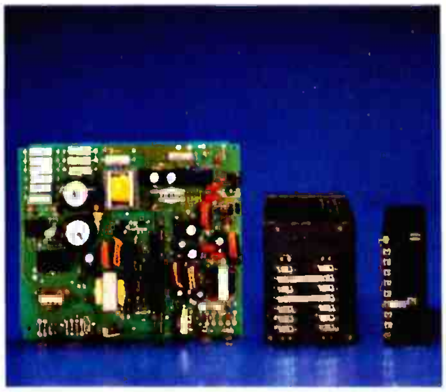
COMPUTERS IN TAIWAN, R.O.C.



INTERACTIVE SMART DATA TERMINAL FROM ATW INC -- introduced this month, ATW's Enhancer AT-200 terminal is designed to meet the needs of the widest possible range of mini- and micro-system users. It includes features normally found only on top-range models: 7 x 9 matrix characters, two-page memory with autoflipping, status line, software set-up screen, fifteen selectable baud rates, ten function keys plus numerical key pad, and detachable keyboard. ATW Inc, 50 Chin 5th Road, Nan Tsu Export Processing Zone (NEPZ), Kaohsiung 800, Taiwan, ROC. TLX: 72278 ATWHEAD

NEW MICRO SYSTEM FROM MULTITECH INTERNATIONAL CORP -- Multitech introduces the MIC500, a powerful small business computer combining high-speed, A 64 KByte RAM, two 5¼-inch thin minifloppy disk drives (expandable to four), and two full-duplex RS-232C serial communications ports for consoles and users applications such as system intercommunications or serial printers. Industry-standard versions of the CP/M operating system gives the user access to more software programs. Optional languages include BASIC, COBOL, and PASCAL. Suggested retail price $1,500. Multitech International Corp, 977 Min Shen East Road, Taipei 105, Taiwan, ROC. TLX: 23756 MULTIIC

MICROPROCESSOR TRAINING KIT WITH EPROM PROGRAMMER -- Plus & Plus Co., Ltd. offers this low price educational kit, the CAN-80. It can read, write, execute, and debug programs, and store the program on cassette tape. The built-in programmer can program 2716, 2732, 2764 PROMs. The Z-80-based CAN-80 is available from Plus & Plus Co., Ltd. 3/F, 217 Roosevelt Rd, Sec. 3, Taipei, Taiwan, ROC, TLX 21140 SIGMALTD TAIPEI

INTELLIGENT CARD READERS FROM JOINING INSTRUMENTS -- Joining Instruments' JP-2000D-series intellignet card readers offer a speed of 400 cards per minute. The readers are microcomputer-based, and include a 512 KByte memory and a pair of 8-inch or 5¼-inch floppy disk drives. Interfaces for CRTs, printers are available. Joining Instrument and Equipment Co., Ltd. 533 Chung-Hsiao E. Rd., Sec. 7, Taipei, Taiwan ROC. TLX: 27774 JOINING □

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Computer Animation with Color Registers

The color registers on the Atari 400 and 800 microcomputers give programmers amazing animation capabilities, even in BASIC.

David Fox and Mitchell Waite
POB 38
San Rafael, CA 94902

The process of drawing colorful images with a computer is fascinating and fairly easy to understand, but animating these images may be a bit difficult. Animation, of course, requires very fast color changes for each of the picture elements or pixels in an image. And many microcomputers may not be able to change a screen full of pixels fast enough for a smooth animation effect.

Fortunately, a technique known as *color mapping* had been used for years in the world of high-tech computer graphics. Here, instead of being directly assigned their colors, the pixels receive color information from a separate table of colors called a color map. By changing the color value of one entry in the color map, it is possible to immediately change the color of thousands of pixels without redrawing the image. Thus, some very-high-speed animation effects can be achieved.

To use this powerful technique, you need look no further than your local computer store. Unbeknownst to many people, the Atari 400/800 contains color-mapping hardware (called *color registers*), and this feature alone gives it awesome capabilities when compared to its competitors.

This article is an excerpt from a new book entitled Computer Animation Primer *by David Fox and Mitchell Waite (BYTE/McGraw-Hill Books, 1982).*

In this article, we will see how Atari's color registers can be put to work in colorful, action-packed, animated scenes. Color-register animation will be used in two programs: to create the illusion that you are rapidly flying through a trench (as in *Star Wars*), and to display the motion of water in a cascading waterfall.

The Magic Paint Store

Imagine a paint store shelf filled with 128 cans of different color paint. In front of you are nine empty "magic paint buckets," each one labeled with a number from 0 to 8. Each bucket has a brush in it with the corresponding number. Also, imagine a large canvas is on an easel before you, begging for a picture. Feeling inspired, you begin by filling the first bucket with a light-blue color, picking up the brush, and painting the sky on your canvas. When you have finished with that color, you fill another bucket with your second color selection and paint some more. You continue this process with the remaining seven buckets. When no empty buckets are left, you decide to empty Bucket 0 and fill it with a different color, a deep orange. Lo and behold, the sky in your picture, originally painted with Brush 0, immediately changes to orange as Bucket 0 is refilled! In fact, *everything* that was previously painted with Brush 0 now appears in the *new* color currently in Bucket 0! When you

try this with Bucket 1, the same thing happens with everything previously painted with Brush 1. You have magically changed your painting from a cool midafternoon scene to a fiery sunset.

Using Color Registers

Color registers were first created to provide the users of professional computer paint systems with a relatively inexpensive way to use a polychromatic palette. In many of these systems, the artist chooses a palette of 256 colors from a selection of more than *16 million*! When color registers (also called color maps) became popular, many advantages other than lower cost were discovered. An artist could alter some of the colors already painted without having to redraw an entire picture. In the field of computer animation, wonderfully animated scenes could be created without changing a single pixel simply by moving the colors around the color map! And in medical applications, as in the analysis of a computer image of an X-ray, formerly unnoticed details could be brought out by assigning contrasting colors to areas that had previously been depicted with only slight shading differences.

The Color Registers on the Atari

The Atari 400/800 is one of the few personal computers that uses this technique to display its colors on the screen. However, you have only 128 possible colors to choose from instead of 16 million (we hope you didn't get your hopes up!), and only nine entries (the color registers) in the color map, rather than 256. And most Atari graphics modes don't use all nine color registers. In fact, many use four or fewer. Table 1 lists most of the different Atari graphics modes and the color registers that are active for each.

First, let's do a brief overview of the table. The first column lists the different Atari graphics modes and the number of colors each mode supports. The Default Colors are the colors set by the OS (operating system) when the computer is first turned on or System Reset is pressed. The SETCOLOR column gives the values for the SETCOLOR commands (which are used to change the color value in the color registers) for that mode. The POKE column lists the corresponding addresses in memory of the color registers for each mode. By using the POKE com-

The ability to change the color of a specific area on the screen instantaneously can be used to create the effect of high-speed motion without resorting to assembly-language programming.

mand to put numbers into these addresses, you can bypass the SETCOLOR command for faster color changing. (This is the only way to change some of the registers in GRAPHICS 10, a new graphics mode available on Ataris equipped with a GTIA chip.) The numbers in the COLOR column are the values for the COLOR command that will choose that color register to draw with.

The Description column lists which of the three screen elements each color register controls. The first one is the screen background. When the screen is cleared, you are looking at pure background. It is the "canvas" of the screen upon which pixels are plotted and text is printed. Next, there is the border around the background. Although this area sometimes has its own color register (depending on the graphics mode), it is really the "frame"

Mode	Default Colors	SETCOLOR (n)	POKE address	COLOR (n)	Description
GRAPHICS 0					
(text mode and text windows for all modes; one hue; two luminances)	Light Blue	1	709	Not normally used	Character luminance (uses same hue as background)
	Dark Blue	2	710		Background
	Black	4	712		Border
ANTIC 4 & 5					
(special text modes; five colors)	Orange	0	708	Not	Character
	Light Green	1	709	normally	Character
	Blue	2	710	used	Character
	Red	3	711		Character
	Black	4	712		Background, Border
GRAPHICS 1 & 2					
(large text modes; five colors)	Orange	0	708	Not	Character
	Light Green	1	709	normally	Character
	Blue	2	710	used	Character
	Red	3	711		Character
	Black	4	712		Background, Border

Table 1 continues on the next page.

Mode	Default Colors	SETCOLOR (n)	POKE address	COLOR (n)	Description
GRAPHICS 3, 5, & 7					
ANTIC E					
(four colors)	Orange	0	708	1	Pixel
	Light Green	1	709	2	Pixel
	Blue	2	710	3	Pixel
	Black	4	712	0	Pixel (Background, Border)
GRAPHICS 4 & 6					
ANTIC C					
(two colors)	Orange	0	708	1	Pixel
	Black	4	712	0	Pixel (Background, Border)
GRAPHICS 8					
(one hue; two luminances)	Light Blue	1	709	1	Pixel luminance (uses same hue as background)
	Dark Blue	2	710	0	Pixel (Background)
	Black	4	712		Border
GRAPHICS 9					
(GTIA mode; one hue; 16 luminances; change hue with SETCOLOR 4, *hue*, 0 or POKE 712, *hue*)	Black	4	712	0	Pixel (Background, Border)
	.	—	—	1	Pixel
	.	—	—	2	Pixel
	.	—	—	3	Pixel
	Dark Gray	—	—	4	Pixel
	.	—	—	5	Pixel
	.	—	—	6	Pixel
	.	—	—	7	Pixel
	Gray	—	—	8	Pixel
	.	—	—	9	Pixel
	.	—	—	10	Pixel
	.	—	—	11	Pixel
	Light Gray	—	—	12	Pixel
	.	—	—	13	Pixel
	.	—	—	14	Pixel
	White	—	—	15	Pixel
GRAPHICS 10					
(GTIA mode; nine colors)	Black	—	704	0	Pixel (Background, Border)
	Black	—	705	1	Pixel
	Black	—	706	2	Pixel
	Black	—	707	3	Pixel
	Orange	0	708	4	Pixel
	Light Green	1	709	5	Pixel
	Blue	2	710	6	Pixel
	Red	3	711	7	Pixel
	Black	4	712	8	Pixel
GRAPHICS 11					
(GTIA mode; one luminance; 16 hues; change luminance with SETCOLOR 4, 0, *lum* or POKE 712, *lum*)	Black	4	712	0	Pixel (Background, Border)
	Light Orange (Gold)	—	—	1	Pixel
	Orange	—	—	2	Pixel
	Red-Orange	—	—	3	Pixel
	Pink	—	—	4	Pixel
	Purple	—	—	5	Pixel
	Purple-Blue	—	—	6	Pixel
	Azure Blue	—	—	7	Pixel
	Sky Blue	—	—	8	Pixel
	Light Blue	—	—	9	Pixel
	Turquoise	—	—	10	Pixel
	Green-Blue	—	—	11	Pixel
	Green	—	—	12	Pixel
	Yellow-Green	—	—	13	Pixel
	Orange-Green	—	—	14	Pixel
	Light Orange	—	—	15	Pixel

Table 1: *The color registers available in each of the Atari graphics modes. For each color register, there is a default color, a value for the SETCOLOR command (SETCOLOR n,hue,lum), an address for the POKE command, a value for the COLOR command (COLOR n), and a general description of how the color register is used. Note that GRAPHICS 9, 10, and 11 are available only on machines equipped with a GTIA chip. ANTIC modes are additional graphics modes that can be set up by creating custom display lists, but are not supported by the Atari operating system.*

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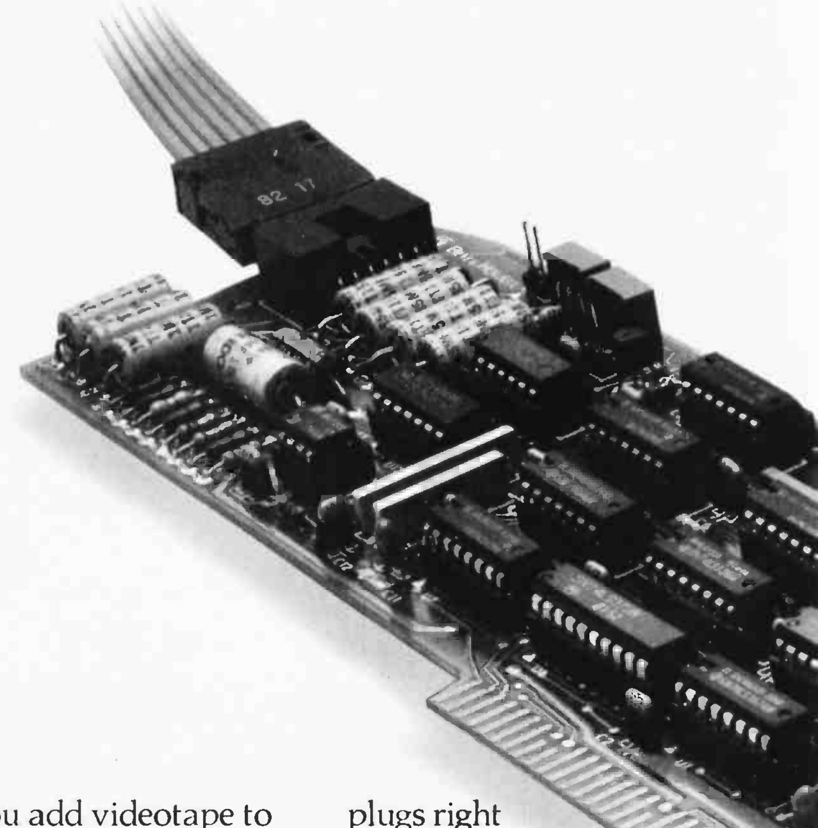

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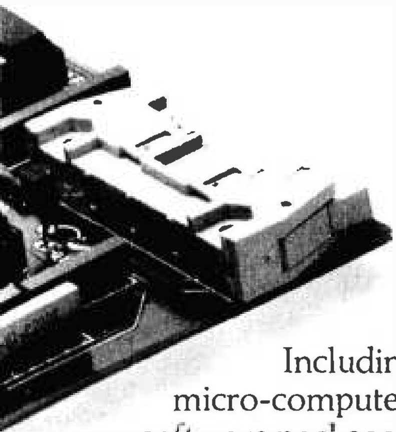

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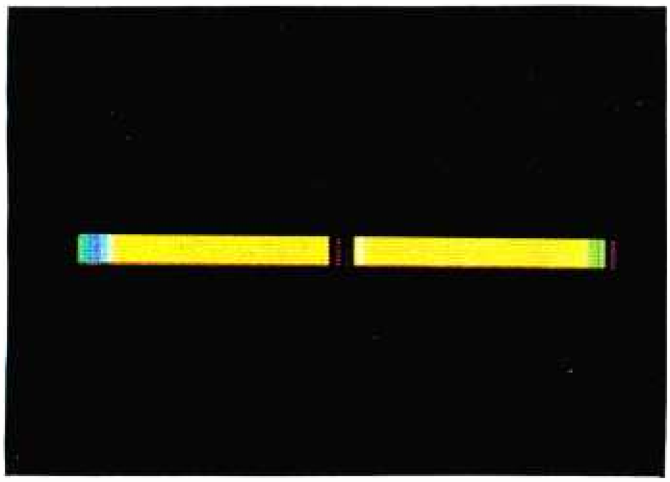

Photo 1: *An example of the default colors used in the GRAPHICS 3 mode of the Atari 400/800.*

surrounding the canvas and cannot be drawn on. The "playfield pixels" (any pixel that is plotted with a non-background color register) are last. Each group of plotted points using a specific color register is considered to be a *separate* playfield. For example, look in the table for the section on GRAPHICS 3. Registers 0, 1, and 2 each control the color of playfields 0, 1, and 2, respectively. Register 4 controls the background of the screen and the border (thus, in this mode the background's color cannot be controlled separately from the border's color). Notice that register 4 can also control a pixel; however, this is not a playfield pixel, but a background pixel. Think of plotting with a background color register as *removing* the playfield pixels so that the background color shows through again.

Using the default colors. At first glance, this table may seem somewhat overwhelming. To help you out, let's look at a few examples. Suppose you want to use GRAPHICS 3. Drawings done in this mode have a very coarse resolution of 40 by 24 pixels. The Magic Paint Store owner (i.e., the Atari operating system) was kind enough to fill some of his buckets when he first opened the store. These are called the default colors and can be selected for drawing with the COLOR command. If you wanted to use only these default colors, you can ignore the SETCOLOR and POKE columns because these colors are automatically placed in the color registers when the computer is first turned on or System Reset is pressed. To use the table, first choose a color from the Default Color column, light green, for example. Look across to the COLOR column and you'll find a 2. Therefore, the command COLOR 2 selects the bucket filled with light-green paint.

To place a light-green pixel at 10,8 (x,y), you would execute the following statements:

```
 10 GRAPHICS 3+16   : REM Full-screen mode
 20 COLOR 2         : REM Choose your bucket
 30 PLOT 10,8
200 GOTO 200        : REM Stay in GRAPHICS 3
```

To return to GRAPHICS 0, merely press Break. Note that the full-screen mode is being used (16 is added to the mode number). This means that no text window will be at the bottom of the screen. Try temporarily removing line 200 and see what happens when you run this program. The screen flashes to black, the pixel is plotted, and before you get to look at it, the blue GRAPHICS 0 screen has reappeared. At the end of a program that uses a full-screen graphics mode, the OS will automatically switch back to GRAPHICS 0. Line 200 is added to prevent this from happening until you press the Break button and exit the program.

To draw an orange line across the screen from this light-green dot, add the following lines:

```
40 COLOR 1          : REM Choose another bucket
50 DRAWTO 29,8
```

And now use one more color register available in this mode. This one is filled with blue:

```
60 COLOR 3          : REM One more bucket
70 PLOT 30,8
```

To erase a pixel, choose the background color (which always happens to be COLOR 0):

```
80 COLOR 0          : REM Select background color
90 PLOT 20,8
```

The screen will now look like that shown in photo 1.

Using the SETCOLOR Command

Now that we understand the use of the default colors, let's see what else is available to us. The Atari computer has 16 different hues from which to choose, and each one can be displayed in any of 8 levels of brightness or luminance (16 hues × 8 luminances = 128 colors). The BASIC command to *change* a color in a color register is

SETCOLOR *n,hue,lum*

where *n* is the value of the color register chosen from the SETCOLOR column in table 1, *hue* is a number from 0 to 15 that controls the hue, and *lum* is an even number from 0 to 14 (0,2,4, . . . 14) that controls the luminance of the color (the odd *lum* values have the same effect as the next lowest even value; i.e., *lum*=1 and *lum*=0 have the same effect). Table 2 lists the different hues available on the Atari.

Let's look at a few examples to see how the luminance value combines with the hue to instantly produce a new color. Try the SETCOLOR commands in table 3 while in GRAPHICS 0 to change the color of the border (just type them in direct mode). With a little experimentation, you'll be able to produce almost any color you wish.

Now let's have a little fun! Add the following lines to the last program you entered. (Note: All our listings have been structured for easier reading. FOR-NEXT loops and IF-THEN statements are indented and each statement is printed on a new line. Don't try to enter this structure into your programs, however.)

```
 80 COLOR 1            : REM Choose Bucket 1 again
 90 PLOT 20,5:
    PLOT 20,6
100 PLOT 19,7:
    DRAWTO 21,7
110 PLOT 19,9:
    DRAWTO 21,9
120 SETCOLOR 1,3,6     : REM Change to Red
130 SETCOLOR 2,12,6    : REM Change to Green
140 FOR I=1 TO 50:
    NEXT I             : REM Pause
150 SETCOLOR 1,0,0     : REM Change to Black
160 SETCOLOR 2,0,0     : REM Change to Black
170 FOR I=1 TO 400
180 IF RND(0)*20<1 THEN
      SETCOLOR 4,0,14:
      SETCOLOR 4,0,0   : REM Random lightning flash
190 NEXT I
200 GOTO 120
```

When you execute this program, you will see a crude airplane heading toward you with red and green lights blinking at the tips of its wings. Every so often, the background will flash as if the plane were flying through a lightning storm.

Lines 120-130 turn on the wing lights. After a pause, lines 150-160 turn them off. SETCOLOR 1 changes the color of the pixel plotted with COLOR 2, and SETCOLOR 2 changes the pixel plotted with COLOR 3. (If this seems a little confusing, refer back to table 1 to see the relationship between the SETCOLOR and COLOR commands.)

If the value of the random number expression on line 180 is less than 1 (1 chance in 20, or 5 percent), the lightning is turned on and off by setting the background color register first to white and then immediately back to black. As you can see in table 1, SETCOLOR 4 controls the screen background.

We could have created the blinking wing lights by replotting the tips with the background color. This technique executes much more slowly than one that changes just the color registers. Although we don't need the speed in this case, the effect would be slightly different. Notice that during the lightning flash the darkened wing lights are silhouetted against the sky. This effect could not be easily duplicated on a computer without color registers.

Using POKEs to Change Colors

Referring back to table 1, you'll notice the POKE column. Each color register has an address in memory associated with it. The value in the color register can be changed by using a POKE command to put a new value into this address. In GRAPHICS 10, the only way to change the values in the first four color registers is with the use of a POKE. To obtain the value to place into a memory location, take the hue value of the color and multiply by 16, then add in the luminance value:

POKE *addr*, *hue* * 16 + *luminance*

In GRAPHICS 7, for example, the following two statements would be equivalent:

SETCOLOR 0,4,8 POKE 708,72

To see why, first find the SETCOLOR 0 row for GRAPHICS 7 in table 1. Then move one column to the right to find the address 708. Multiply the hue in the above SETCOLOR command by 16 ($4 \times 16 = 64$), add the luminance value to it ($64 + 8 = 72$), and you have your POKE value. In many cases, you may want to use a POKE command instead of SETCOLOR because POKE will execute more rapidly. This is because it takes time for BASIC to do the necessary conversion from SETCOLOR's hue and luminance values to a single value that it then puts into the proper address by using POKE. You speed up the process by precalculating the value while you are *writing* your program. Then, you have

Hue	Value for SETCOLOR Command (*hue*)
Gray	0
Light Orange (Gold)	1
Orange	2
Red-Orange	3
Pink (Magenta)	4
Purple	5
Purple-Blue	6
Azure Blue (Cyan)	7
Sky Blue	8
Light Blue	9
Turquoise	10
Green-Blue	11
Green	12
Yellow-Green	13
Orange-Green	14
Light Orange	15

Table 2: *The hues available on the Atari 400/800 and their corresponding values to be used in the SETCOLOR command.*

Command	Hue	Luminance	Color Result
SETCOLOR 4, 0, 14	Gray	14	White
SETCOLOR 4, 0, 0	Gray	0	Black
SETCOLOR 4, 1, 4	Light Orange	4	Brown
SETCOLOR 4, 1, 12	Light Orange	12	Bright Yellow
SETCOLOR 4, 3, 4	Red-Orange	4	Deep Red
SETCOLOR 4, 3, 12	Red-Orange	12	Flesh

Table 3: *Some examples of SETCOLOR commands and the colors that result.*

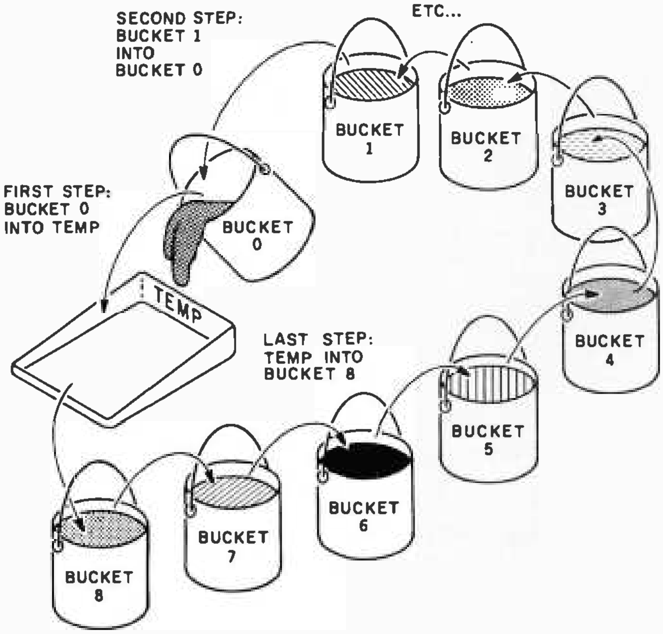

Figure 1: *An analogy showing how colors can be rotated through color registers to simulate movement. In this case, paint is transferred from one bucket to another.*

BASIC just use POKE to place it in during execution.

This technique can be used to rapidly flash the background when simulating an explosion with the following line:

```
100 FOR I=1 TO 10:
       POKE 712, RND(0)*255:
    NEXT I:
    POKE 712,0: REM Flash background
```

This line selects 10 random colors to flash on the background and then resets the background color to black.

Now type in the following short program and see what happens:

```
10 GRAPHICS  3+16
20 FOR I=0 TO 254 STEP 2     : REM Step through
                               every color
30    POKE 712, I            : REM Change back-
                               ground color
50 NEXT I
60 GOTO 20
```

When you run it, your screen will flash through all the colors so quickly that you will hardly be able to see them. Add the following line to slow it down to human speeds:

```
40     FOR W=1 TO 50:
       NEXT W
```

Try doing *this* trick without color registers!

Thus, color registers can be used to rapidly change portions of the screen with a simple SETCOLOR or POKE. But what purpose do they serve for animation? Next, the real power of color registers will be explored in two amazing demonstration programs.

Creating Motion with Color Registers

With careful planning, the ability to change the color of a specific area on the screen instantaneously can be used to create the effect of high-speed motion without resorting to assembly-language programming.

To understand how to create motion using color registers, consider our paint store analogy again. It had nine paint buckets numbered from 0 to 8, each filled with a different color. Now, let's add a temporary paint tray called TEMP. We are going to use the nine buckets and the tray to play "pass the colors" (see figure 1). First, empty the paint contained in Bucket 0 into the temporary tray. Then pour Bucket 1's contents into the now empty Bucket 0. Next, pour the paint in Bucket 2 into Bucket 1. Continue passing the colors until Bucket 8 is emptied into Bucket 7. No more buckets are left with which to fill Bucket 8. Stored in TEMP, however, we still have the paint that first filled Bucket 0. So we take the paint in TEMP and empty it into Bucket 8. Then we go back to the very first step and empty the paint now in Bucket 0 into TEMP (this is called a "bucket brigade" in elec-

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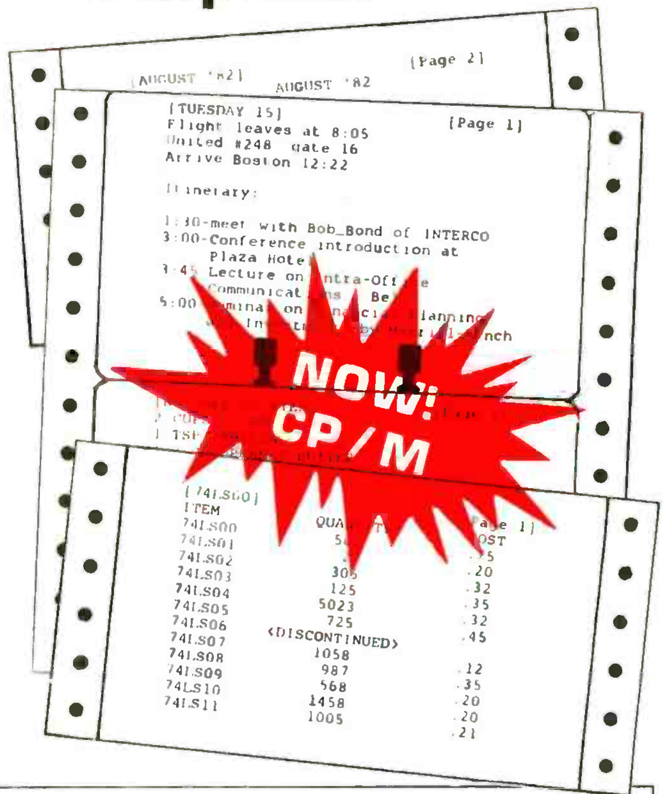

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Listing 1: *A program in Atari BASIC simulating movement through a* Star Wars*-like trench. The animation effect is achieved entirely through the use of color-register animation. Note that the listing has been structured for easy reading. When the program is entered into the computer, normal Atari line structures should be used.*

```
10  REM        *** THE TRENCH ***
20  REM
30  REM
40  REM Program to create the illusion of flying through a trench by rotating
50  REM the Color Registers in GRAPHICS 7
60  REM Copyright (C) 1982 by David Fox and Mitchell Waite
70  REM
80  GOTO 200
90  REM
100 REM Rotate the Colors
110 SOUND 3,255,0,8: REM Background roar (always on)
120 REM If the trigger on PADDLE 0 is pressed, reverse the direction
130 IF PTRIG(0)=1 THEN
      TEMP=PEEK(710):
      POKE 710,PEEK(709):
      POKE 709,PEEK(708):
      POKE 708,TEMP:
      GOTO 150: REM Not pressed
140 TEMP=PEEK(708):
    POKE 708,PEEK(709):
    POKE 709,PEEK(710):
    POKE 710,TEMP: REM Pressed
150 PDL=PADDLE(0)/5: REM Speed and sound controlled by PADDLE 0
160 SOUND 0,PDL,0,8:
    SOUND 1,PDL+80,0,8:
    SOUND 2,PDL+160,0,8
170 FOR PAUSE=1 TO PDL:
    NEXT PAUSE
180 GOTO 130
190 REM
200 REM Initialize
210 COL=1:
    Y1=45:
    Y2=49
220 REM
300 REM Draw Trench on Screen
310 GRAPHICS 7+16: REM Full screen graphics
320 SETCOLOR 0,3,8: REM Set Color Register values
330 SETCOLOR 1,3,8
340 SETCOLOR 2,3,4
350 FOR X=2 TO 79: REM Increment horizontal coordinates
360   COLOR INT(COL+0.5): REM Choose which Color Register to draw with
370   PLOT X+80,Y1:
      DRAWTO X+80,Y2:
      DRAWTO 79-X,Y2:
      DRAWTO 79-X,Y1
380   Y1=Y1-0.6:
      Y2=Y2+0.6: REM Increase vertical line length
390   IF Y1<0 THEN
        Y1=0: REM Prevent overflow
400   IF Y2>95 THEN
        Y2=95
410   COL=COL+(79-X)/160: REM Increment Color Register
420   IF COL+0.5>=4 THEN
        COL=COL-3
430 NEXT X
440 GOTO 100
```

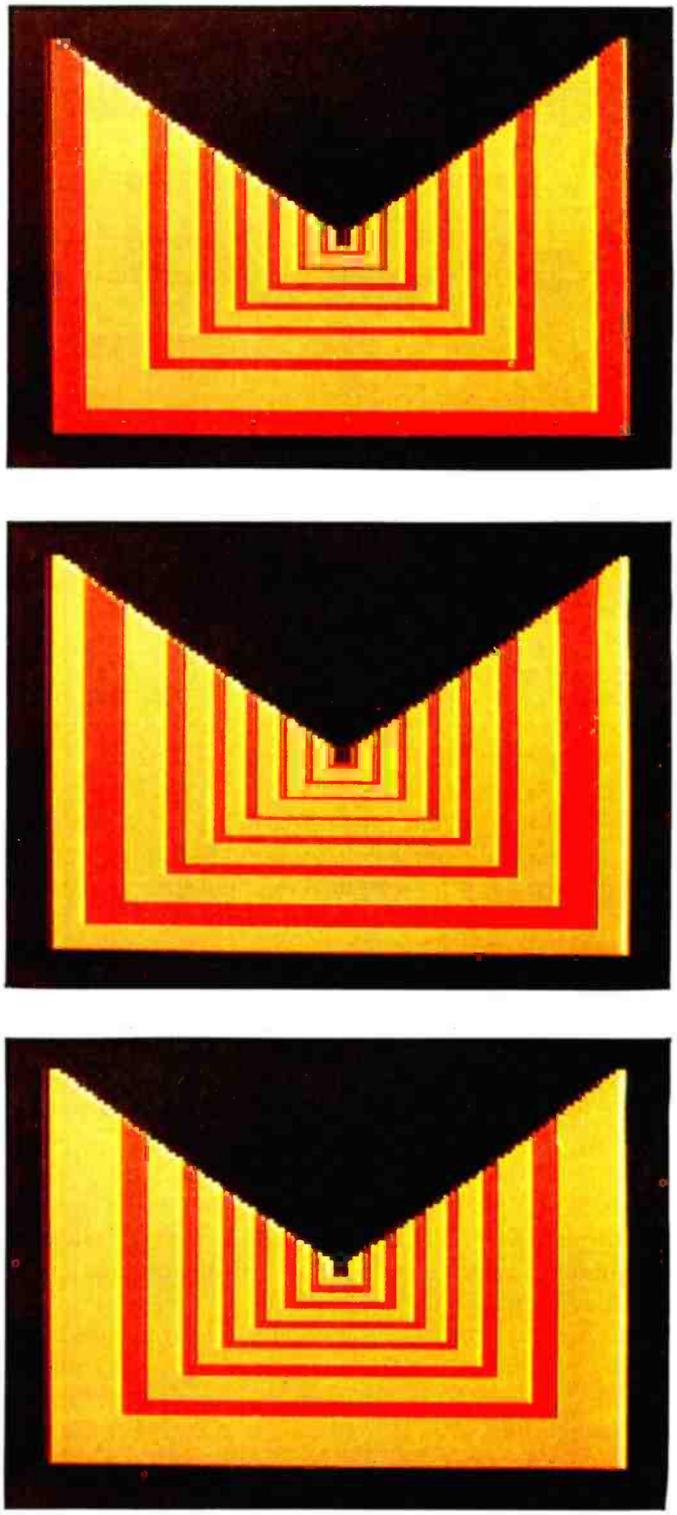


Photo 2: *Three displays generated by the program in listing 1 entitled "The Trench." The effect of movement is achieved by rapidly cycling two colors through three registers.*

tronics). We have just created an endless loop of moving colors that is seen on the screen as a rapidly changing pattern. Depending on what was drawn and how it was organized on the screen, a hypnotically abstract design or an exciting, realistic scene can be produced.

As animators, we must now "form" this pattern of moving colors into something interesting to look at.

The Trench Program

Everyone who saw the first *Star Wars* movie remembers the flight through the Deathstar's trench. In the next program, listing 1, we will use color-register animation to create this effect. We will be using GRAPHICS 7, which has a resolution of 160 by 96 and uses four color registers.

Our goal will be to draw a trench on the screen in GRAPHICS 7 in such a way that the viewer will have the experience of rapidly traveling through it (see photo 2). The trench will be U-shaped with two vertical sides and a horizontal bottom. Using a game paddle, the viewer will have control of speed through the trench and forward/reverse motion. The roar of the engines will change as the velocity changes. This program could be the core of an exciting game.

This program has three main sections: the initialize section, the section that draws the trench on the screen, and the section that animates the picture by rotating the colors and reading the game paddle. You'll notice that this

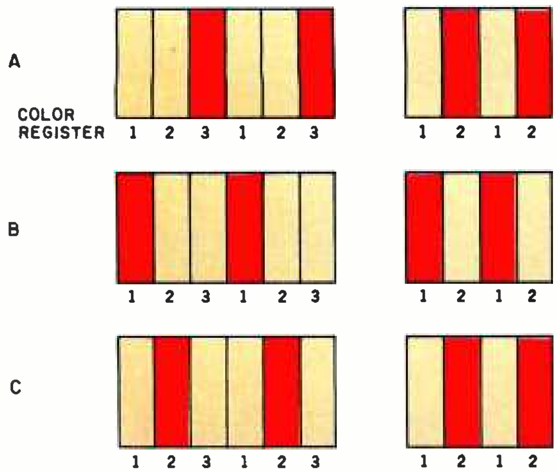


Figure 2: *Simulating movement by rotating two colors through three color registers. The use of three color registers (on the left) results in a smooth animation effect. If only two color registers are used (as on the right), there is just a flickering effect.*

The GTIA and CTIA Chips

When the Atari computer first came out, it had a special television interface chip called CTIA. Beginning in early 1982, all Ataris were manufactured with a new and better chip called GTIA. The GTIA supports three additional BASIC graphics modes, 9, 10, and 11, which were not available on the earlier Atari computers. The resolution on these modes is 80 by 192, yielding the same vertical resolution as GRAPHICS 8 (as well as the same memory consumption), but a much coarser horizontal resolution. GRAPHICS 9 allows the selection of one hue that can then be simultaneously displayed on the screen with 16 different luminances. GRAPHICS 11 allows the placement of up to 16 different hues on the screen, all set to the same luminance value. These two modes are not covered in the article because they can't be used for color-register animation. We do discuss GRAPHICS 10, however, which allows you to choose any nine colors from the Atari palette of 128 colors.

To tell whether your Atari has the CTIA or GTIA chip, enter and run the following program:

```
10 GRAPHICS 10
20 GOTO 20
```

If your screen first flashes black and then returns to blue, you have the CTIA. The program will still be running, but the CTIA chip will not be able to display a GRAPHICS 10 screen. If your screen stays black, congratulations! You have the GTIA and can run the Fall Waterfall program. If not, you can get your computer upgraded to the GTIA chip for a small fee. If you don't do this, you will miss out on many new Atari programs that require this chip.

last section was placed at the beginning of the program. It makes use of the fact that statements toward the beginning of an Atari BASIC program are executed at a faster rate than those at the end.

The drawing section was the hardest for us to write. It took quite a while to create a formula that could simulate the perspective of the trench. We could have drawn the trench on paper and just translated the plotting coordinates to the program, but that would have used much more memory.

Initialize (listing 1, lines 200-220). The initial values are set along with the colors to be drawn. Notice that two of the registers are set to the same color. Even though we are using three color registers in our animation sequence, only two colors will be passed through them. This yields a smoother animation effect (see figure 2). The three boxes, A, B, and C, show the progression of the two colors through the three registers. Even though the width of one of the moving colors is two bars wide, the step size of the movement is only one bar wide.

If only two colors and two registers were used, the viewer would just see the two colors alternating places. There wouldn't be any illusion of movement, just a flickering effect. With three colors and three registers, there would be too many colors in the trench and the effect would be spoiled.

Drawing the trench (lines 300-440). This section draws the trench on the screen using the appropriate color register. We start near the horizon, draw the three sides of the trench, and then move out toward the edges of the screen. The algorithms used here were all arrived at through trial and error. Line 370 increments the value of C in smaller and smaller steps as X (the horizontal position of the lines) increases. This creates the illusion of perspective—the closer the different-colored panels are to the viewer, the wider they appear.

Rotating the colors (lines 100-180). This program calls for sound effects and an element of interactiveness. Sound register 3 is used to give a constant background roar (line 110). The game paddle is used to control the speed through the trench (line 150) and to reverse the direction we are traveling (line 130). If the paddle button is pressed, we move backward (line 140). The POKEs in lines 130-140 could have been replaced with a FOR-NEXT loop that would have placed in each color register the contents of the next higher (or lower) color register, but this would have required much more execution time. In line 160, the position of the game paddle is also used to control the pitch of the other three sound registers. To add to the realism, the whine of the engine rises in pitch as velocity increases. Line 170 takes the paddle value and uses it to control a pause loop.

If you don't have game paddles, use a joystick to change the value in PDL. If the joystick is pushed forward, increment PDL; if it is pulled back, decrement PDL.

Now, moving from the excitement of outer space, we will visit a sylvan scene of the wilderness.

The Fall Waterfall Program

In this program, we will use GRAPHICS 10, the new graphics mode that is especially suited for color-register animation, as it allows us to use all nine Atari color registers (see the text box on the GTIA and CTIA chips).

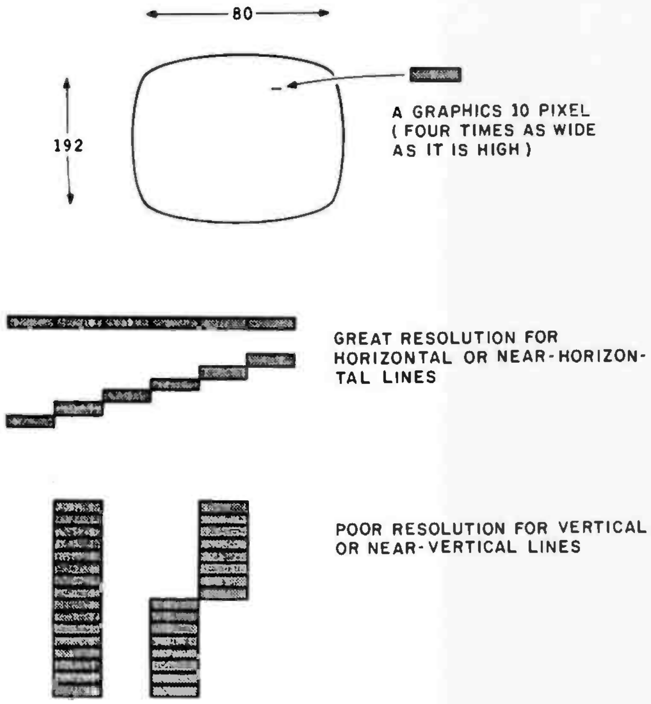


Figure 3: *Diagram illustrating the pixel shape in GRAPHICS 10, a new graphics mode (GTIA) for the Atari 400/800.*

We will draw an autumnal landscape complete with trees casting long shadows from an early morning sun. The scene is brought to life by a foaming waterfall cascading down a steep cliff and across a green valley.

Using the Amazing GRAPHICS 10

GRAPHICS 10 has a rather strangely shaped pixel (see figure 3). Each pixel is about four times as wide as it is high, with a screen resolution of 80 by 192, making it awkward to use when drawing curved surfaces. As you can see in the figure, lines that are almost horizontal show very fine resolution, and those that approach vertical are extremely coarse.

To change the values in the color registers for the standard CTIA graphics modes (0 through 8), you can use the SETCOLOR command. However, Atari BASIC isn't fully set up for the GTIA graphics modes. The only way to change the colors in the first four color registers of GRAPHICS 10 is by using POKE to put them directly into the color register's RAM (random-access read/write memory) address. Table 1 shows the relationship between this RAM address and the SETCOLOR command. Even though BASIC's SETCOLOR isn't adequate in GRAPHICS 10, BASIC's COLOR command *can* be used to choose any of the registers for painting. For example, to draw orange (hue 2, luminance 8) pixels on the GRAPHICS 10 screen with register 1, use the following statements:

```
POKE 705,40 : REM Fill register 1 with orange
              (hue=2, lum=8)
COLOR 1     : REM Select register 1 for
```

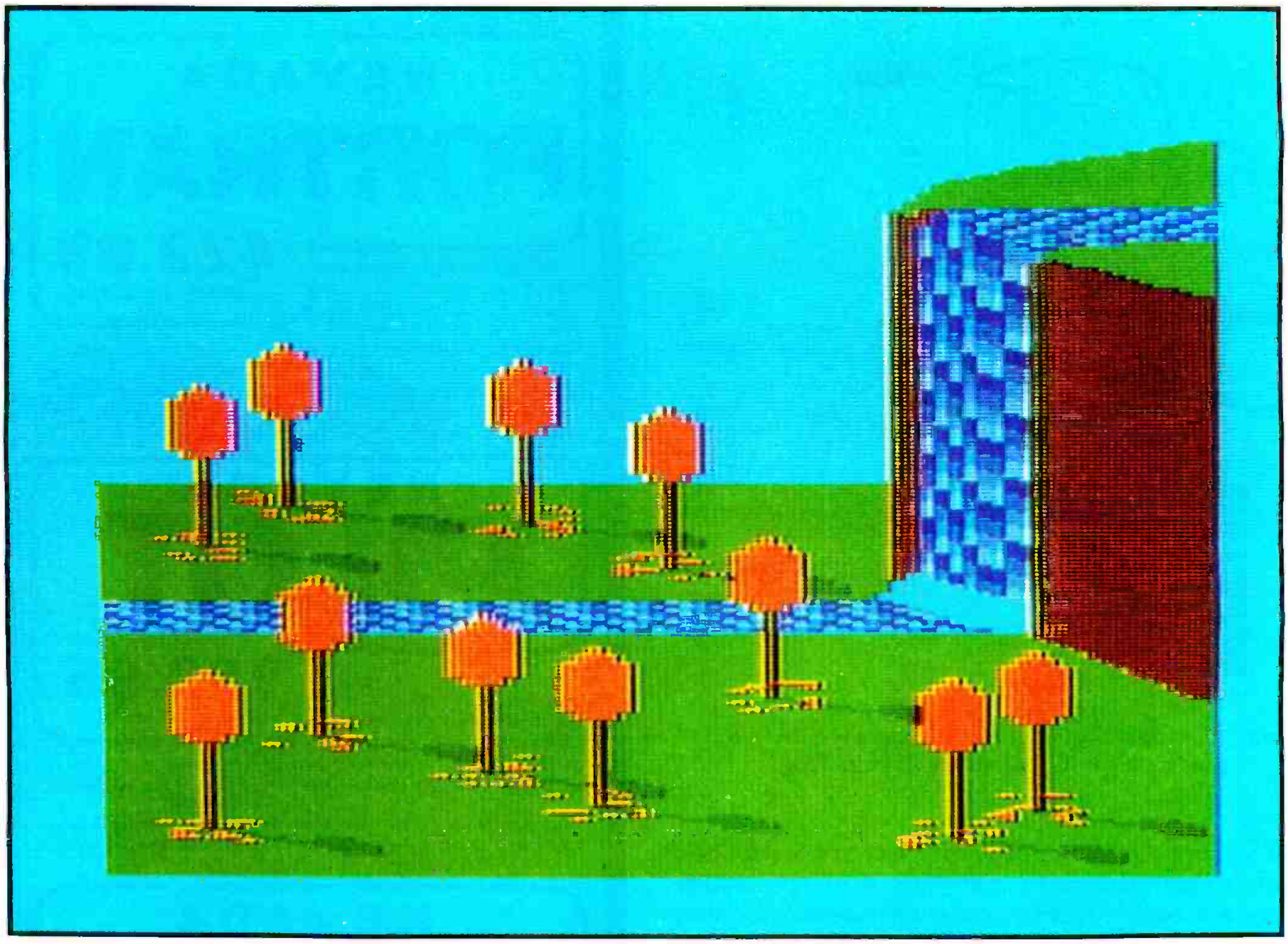


Photo 3: *An autumnal waterfall scene produced by the program in listing 2. The effect of moving water is produced by cycling different shades of blue through the color registers.*

```
                drawing
PLOT X,Y      : REM Place an orange pixel at
                X,Y
```

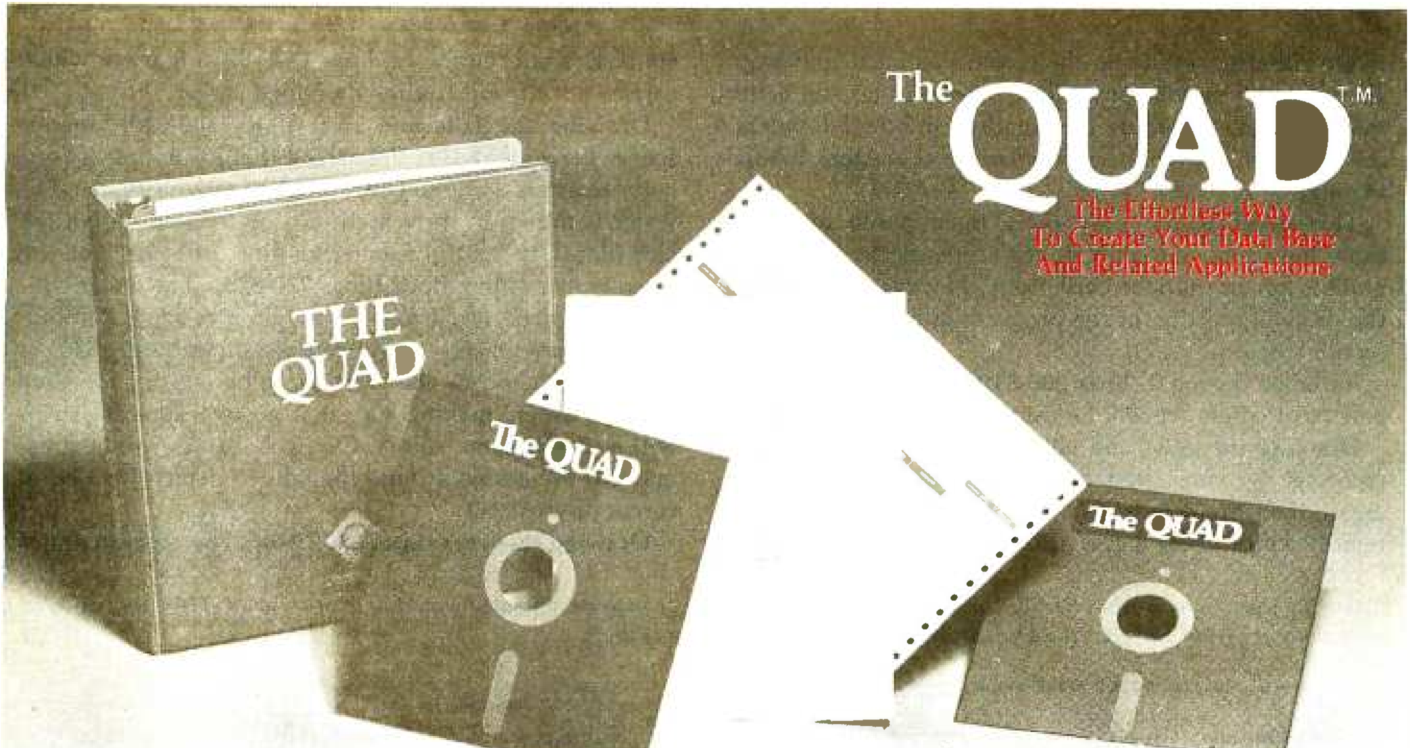
To draw with register 6, you could use either the SETCOLOR command *or* a direct POKE:

```
SETCOLOR 2,2,8      or      POKE 710,40
```

Because of the complexity of our autumnal waterfall scene (see photo 3), this program is quite a bit longer than the last one. The section that actually animates the scene, however, is only three lines long. This reveals that much of our Atari animation involves "setup," whereas the actual "motion code" is simple.

Even though we have nine color registers to play with on a GTIA Atari, we seldom use *all* of them for color rotations in an animated scene. Only four color registers will be used for the program's animation. The other five registers will be used to draw the landscape. This takes some planning because there is an interdependency between what we want to include in the picture and how many colors can be used. One way to plan the picture is to keep adding details as long as colors are left. That's the method we used. The background register was used for the sky, another register for the brown cliffs, and a third for the grass covering the top of the cliff and the valley floor. Since that left two unused registers, we planted trees across the valley floor. The brown of the cliffs was also used for the trunks of the trees, and the treetops were painted orange-red to add some color. Finally, a darker shade of green was used in the last register for tree shadows. The foam at the base of the waterfall was drawn with the sky's color rather than one of the waterfall's colors, because we didn't want its color to change at all. No more registers were left for new colors. Therefore, the scene was completed.

To make it easier to color large areas of the screen rapidly, the Atari operating system's built-in "Fill" routine is used. Unfortunately, this Fill is not the same as the FILL or FLOOD used in professional computer paint systems. Atari's Fill will not seek out all the adjacent nooks and crannies within the area to be filled. Since it's more of a "box" fill, it just draws a series of horizontal lines toward the right of the screen. Each line is completed when it hits a nonbackground color. Even worse is the fact that there is no simple Atari BASIC statement to implement this routine (although there is a FILL statement in Atari Microsoft BASIC). Instead, we must use a special call to the OS (using the XIO command) to ac-



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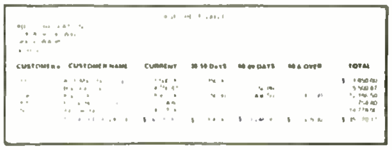

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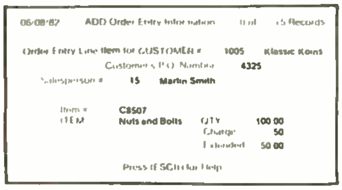
SAMPLE SCREEN:



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tivate Fill after setting up the screen in a particular way. This makes it very inconvenient to use, but it's still better than nothing. (For more information on how Fill works, see *Computer Animation Primer* or the Atari BASIC manual.)

This program has only three main parts: initialize, draw the scene, and animate the scene. Because the program is longer than the earlier one, however, we divided the drawing portion of the program into several smaller sections (see listing 2).

Initialize (listing 2, lines 200-310). Here we set up the palette of colors we will be using.

Drawing the grass and cliff (lines 400-490). As in oil painting, we must first paint in the large background areas, then the details. We are using the Fill routine to rapidly color these large areas. To make this process simpler, a subroutine on lines 1300-1310 is used, which carries out the Fill routine described earlier.

Drawing the falls and river (lines 500-820). In our scene, the water is the only thing that is animated. Four color registers are used to animate the moving water. The water is drawn in three sections: the river on top of the cliff (lines 510-600), the waterfall (lines 610-720), and the river on the valley floor (lines 730-820). The water consists of a series of parallel strips. To give some randomness to these strips, a subroutine (lines 1500-1530) is called that chooses the starting color register for each strip of water, making sure that no two adjacent strips will have the same colors. On lines 710-720, some grass and dirt are added around the falls to depict the natural forces of erosion.

Drawing the trees (lines 900-1070). This section draws

Listing 2: *A program in Atari BASIC for generating an autumnal scene with an animated waterfall. Note that a GTIA chip is needed to run this program and that the listing has been structured for easy reading.*

```
10  REM *** FALL WATERFALL ***
20  REM
30  REM
40  REM Demonstration of animating a scene by rotating the Color Registers
50  REM (Uses GRAPHICS 10 - GTIA is needed)
60  REM Copyright (C) 1982 by David Fox and Mitchell Waite
70  REM
80  GOTO 200
90  REM
100 REM Rotate the Colors
110 TEMP=PEEK(705):
    POKE 705,PEEK(706):
    POKE 706,PEEK(707):
    POKE 707,PEEK(708):
    POKE 708,TEMP
120 FOR WT=1 TO 5:
    NEXT WT
130 GOTO 110
140 REM
200 REM Initialize
210 FILL=1300
220 GRAPHICS 10
230 POKE 704,9*16+10: REM Sky - COLOR 0
240 POKE 705,8*16+10: REM Water - COLOR 1
250 POKE 706,8*16+8: REM Water - COLOR 2
260 POKE 707,8*16+6: REM Water - COLOR 3
270 SETCOLOR 0,8,4: REM Water - COLOR 4
280 SETCOLOR 1,12,4: REM Tree shadow - COLOR 5
290 SETCOLOR 2,2,4: REM Cliff & tree trunks - COLOR 6
300 SETCOLOR 3,12,6: REM Grass - COLOR 7
310 SETCOLOR 4,3,6: REM Treetops - COLOR 8
320 REM
400 REM Draw Grass and Cliff
410 COLOR 7:
    POKE 765,7: REM The grass
420 PLOT 79,10:
    DRAWTO 79,45:
    X1=78:
    Y1=10:
    X2=66:
    Y2=15:
    GOSUB FILL
430 X1=65:
    Y1=15:
    X2=61:
    Y2=18:
    GOSUB FILL:
    X1=60:
    Y1=18:
    X2=56:
    Y2=25:
    GOSUB FILL
440 X1=56:
    Y1=25:
    X2=65:
    Y2=35:
    GOSUB FILL:
    X1=66:
    Y1=35:
    X2=78:
    Y2=45:
    GOSUB FILL
450 COLOR 6:
    POKE 765,6: REM The cliff
460 PLOT 79,46:
    DRAWTO 79,145:
```


Listing 2 continued:

```
    X1=56:
    Y1=26:
    X2=56:
    Y2=117:
    GOSUB FILL
470 Y1=117:
    X2=68:
    Y2=132:
    GOSUB FILL:
    X1=68:
    Y1=132:
    X2=78:
    Y2=145:
    GOSUB FILL
480 COLOR 7:
    POKE 765,7: REM More grass
490 PLOT 0,191:
    DRAWTO 79,191:
    DRAWTO 79,146:
    X1=0:
    Y1=191:
    X2=0:
    Y2=91:
    GOSUB FILL
500 REM Draw the Falls and River
510 FALL=58:
    CFLAG=0: REM Draw the river on top of the cliff
520 FOR Y=25 TO 34
530   GOSUB 1500
540   FOR X=79 TO FALL STEP -1
550     COLOR COL
560     PLOT X,Y
570     COL=COL-1:
        IF COL=0 THEN
          COL=4
580   NEXT X
590   FALL=FALL+1
600 NEXT Y
610 FALL=0:
    CFLAG=-1: REM Draw the falls
620 FOR X=58 TO 66
630   FALL=FALL+1
640   GOSUB 1500
650   PLOT X,25+FALL
660   FOR Y=30 TO 120 STEP 4
670     COLOR COL
680     DRAWTO X,Y+FALL
690     COL=COL-1:
        IF COL=0 THEN
          COL=4
700   NEXT Y:
    NEXT X

710 COLOR 6:
    PLOT 58,28:
    DRAWTO 58,25:
    DRAWTO 59,25:
    PLOT 66,38:
    DRAWTO 66,129: REM Cleanup
720 COLOR 7:
    PLOT 73,33:
    DRAWTO 79,33:
    PLOT 68,34:
    DRAWTO 79,34
730 FALL=57:
    CFLAG=1: REM Draw the river on the valley floor
740 FOR Y=121 TO 128
750   GOSUB 1500
760   FOR X=FALL TO 0 STEP -1
770     COLOR COL
780     PLOT X,Y
790     COL=COL-1:
        IF COL=0 THEN
          COL=4
800   NEXT X
810   FALL=FALL+1
820 NEXT Y
830 REM
900 REM Draw the Trees
910 FOR T=1 TO 11
920   READ X,Y
930   COLOR 8: REM Treetop
940   FOR I=0 TO 2:
        PLOT X-I,Y-40+2*I:
        DRAWTO X-I,Y-20-2*I:
      NEXT I
950   FOR I=-2 TO -1:
        PLOT X-I,Y-40-2*I:
        DRAWTO X-I,Y-20+2*I:
      NEXT I
960   COLOR 6: REM Tree trunk
970   PLOT X,Y:
      DRAWTO X,Y-21
980   COLOR 5: REM Shadow of tree
990   PLOT X,Y+1:
      DRAWTO X+7,Y+4:
      PLOT X+8,Y+3:
      DRAWTO X+8,Y+5:
      DRAWTO X+9,Y+6
1000  DRAWTO X+9,Y+3:
      DRAWTO X+10,Y+3:
      DRAWTO X+10,Y+7
1010  PLOT X+11,Y+7:
      DRAWTO X+11,Y+4:
      DRAWTO X+12,Y+5:
      DRAWTO X+12,Y+7
1020  COLOR 8: REM Fallen leaves around tree trunk
1030  FOR I=1 TO 15
1040    RX=X+INT(RND(1)*7)-3:
        IF RX=X THEN 1040
1050    RY=Y+INT(RND(1)*8)-3:
        PLOT RX,RY
1060  NEXT I
1070 NEXT T
1080 REM
1100 REM Draw the Foam
1110 COLOR 0: REM Same color as the sky
1120 PLOT 57,114:
     DRAWTO 65,122
1130 PLOT 57,115:
     DRAWTO 65,123
1140 PLOT 57,116:
     DRAWTO 65,124
1150 PLOT 56,116:
     DRAWTO 65,125
1160 PLOT 56,117:
     DRAWTO 65,126
1170 PLOT 56,118:
     DRAWTO 65,127
1180 PLOT 56,119:
     DRAWTO 65,128
1190 PLOT 55,119:
     DRAWTO 64,128
1200 PLOT 55,120:
     DRAWTO 63,128
1210 REM
1250 REM Turn on the Sound
1260 FOR I=0 TO 3:
       SOUND I,I*50,0,8:
     NEXT I
1270 GOTO 100
1280 REM
1300 REM Fill Subroutine
1310 PLOT X1,Y1:
     POSITION X2,Y2:
     XIO 18,#6,0,0,"S:":
     RETURN
1320 REM
1500 REM Choose Color
1510 COL=INT(RND(1)*4)+1:
     IF COL=STARTCOL THEN 1510:REM No two adjacent strips with same color pattern
1520 STARTCOL=COL+CFLAG: REM Calculate next starting color to avoid
1530 IF STARTCOL=0 THEN
       STARTCOL=4
1540 IF STARTCOL=5 THEN
       STARTCOL=1
1550 RETURN
1560 REM
2000 REM Data for Location of Trees
2010 DATA 7,106,13,96,30,100,40,112,47,145,7,179,15,155,27,164,35,173,60,181,66,174
```

11 identical trees. The x and y "base" coordinates for the trees are stored on line 2010. An x,y coordinate pair is read and a new tree is drawn at that location. Lines 980-1010 add realism by creating a shadow in a darker shade of green. Lines 1020-1060 create some randomness by scattering 15 leaves about the base of each tree.

Drawing the foam (lines 1100-1200). As the water hits the base of the falls, white foam is created. Since no color registers are left for white foam, the sky color is used again.

Turning on the sound (lines 1250-1270). All the sound registers are used to create the roar of the waterfall. The sound is constant and does not need to be changed.

Rotating the colors (lines 100-130). This section is similar to the corresponding sections in the other program. Of course, we need to rotate only the color registers for the four colors of the water.

Modifications. We can also modify the scene by doing the following:

- Simulate a sunset by gradually changing the sky color to orange, pink, and purple, and by decreasing the luminance values of each of the color registers. Then, after a period of time, we can reverse the process for a sunrise.
- Change this program into a representation of the different seasons of the year. Simply by changing the colors in the appropriate registers, you could turn this into a summer scene (i.e., by turning the treetops green). And by altering the color of the grass and treetops to white, the sky to gray, and slowing or stopping the flow of the river, you can create a winter scene.

Summary

The increase in performance from pixel-to-pixel mapping to color mapping using color registers is an enormous one. Animation and special effects never before thought possible can now be accomplished on personal computers with very few program statements. As we have shown with our Trench program, color mapping makes it possible to create dramatic motion effects and perspective changes, similar to those used in arcade games, on a low-cost computer like the Atari 400/800. Furthermore, for the Chagalls and Rembrandts of the world, wonderful and complex background scenes can be brought to life with just the briefest of program statements (as witnessed by the Fall Waterfall program). But we have only scratched the surface of the Atari's animation power. User-definable character sets, player-missile graphics, fine scrolling, vertical-blank interrupts, and display-list interrupts can be combined with color mapping to give the Atari a performance edge that will probably never be equaled (except by Atari). The book *Computer Animation Primer* provides much detailed information for anyone interested in learning more about these computer-animation techniques.■

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The Victor 9000 Computer

Phil Lemmons
West Coast Editor

Microcomputers are proliferating because they can do so many tasks so well. Each time microcomputers take over another task, they threaten some old technology. As word processors, for example, microcomputers threaten the typewriter. As number crunchers, microcomputers threaten the calculator. Each company whose main product is threatened faces a hard choice: perish or become a computer company. What's more, such a company must make the right computer on the first try because the fierce competition in the microcomputer market gives few entrants a second chance. The rules permit only one roll of the dice in the game called "You bet your company."

Victor Business Products has been making calculators for 60 years. Victor saw the need to make a computer, and the Victor 9000 is Victor's roll of the dice. I've been lucky enough to have the use of a Victor 9000 for a few months, and I think the machine is an excellent microcomputer with an outstanding array of standard features.

Of course, the microcomputer business is not really a game of chance like dice, but a competition requiring judgment, expertise, and a variety of resources. Victor comes to the competition much better prepared than most new entrants. First of all, Victor is a subsidiary of Kidde Inc., a three-billion dollar conglomerate. Second, Victor has experience in designing and manufacturing microprocessor-based electronic products. Third, Victor has a great deal of experience in dealing with business people and the needs of the contemporary office. Fourth, Victor is starting out with a network of 50 branch offices in the United States to distribute and support the machine. Fifth, and perhaps most important, the chief designer of Victor's machine is not a novice but Chuck Peddle, a founder of the microcomputer industry who understands as well as anyone where the technology is going and how to bring maximum performance to the market at an affordable price. (In an interview starting on page 256 of this issue, Chuck Peddle discusses his goals in designing the Victor 9000 and makes some observations on trends in the microcomputer industry.)

Getting Started with the Victor 9000

Victor's experience has shown them that business people want a machine they can set on a desk, turn on, and use. As photo 1 shows, the Victor 9000 consists of a system unit, a detached keyboard with a coiled cable, and a monochrome monitor that can rest atop or alongside the system unit. The system unit and keyboard fit comfortably on a standard typing table, or on a cluttered desk designed before microcomputers came out. While the Apple III occupies 361 square inches and the IBM Personal Computer 420 square inches, the Victor 9000 takes up only 310. If you buy the machine directly from your local Victor branch office, Victor will deliver the machine, set it up, connect the cables, and make sure everything is working. The Operators' Reference Manual takes it from

Photo 1: *The Victor 9000 microcomputer, consisting of a system unit, keyboard, and high-resolution green-phosphor video monitor that tilts and swivels.*

there. It tells you how to turn on the machine and insert the user-orientation disk that comes inside the manual's front cover. Once turned on, the machine reinforces the manual's advice: the bottom of the monitor's screen shows the image of a little floppy disk with an arrow indicating you should put a disk into a drive. The user-orientation disk displays a menu that leads you into explanations of how to back up the system disk, how to control the volume of the Victor 9000's speaker, how to set the numeric keypad so that it works just like a calculator, how to use the keyboard, how to control the display, how to use the fundamental commands of the operating system, and so on. The Operators' Reference Manual explains how to run applications programs, and each program sold by Victor has its own instructional manual. At least two of these programs have their own disk-based tutorials, too. In short, you can set the machine on a desk, turn it on, and start to use it.

Standard Equipment: Complete and Versatile

Some computer systems today are sold "unbundled," that is, in parts. This makes the initial purchase price seem low. For example, you can buy a $1500 computer that lacks interfaces for a modem or a printer, doesn't have enough system memory to run a major applications program, and has no high-speed mass storage at all. To be sure, you can complete such a system by ordering all the necessary components one by one, but dining a la carte is always more expensive than ordering a full dinner. If the unbundled system is an IBM Personal Computer or an Apple II Plus, the buyer can save money by buying many of the components from third-party manufacturers. But that can make it harder for owners to get service for their completed machines, mainly because the manufacturer of the system unit can't be expected to support an add-on product.

The standard Victor 9000 costs $4995. Although it is an open-bus system with slots for adding boards, the Victor 9000 isn't just a lonely 8088 sitting in a box of empty slots and sockets. The Victor 9000 comes with 128K bytes of RAM (random-access read/write memory) on the system board, two 612K-byte disk drives, two serial I/O (input/output) ports, two parallel ports, a truly high-resolution video monitor, a choice of three keyboards with up to 103 keys, an amplifier and accompanying speaker, and a CODEC (coder-decoder) that can digitize and reconstruct a real human voice. This standard hardware configuration leaves four bus slots open. Even if you increase memory to 896K bytes, the machine still has two empty slots. The standard purchase price also includes the two most popular operating systems for the 8086/8088 processors—Digital Research's CP/M-86 and Microsoft's MS-DOS. Documentation is good, too. The Operators' Reference Manual is clearly written, beautifully typeset and printed, and carefully coordinated with a menu-driven user-orientation program that is the best I've seen. (There *are* hardware options on the Victor 9000; I'll discuss them later.)

All the hardware features are flexible. In one case, the flexibility is mechanical: a cleverly designed turntable on top of the system unit enables the monitor to tilt as much as 11 degrees and swivel as much as 42 degrees in either direction. Most of the hardware is flexible, however,

At a Glance

Name
Victor 9000

Manufacturer
Victor Business Products
3900 North Rockwell St.
Chicago, IL 60618

Hardware
Size: width 15 inches, depth 13 inches, height 7 inches; weight (including two disk drives) 28 pounds
Electrical needs: input voltage, 95–137 V AC, 190–270 V AC; input frequency, 47–63 Hz
Processor: Intel 8088
Cycle time: main storage, 333 ns; access time, 333 ns
Memory: 16K bytes of built-in ROM and 128K bytes of built-in user RAM; expandable to 896K bytes
Standard: keyboard; two disk drives; four expansion slots; built-in speaker; CODEC (coder-decoder for digitized voice); power-on self-test; 128K bytes of dynamic RAM, 4K bytes of static graphics RAM, 16K bytes of ROM; two 612K-byte floppy-disk drives; high-resolution (800 by 400) green-phosphor monitor with antiglare screen, tilt and swivel; two programmable asynchronous/bisynchronous RS-232C serial I/O ports; two parallel I/O ports, one Centronics standard, one 50-pin KK; MS-DOS and CP/M-86 operating systems; choice of three keyboards, detached, with numeric pad and up to 103 keys, cursor controls, editing keys, programmable function keys
Disk drives: two 612K-byte 5-inch, single-sided floppy-disk drives; average access time, 235 ms; track-to-track stepping time, 3 ms

Software
Operating Systems: CP/M-86, MS-DOS, Unix (to be available first quarter 1983)
Languages: Microsoft GW-BASIC, price to be determined; Microsoft BASIC-86, $400; CBASIC-86, $400; MS-Pascal, $600; MS-FORTRAN, $600; MS-COBOL, $800; Microfocus Level II COBOL, $1100, with Forms 2, $1300
Applications:
Word processing: Victorwriter I (Select), $500; Victorwriter II (Benchmark), $645, with mailing list, $890; Wordstar, $500, with Mailmerge, $700
Electronic spreadsheets: Victorcalc (Report Manager), Multiplan, Supercalc, $300 each
Database management: dBase II, $695
Accounting: accounts payable, accounts receivable, general ledger, payroll
Other: order processing, inventory control, purchase-order writing, Time Manager (scheduling), Project Manager, Personnel Manager, Victor Pharmacy System, Victor Business Equipment Dealers System, Victor Financial and Banking System, installment lending, communications

Hardware Prices
Standard system with system unit, 128K bytes of RAM, two single-sided disk drives, keyboard, monitor, CP/M-86, MS-DOS, $4995
System with double-sided floppy disks, $5950
Winchester disk and controller, 10 megabytes (formatted), $4495
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because it is "soft-tooled," i.e., under software control. Every key on the keyboard can be programmed, not just the 10 programmable function keys. If you don't like the typefaces displayed on the screen, you can design your own with a utility called CEDIT. The serial ports can be programmed for both asynchronous and bisynchronous communications. In the same spirit of adapting to everyone's needs, Victor is offering a variety of applications software—more than one application program for every common major task.

The System Unit

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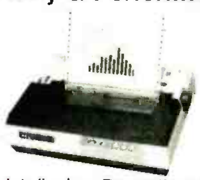

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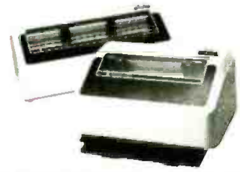

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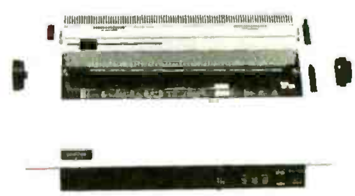

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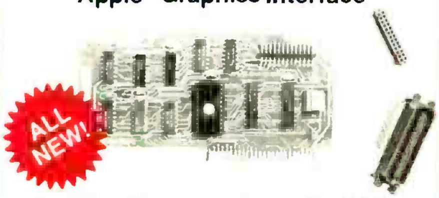

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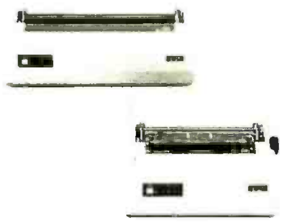

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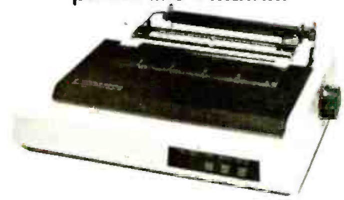

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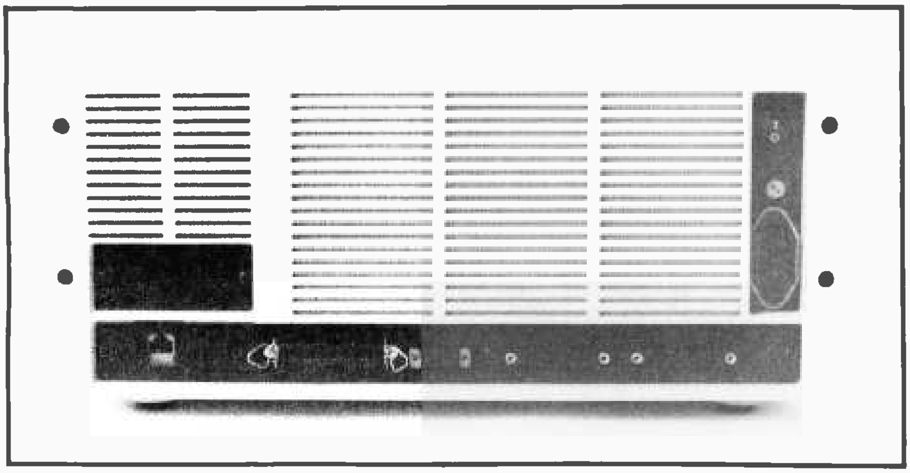

Photo 2: *The back of the system unit. Shown from left to right are the keyboard connector, reset button, Centronics-compatible parallel port, video-display-terminal connector, two RS-232C serial ports, and power connector. The on-off switch is just above the power connector.*

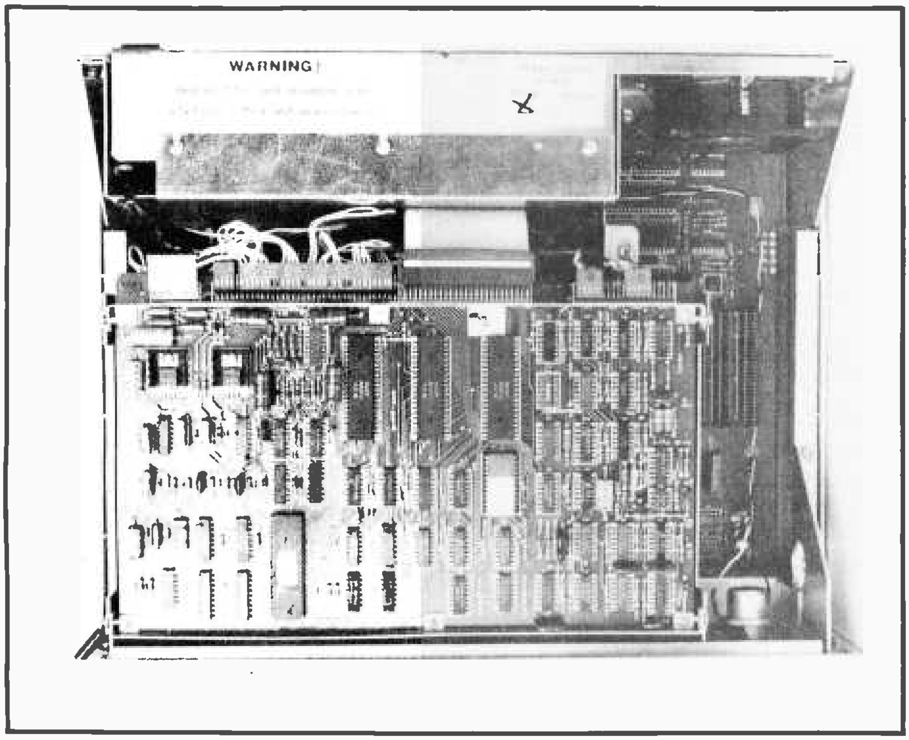

Photo 3: *The inside of the system unit viewed from above. The disk-controller board appears at the top, the power supply at the bottom, the speaker at the upper left, and two of the four expansion slots at center left. The disk-controller board hides the other two expansion slots at left and the 8088 processor, which is at the extreme right.*

serial ports, the monitor, and two parallel ports. Connectors for the serial ports and the keyboard and monitor are on the back of the system unit, shown in photo 2. One of the parallel ports comes out to the back of the system unit with a 36-pin connector that uses standard Centronics pin assignments. With a special 24-pin connector and appropriate software, you can use this port to connect an IEEE-488 device to the Victor 9000. The second parallel port has a 50-pin KK-type connector on the main printed-circuit board. This port, called the "user" port, is also fully programmable.

The main printed-circuit board contains an Intel 8088 microprocessor, 128K bytes of RAM in the form of sixteen 64K-bit chips (parity memory is an option), 16K bytes of ROM (read-only memory), 4K bytes of static RAM, a real-time clock, an expansion bus with four empty slots, a programmable serial-communications chip, parallel I/O chips, an 8259 programmable interrupt controller (to support real-time, multi-user, and multitasking operations), a CRT-controller chip, and the 50-pin parallel port mentioned earlier. Photo 3 shows the inside of the system unit viewed from above. The custom floppy-disk controller board hides the disk drives and most of the system board. Photo 4 shows the system board after removal of the drives. Figure 1 shows a block diagram of the Victor 9000.

The 8088 is a 16-bit microprocessor that does all I/O 8 bits at a time. Two separate 8-bit data buses, the ID bus and the BD bus, are in use in the Victor 9000. All the Victor 9000's LSI (large-scale integration) I/O devices (including the ones on the disk-controller board) are driven from a separate data bus consisting of lines ID0-ID7. Memory, the expansion bus (see table 1 on page 230), and the buffers for the ID bus are driven by the bus consisting of lines BD0-BD7. The programmable interrupt controller and the "boot" ROM connect directly to the processor data bus.

The system clock runs at 15 MHz and the 8088 runs at 5 MHz, or slightly faster than the 8088 in the IBM Personal Computer. The cycle time for main memory is 333 nanoseconds (ns); the access time is also 333 ns.

The 8259 programmable interrupt controller provides eight levels of prioritized interrupts, that is, signals to the 8088 that something else has to be attended to. One interrupt lets the disk controller indicate the readiness of a sector header from a disk drive; one interrupt is for the serial ports; one interrupt is for the real-time clock and other timed operations; one interrupt is for parallel I/O chips, including the chip that communicates with the CODEC; two interrupts are for the expansion bus, to be controlled by boards to be added there; one interrupt is for the keyboard; and one is for the CRT (cathode-ray tube) controller.

The 8088 can address a megabyte

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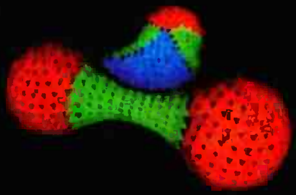
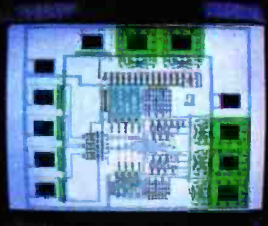


"*Three Atoms*" Courtesy of Greg Abram, University of North Carolina at Chapel Hill

"*Aurora*" By Richard Katz, Vectrix Corporation



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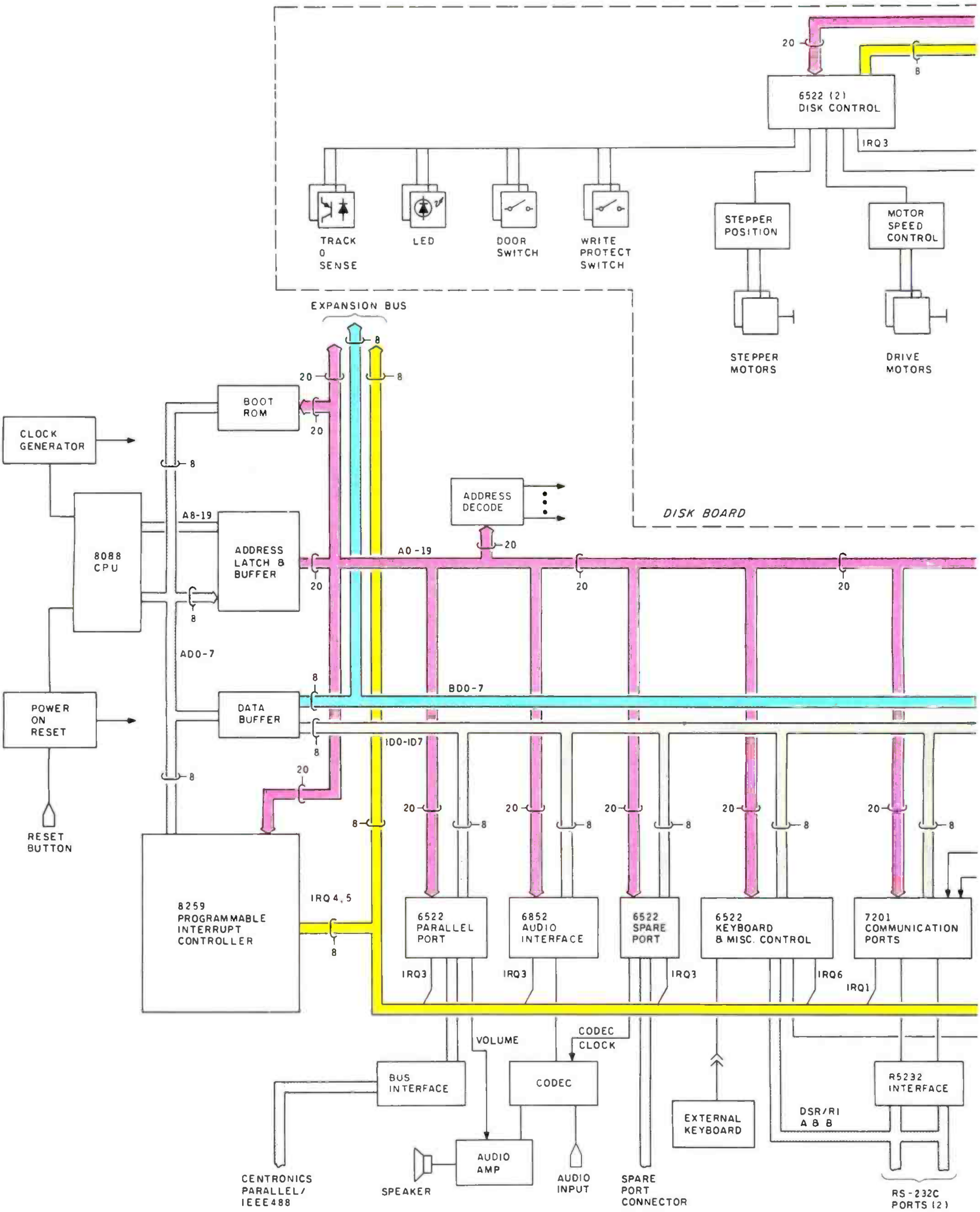
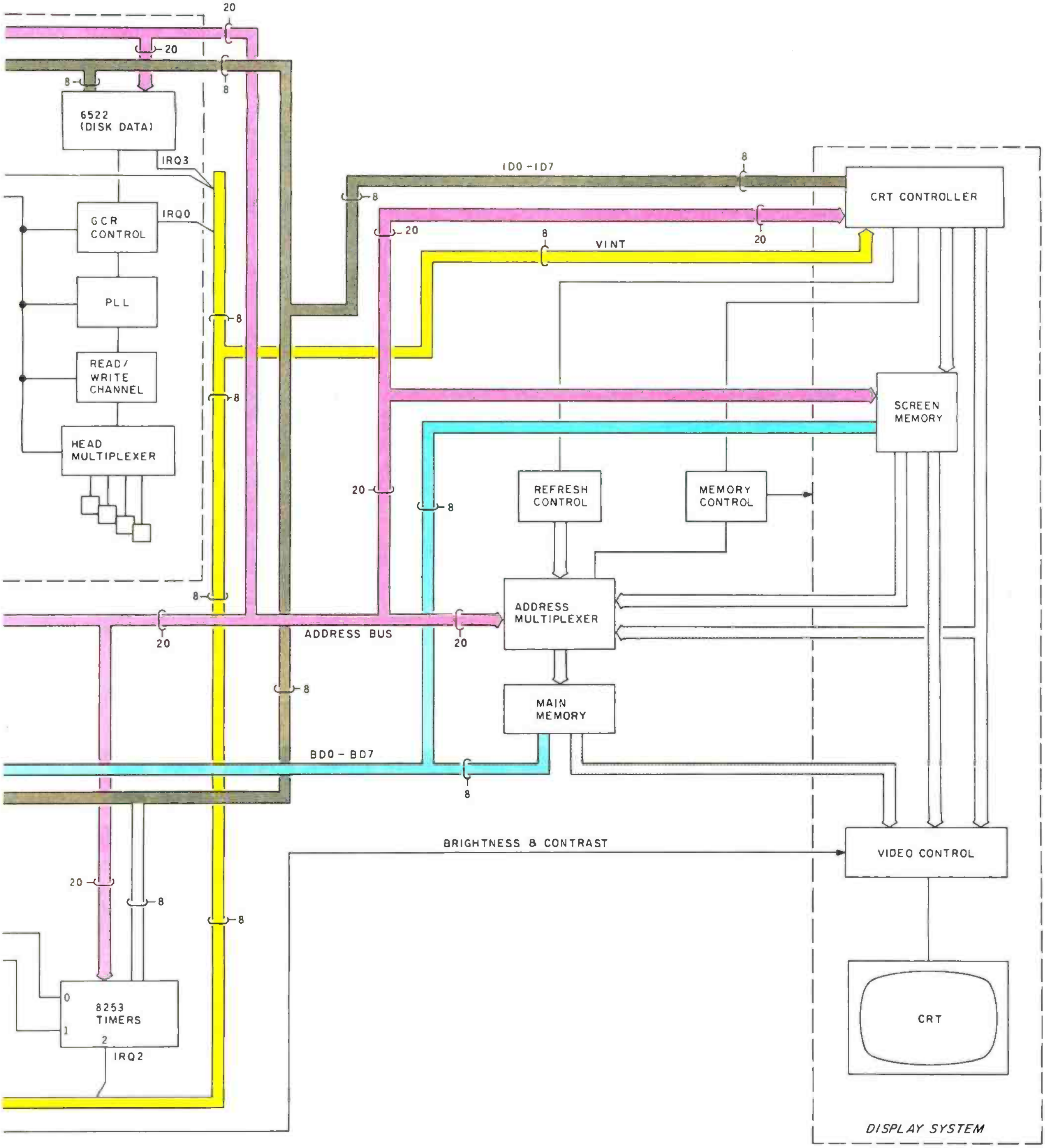


Figure 1: *A block diagram of the Victor 9000. The 8088 processor is at the left, as are the power-up ROM and the programmable interrupt controller. At top left is the expansion bus. The entire top center consists of the disk-controller board. The CRT controller and associated static RAM appear at right. From left to right along the bottom of the diagram, you see a parallel I/O port that can be configured as either a Centronics-compatible or an IEEE-488 interface; a synchronous I/O interface that drives the CODEC*



(coder-decoder) that can turn a voice into a serial bit stream and vice versa; another parallel port; a keyboard interface port, based on a 6522 that also controls some other functions in the system; two RS-232C serial ports that can be programmed for asynchronous or bisynchronous communications; and the timer that sets the bits per second (bps) for the communications ports and provides an interrupt for the system clock. Table 1 identifies the descriptions and names of the signals on the data buses and the expansion slots.

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of memory, but the Victor 9000 uses memory-mapped I/O—that is, it addresses some of the input and output devices as if they were part of system memory. This increases the speed of I/O but reduces the amount of real memory that can be addressed. Since the 8088 can address a megabyte, however, you are unlikely to feel a pinch. Despite the memory-mapped I/O, the user of the Victor 9000 can still have 896K bytes of available RAM. Memory can be expanded with 128K-byte, 256K-byte, and 384K-byte memory boards. If you add two of the 384K-byte boards, you can have the full 896K bytes of RAM and still have two bus slots open. Besides the RAM already described, the Victor 9000 also has 4K bytes of static RAM used with the video monitor, and 16K bytes of ROM containing "sanity test" diagnostics and instructions for loading the operating system from disk.

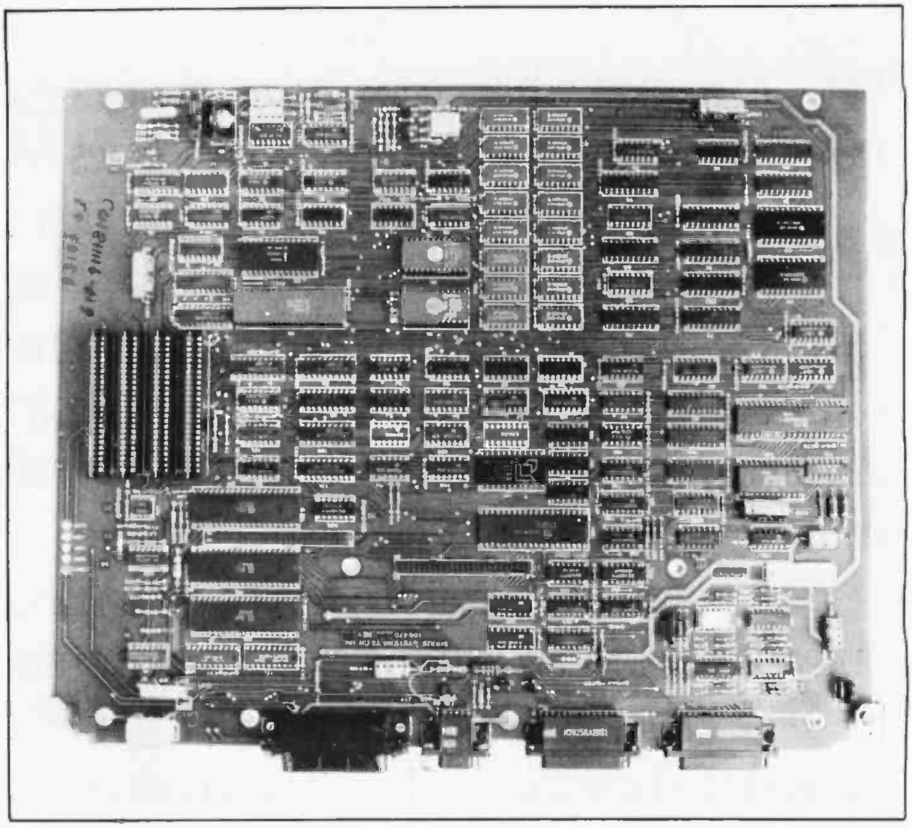

Photo 4: *The system board viewed from above. The 8088 processor is at the right, the four expansion slots at the left, and one of the parallel and both serial ports are along the bottom. The two vertical rows near the top, which consist of 8 chips each, are 128K bytes of dynamic RAM.*

Mass Storage

Packing 612K bytes of data onto one side of a 5¼-inch floppy disk may cause jitters in people who witnessed problems in mere double-density systems only a year or so ago, but I used the drives hard during the time I had the Victor 9000 and didn't experience any problems with the drives in any operation with either CP/M-86 or MS-DOS. One thing I did to tempt fate and strain technology was to edit and save and re-edit and resave huge Wordstar text files. Even with files approaching 60K bytes, the Victor 9000's drives performed flawlessly.

The quality and reliability of the disk drives result from the ingenuity used in designing the disk-controller board and in encoding the data. The Victor 9000 uses Group Code Recording (GCR), a technique of compressing data by squeezing out zeros. Data is encoded for storage in such a way that there are never more than two zeros in a row.

The Victor 9000 also has unusually precise control of the rotational speed of the drives. One common source of read-and-write errors is a difference in rotational speed between two drives. To achieve highly precise control of rotational speed, Victor replaced the control electronics normally supplied by drive manufacturers with a custom board that controls both drives. A microprocessor on the Victor disk board takes tachometer pulses from the drive motor and uses them to control motor speed. The board can set motor speed to any of 15 values, controlled within 1 percent. Different speed settings are used for different tracks. Why? In order to achieve constant linear speed of the media traveling under the read/write heads. When the Victor 9000 is doing disk input or output, you can hear the drive motors quietly changing speed, as if there were a 15-speed transmission inside with a gifted driver shifting from one speed to another as necessary. One benefit of constant linear speed is that the outer tracks of the disk can hold much more data. Another benefit is increased reliability.

Three 6522 versatile interface adapters (VIAs), which are special parallel I/O chips, divide most of the work of controlling the drives. Two ports on one 6522 VIA select read-and-write data; the second 6522 selects speed and controls the drives' stepper motors; the third 6522 controls head selection and the LEDs (light-emitting diodes) that indicate drive activity and also determines the status of the spindle motors. The 8088 processor controls and monitors all the signals coming from the 6522s, besides monitoring the status of the drive doors, turning on the LEDs, and transferring data into memory.

The track-to-track stepping time is 3 milliseconds (ms) and average disk-access time is 235 ms. The Victor 9000's operating systems use a logical sector size of 128 bytes and a physical sector size of 512 bytes.

A valuable feature for programmers who want to write disaster-proof applications software is the Victor 9000 disk system's ability to condition an interrupt on the opening or closing of the disk drive doors. Using this feature, a program might save a user from trying to write to a drive with an open door, which,

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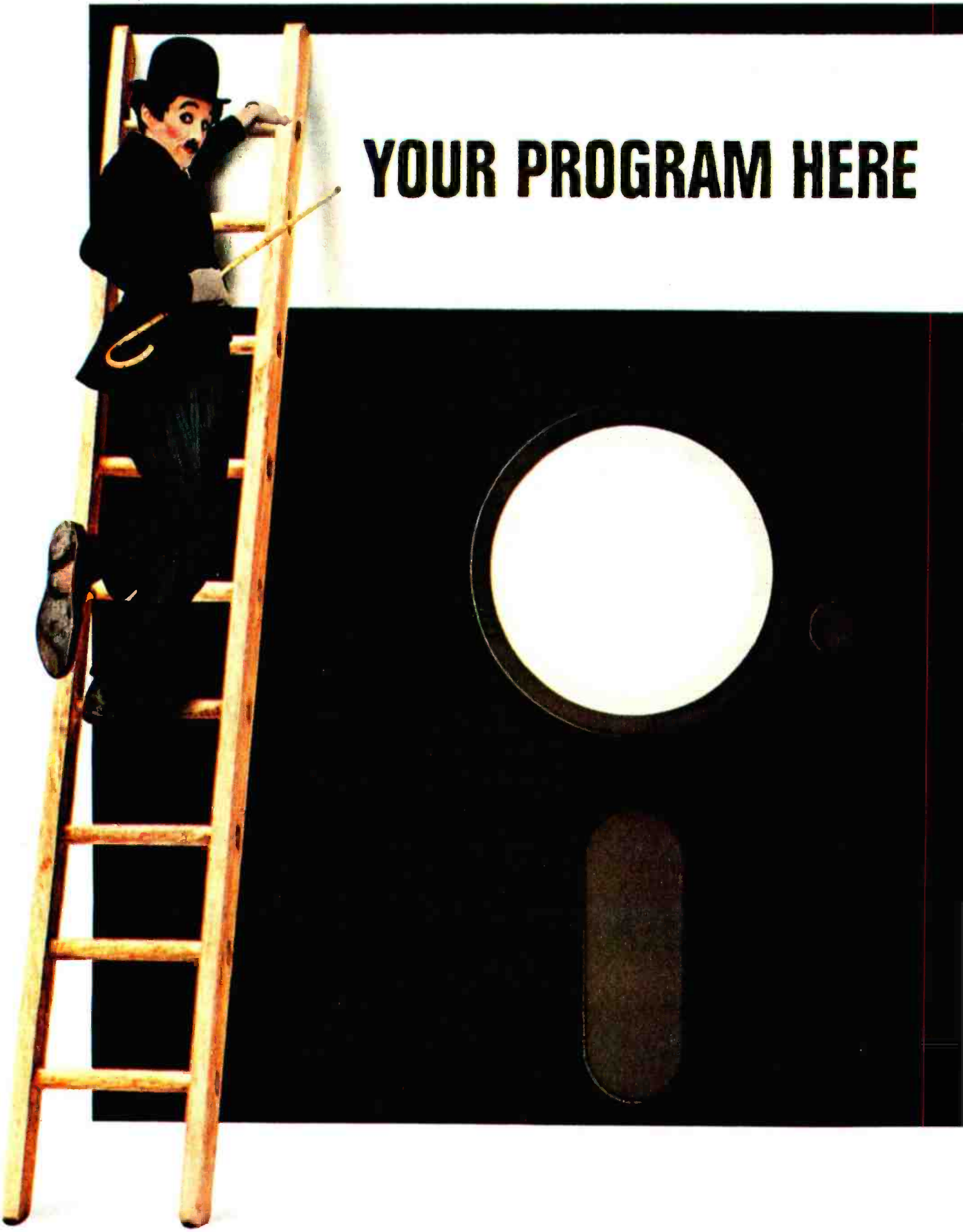
50	A19	I/O	Buffered-address bits 8 to 19. These lines are driven from the 8088 during normal operation and are valid from the falling edge of address-latch enable (ALE) to the rising edge of the next ALE. If an external device takes control of the system via HOLD and HOLD ACKNOWLEDGE, these lines are tri-stated.
1	A18	I/O	
49	A17	I/O	
2	A16	I/O	
48	A15	I/O	
3	A14	I/O	
47	A13	I/O	
4	A12	I/O	
46	A11	I/O	
5	A10	I/O	
45	A9	I/O	
6	A8	I/O	
29	BD7	I/O	Time multiplexed buffered address/data bus. During normal operation, the lower 8 bits of address (AD0-AD7) are valid on the falling edge of ALE.
22	BD6	I/O	
28	BD5	I/O	
23	BD4	I/O	
27	BD3	I/O	
24	BD2	I/O	
26	BD1	I/O	
25	BD0	I/O	
9	ALE	O	Buffered address-latch enable. Processor signal that indicates BD0-BD7 contain valid addresses. Typically used to latch low-order 8 bits of address.
11	RD	O	Buffered read strobe. Processor signal indicating a read cycle.
14	$\overline{WR}$	O	Buffered write strobe. Processor signal indicating a write cycle.
8	$\overline{DEN}$	O	Buffered data enable. Provided by the processor for use as an enable for transceivers.
33	$\overline{DLATCH}$	O	Data latch. The falling edge of this signal may be used to strobe data generated from a processor read access.
30	$\overline{EXTIO}$	I	External I/O. Control line that prevents internal data-bus buffers from conflicting with external buffers when mapping external I/O into address space E0000 to EFFFF hexadecimal. CSEN should be used as a control signal to disable internal buffers via EXTIO and enable external buffers if using address space E0000 to EFFFF. Addresses used by the system cannot be disabled by EXTIO.
19	CSEN	O	Chip select enable. This line is synchronized to PHASE2. It is true from a falling edge of PHASE2 to the next falling edge of PHASE2, when address space E0000 to EFFFF hexadecimal is accessed.
40	CLK15B	O	15-MHz clock. Signal from which all system timing is derived. Its period is 66.6 ns with a 50% ± 10% duty cycle.
38	CLK5	O	5-MHz clock. Signal is in phase with the 8088 clock input. Its period is 200 ns with a 33% duty cycle.
20	PHASE2	O	1-MHz clock. Signal is asynchronous with CLK5. Its period is 1µs with a 40/60% duty cycle. Useful to interface 6800-type I/O circuits.
21	XACK	I	External acknowledge. This line is normally high and may be pulled low by external devices resulting in pulling the 8088 READY input low, generating wait states. This line is resynchronized by the system logic.
17	$\overline{HOLD}$	I	Input to the 8088. This is an external request for control of the system buses.
18	HLDA	O	Buffered hold acknowledge. System response to HOLD request. When true (high) the following signals are tri-stated: A8-A19, BD0-BD7, ALE, IO/$\overline{M}$, $\overline{RD}$, $\overline{WR}$, DT/$\overline{R}$, $\overline{DEN}$, $\overline{SSO}$, and $\overline{INTA}$. $\overline{DLATCH}$ is controlled by external logic.
41	READY	O	Status line. This line reflects the synchronized READY input to the 8088.
10	IO/$\overline{M}$	O	Buffered 8088 status line. Distinguishes between a memory or I/O bus cycle.
7	$\overline{SSO}$	O	Buffered 8088 status line.

Continued on page 234

Table 1: *The signal names and descriptions for the Victor 9000 expansion bus. The expansion bus is basically a buffered extension of the system's 8088 processor plus additional timing and control signals required to interface the system. The expansion bus consists of a multiplexed buffered data bus (BD0-BD7), a buffered address bus (A8-A19), and various timing, control, interrupt, and power lines.*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High-resolution*
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Green phosphor screen*
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Languages
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Printer
Bidirectional*
80 characters/second
12 character styles, up to 132 characters/line*
9 x 9 character matrix*

Permanent Memory
(ROM) 40K bytes*
Color/Graphics
Text mode:
16 colors*
256 characters and symbols in ROM*
Graphics mode:
4-color resolution: 320h x 200v*
Black & white resolution: 640h x 200v*
Simultaneous graphics & text capability*
Communications
RS-232-C interface
Asynchronous (start/stop) protocol
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Pin	Signal	I/O	Description
12	DT/$\overline{R}$	O	Buffered data transmit/receive. Processor signal typically used to control the direction of system transceivers. The combination of IO/$\overline{M}$, DT/$\overline{R}$, and $\overline{SSO}$ provide current bus-cycle status:

IO/$\overline{M}$	DT/$\overline{R}$	$\overline{SSO}$	Description
0	0	0	Instruction fetch
0	0	1	Read from memory
0	1	0	Write from memory
0	1	1	Passive (no bus cycle)
1	0	0	Interrupt acknowledge
1	0	1	Read from I/O
1	1	0	Write to I/O
1	1	1	Halt

Pin	Signal	I/O	Description
15	$\overline{NMI}$	I	Nonmaskable interrupt. An edge-triggered input which causes a type-2 interrupt. A transition from high to low initiates the interrupt at the end of the current instruction.
16	$\overline{IRQ}$	I	Interrupt request. This input should be driven with an open collector driver; it is "collector ORed" with five 6522s and one 6852 and is pulled to +5 volts (V) through a 3.3K-ohm resistor. A low level on any of these circuits generates a high-level input to the system 8259 at IR3 level.
43	IR4	I	Interrupt request level 4. Direct access to IR4 of the system 8259.
42	IR5	I	Interrupt request level 5. Direct access to IR5 of the system 8259.
13	RESET	O	System reset. Generated at power on or from the Reset switch.
44	Ground		
39	Ground		
35	Ground		
31	Ground		
37	+5 V		
36	+5 V		250 mA/expansion board
34	+12 V		250 mA/expansion board
32	−12 V		50 mA/expansion board

under CP/M-86 and depending on the BIOS (basic input/output system), would crash the program and lose the data that the user intended to save.

Display

The first thing that you notice about the Victor 9000 is the quality of its display. The clear definition of characters and the sharp monochrome graphics are a pleasure to the eyes. A nylon mesh minimizes glare.

A total of 320,000 pixels (picture elements), 800 by 400, account for the high resolution. (The Apple III has graphics resolution of 560 by 192, and the IBM Personal Computer offers 640 by 200). One immediate benefit of the high resolution is the availability of a 132-column by 50-line display format for electronic spreadsheets like Victorcalc and Multiplan. The extra 52 columns and 25 lines make a large table much easier to comprehend and reduce your dependence on notoriously volatile human memory. It should be possible to have more than the standard 25 lines available for word processing, too, but the two Victor word-processing programs that I used did not take advantage of the higher resolution, nor did the third, which I saw but did not use. Photo 5 shows the Victor display with an assortment of character sets. Photo 6 gives a taste of the machine's breathtaking graphics capabilities, and photo 7 shows a scientific application of the high resolution.

The Victor 9000 uses the Hitachi 46505 CRT-controller chip, equivalent to a Motorola 6845. A separate memory-arbitration circuit allows the CRT logic to access system memory. Together the controller chip and the memory-arbitration circuit minimize the demands made by the display on the processor and give the display logic access to the entire 128K bytes of on-board RAM.

Two hardware registers contain pointers to tell the CRT-controller

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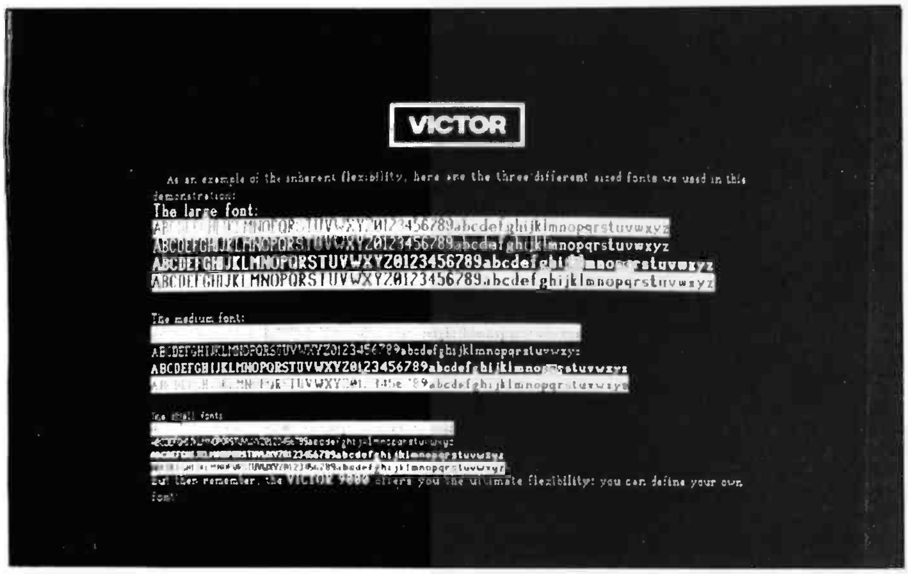

Photo 5: *The video monitor displaying characters in different fonts and sizes.*

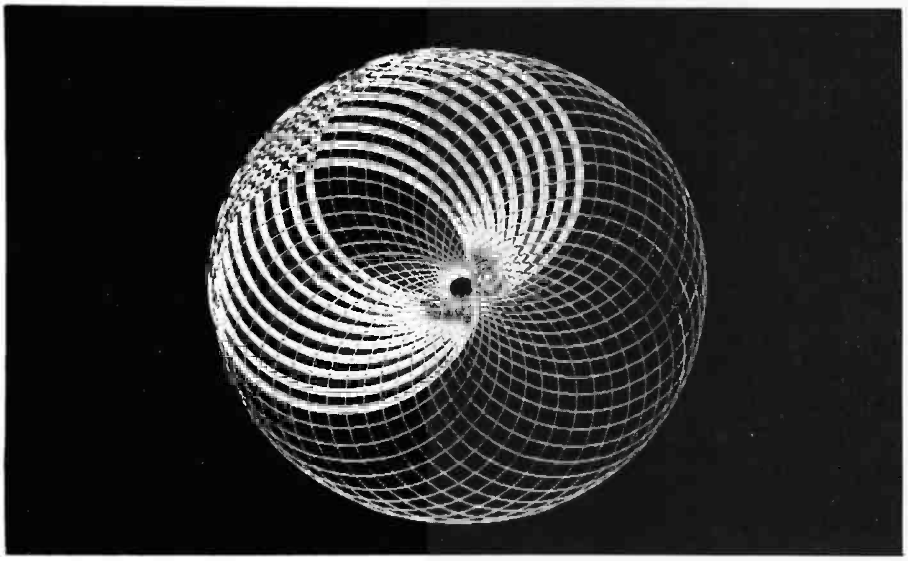

Photo 6: *A graphics display on the Victor 9000 video monitor.*

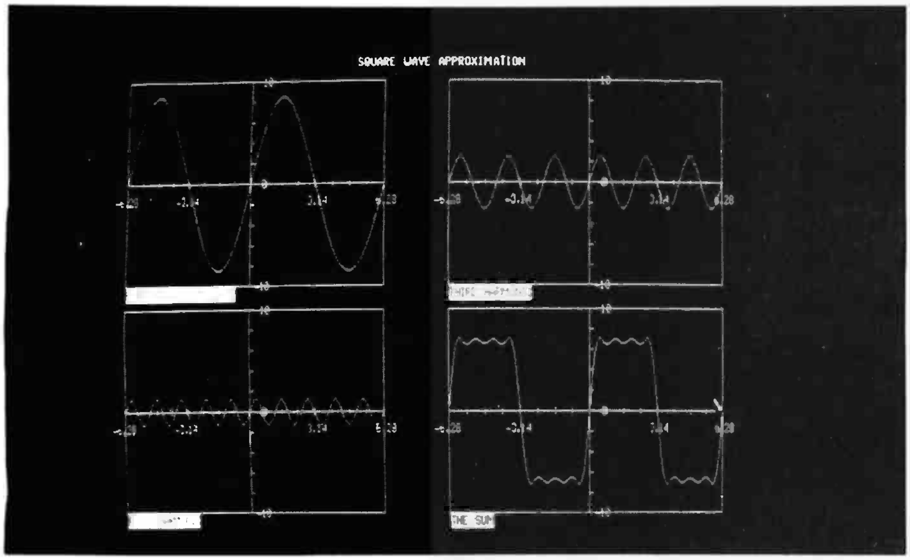

Photo 7: *A scientific application of the Victor 9000 video monitor.*

chip where two tables are located in system memory. The first table is called *screen RAM* and the second table is called *dot RAM*. These two tables interact together with the CRT-controller chip to produce the display on the monitor. Just how they interact depends on whether you are in the character mode or the high-resolution graphics mode.

In the character mode, the screen RAM (which is really the 4K bytes of static RAM) acts in a manner similar to the refresh RAM of modern video terminals. The screen RAM in the Victor 9000, however, uses a 16-bit word to represent each of the 2000 character positions displayed on the monitor: 7 bits define the character according to its ASCII value, 4 bits can be thought of as font designators, and the remaining 5 bits determine the character's attributes (underscore, reverse, etc.). In order to locate the actual dot representation of the character in dot RAM, the 11 bits defining the character and font are then combined with the pointer that points to the dot RAM by the CRT-controller chip.

Each character is made up of 16 scan lines of 10 pixels (dots) each. Dot RAM contains a pixel map of each character in the font, with a 16-bit word devoted to each of the 16 scan lines of the character cell for a total of 32 bytes per character. Only 10 bits of each scan line are actually displayed, however.

A 128-character font occupies 4K bytes of dot RAM, and multiple fonts may reside in dot RAM simultaneously. Thus the entire process is similar to that of modern video terminals except that system RAM is used instead of a fixed character ROM.

In graphics mode, however, the process is different. When graphics mode is entered, the screen RAM is loaded with data so that the CRT-controller chip is forced to cycle through 1250 consecutive "character" cells in dot RAM. Because the dot RAM is actually system RAM, you can then use this 40,000-byte area (1250 cells, 32 bytes per cell) as a bit map for high-resolution graphics, with each of the 320,000 bits being individually addressable.

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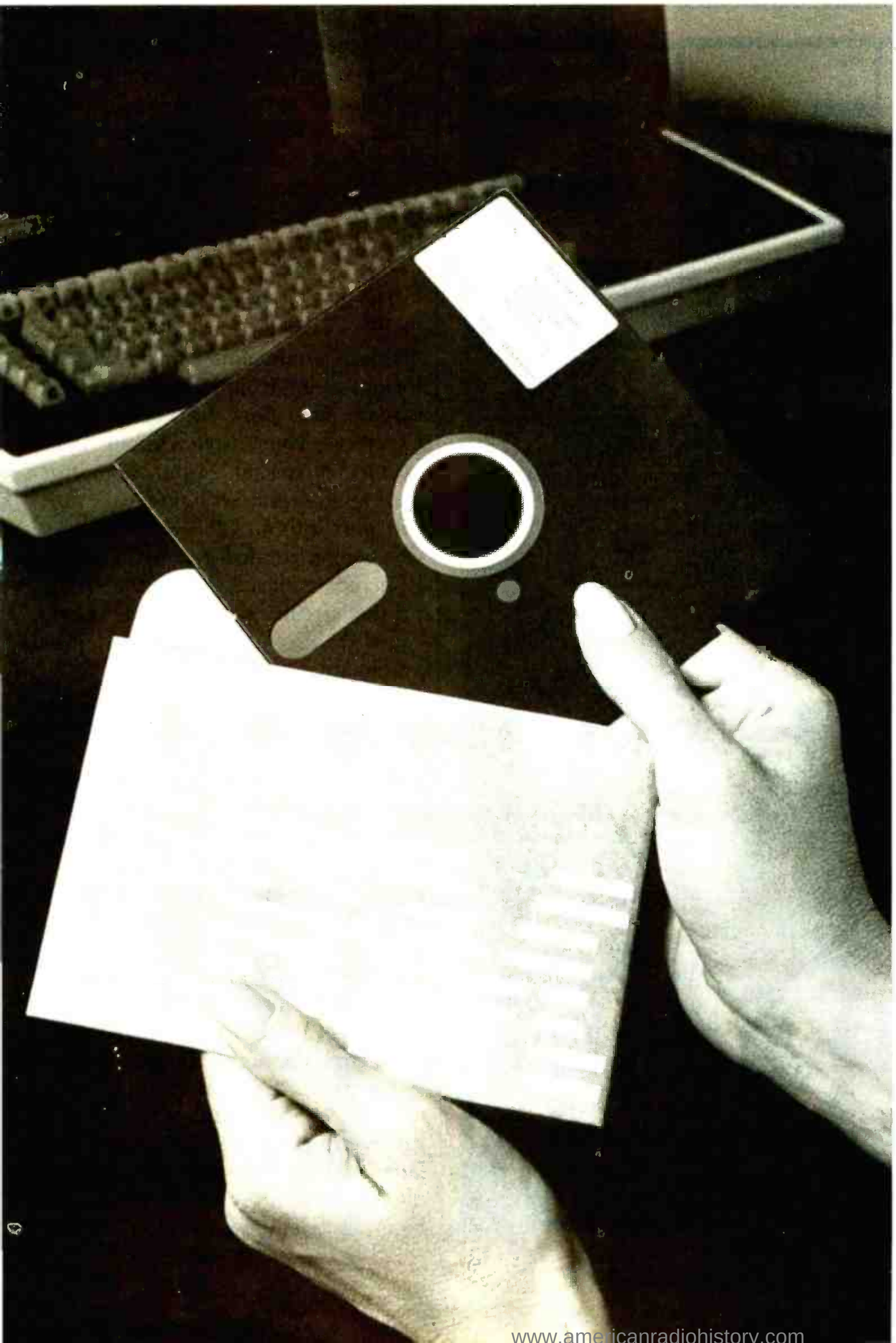

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The Victor 9000 can display characters in half intensity, in reverse video, underscored, or blinking. Brightness and contrast of the screen as a whole are also under software control. Applications programs should therefore be able to manipulate these factors, and the Victor operating systems themselves enable you to adjust brightness and contrast from the keyboard. While software control of brightness and contrast could be useful for achieving special visual effects, I found myself wishing for plain, old-fashioned contrast and brightness knobs on the monitor. Whenever you load the operating system, it resets brightness and contrast to its own default values. Presumably these default values could be altered to suit individual taste, but otherwise you have to enter a few keystrokes (pressing the Alternate key along with the Brightness key and the Contrast key) to adjust the monitor whenever you reload the system. This becomes a minor annoyance if you're in a hurry.

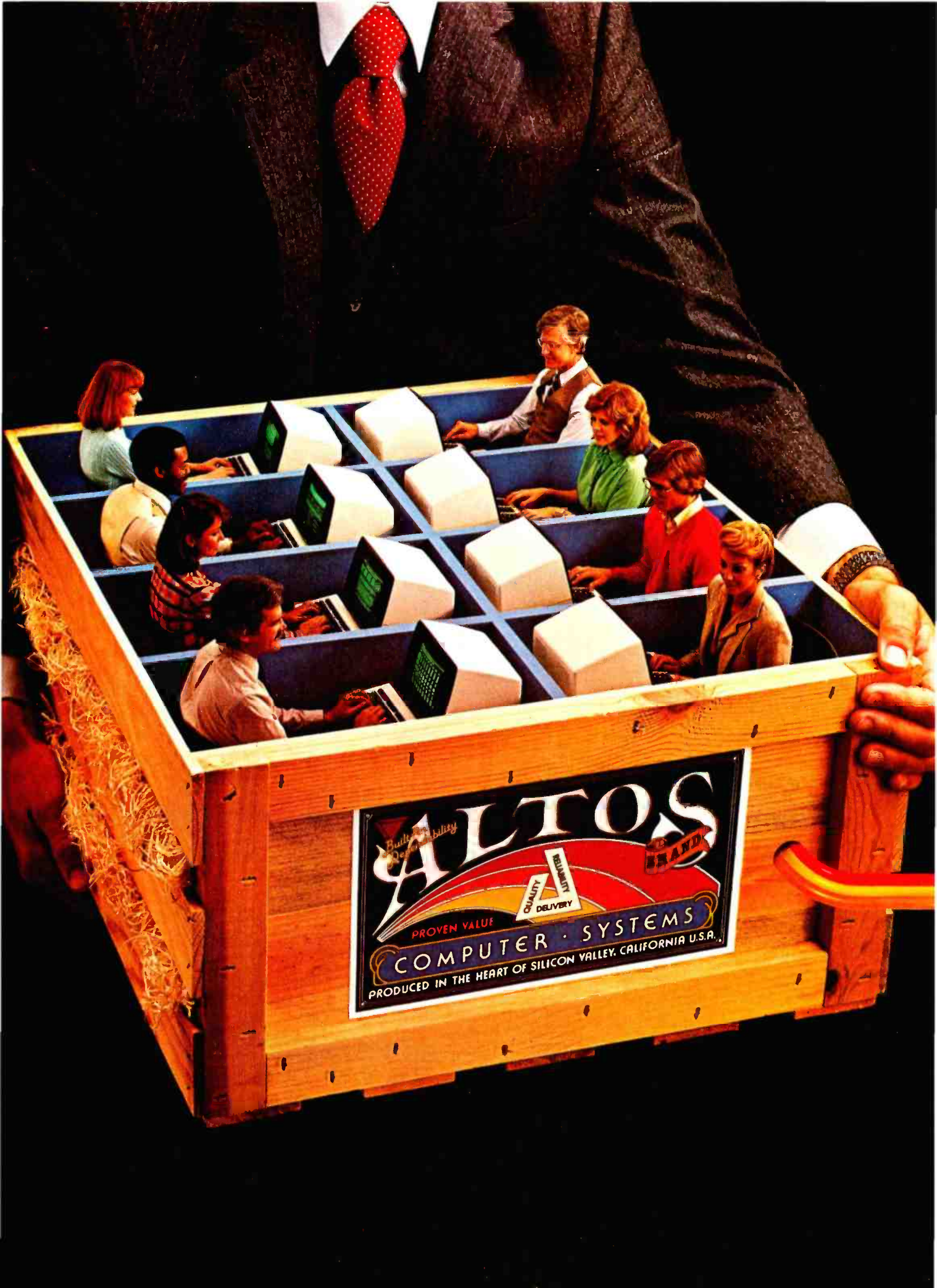
I/O Ports

The two standard RS-232C serial ports on the Victor 9000 have remarkable versatility. The Intersil 7201 programmable communications chips can support full-duplex asynchronous communications, as can most serial ports on other microcomputers. But the 7201s can also support both bisynchronous communications and SDLC (synchronous data link control), a special kind of bisynchronous communication. Software determines which type of communication the ports will perform and at what speed (up to 19.2 kbps for asynchronous operations, and up to 56 kbps for bisynchronous). The significance of the Victor 9000's use of 7201 chips is that you will probably never have to add a special board to communicate with another computer, even if your company switches from IBM to DEC mainframes or vice versa.

The 6522 parallel ports (designer Peddle's favorites) are also programmable. Certain pins can be selected for use as interrupt signals. As noted earlier, one port has a standard Centronics-compatible 36-pin connector. A special 24-pin connector and appropriate software can turn this port into an IEEE-488 interface. The second parallel port has a 50-pin KK-type connector on the main printed-circuit board. This port, called the *user port*, is also fully programmable.

Keyboard

The Victor 9000 has a separate keyboard connected to the system unit by a coiled cable that is long enough to let you hold the keyboard in your lap if you wish. A still longer cable (12 feet) is available as an option. Three keyboards with up to 103 keys, all sculpted and most with autorepeat capability, are available and have a soft touch that is easy to adjust to. Victor gives its distributors a utility program, KEYGEN, that programs the keyboard without requiring knowledge of 8088 assembly language. That should make it possible for distributors to tailor the keyboard for any application that a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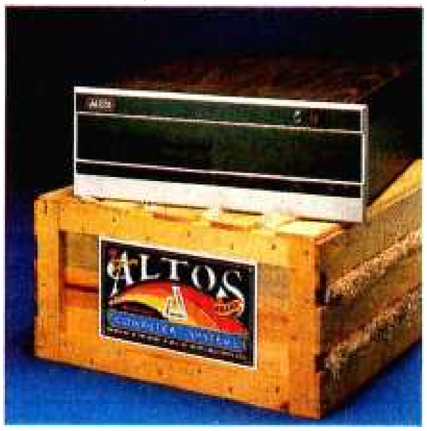

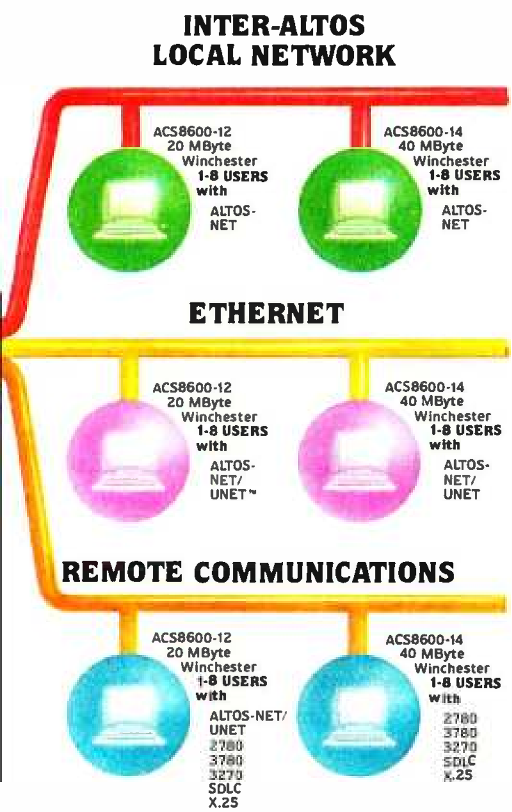

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:em owner happens to have. For _ matter, since the key caps are easy to rearrange, you could replace the standard QWERTY keyboard layout with the Dvorak (see "A Short History of the Keyboard" by Phil Lemmons in this issue, page 386), and the calculator-style numeric pad with the more efficient push-button telephone arrangement.

Three principal models of the keyboard are available: one for programmers, one for word processing, and one called "standard." Some of these leave 7 programmable keys free, some leave 10 free. But these three models are only the beginning. Like almost everything in the Victor 9000, the keyboard is "soft-tooled." An 8048 8-bit microcomputer, which has its own ROM, translates the output of each key. Pressing or releasing a key causes the generation of a code corresponding to the key's location. The 8048 constantly scans the keyboard to detect changes in the state of any key. When the 8048 sees a change, it generates an 8-bit code. Seven bits identify the key, and the other bit indicates the key's new state. The data is sent serially to a 6522 parallel I/O processor that interrupts the central processor after receiving 8 bits. The 8088 performs final interpretation of the keystroke using the keyboard table produced by the KEYGEN utility and then incorporated into the operating system.

Victor's system-generation software enables you (or Victor distributors and offices) to construct versions of the operating systems that incorporate different tables of keyboard values. Several standard tables to support specific applications packages exist, such as a table that programs the keyboard for Wordstar, and Victor's software-support people can construct more keyboard tables as the library of software grows.

It is conceivable for two people, one using the QWERTY keyboard and the other using the Dvorak keyboard, to share the same machine without coming to blows. In order to avoid having to move the key caps around at every change of user, the two people would have to have one keyboard each. All they would need then would be two different versions of the operating system, one incorporating each person's favorite keyboard table. Just plug in one keyboard and load one operating system, then unplug the first keyboard, plug in the second, and load the second operating system. The change would take less than a minute.

To sum up, the Victor keyboard has lots of keys and unsurpassed adaptability.

Software

Operating systems: Both CP/M-86 and MS-DOS come with the machine at no extra charge. Each is approximately 40K bytes in size. Victor is promising to offer Unix for the Victor 9000 sometime in the first quarter of 1983. The company is planning to demonstrate it at COMDEX (Las Vegas) later this month.

Languages: Victor offers Digital Research CBASIC-86, Microsoft GW-BASIC, Microfocus CIS-COBOL, Microsoft COBOL, Microsoft FORTRAN, and Microsoft Pascal. GW-BASIC (GW for Gee Whiz) is an enhanced version of Microsoft BASIC-86. It is the BASIC that runs on the IBM Personal Computer. Gregg Williams discussed it in his January 1982 BYTE article "A Closer Look at the IBM Personal Computer" (page 36). The Victor version of GW-BASIC implements all the commands listed in that article except On Pen and On Strig. (On Pen enables handling input from a light pen. On Strig does the same for a joystick.) Victor GW-BASIC maps the color-related commands on the IBM Personal Computer to levels of intensity on the Victor monochrome monitor.

Microsoft FORTRAN is an implementation of FORTRAN 77 and requires 256K bytes of RAM. CIS-COBOL from Microfocus (with Forms 2, Level 5) is an ANSI (American National Standards Institute) high-intermediate-level version of COBOL and runs in a 128K-byte CP/M-86 system. MS-

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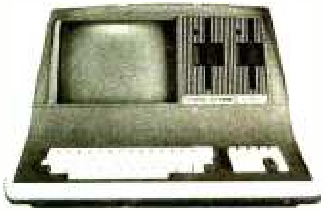

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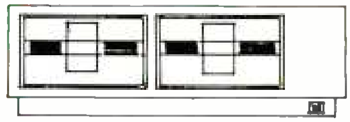

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COBOL is an ANSI intermediate-level implementation of the language and requires MS-DOS and 128K bytes of RAM. CBASIC-86 runs under CP/M-86 and requires 128K bytes of memory. GW-BASIC requires the same amount of memory and MS-DOS. MS-Pascal runs under MS-DOS and requires 256K bytes of RAM.

Applications software: The applications software available directly from Victor for the Victor 9000 must set some kind of record. A variety of software ultimately becomes available for every popular microcomputer, but Victor is itself providing a variety of correctly installed software from the beginning. Taking into account the variety of human taste, Victor is offering more than one program for the three kinds of major applications that almost everyone needs: word processing, electronic spreadsheets, and database management.

For word processing, Victor offers three different programs: Victorwriter I (Select, from Select Information Systems), Wordstar (from Micropro), or Victorwriter II (Benchmark, from Metasoft). Select is easy to learn, but Wordstar seems to me to do more and run faster. I haven't used Benchmark but I've seen it in use, and it seems to rival Wordstar.

Victor also offers three electronic spreadsheets: Victorcalc, a version of Report Manager (from The Image Producers), which has an optional training disk; Multiplan (from Microsoft), said to be quite powerful; and Supercalc (from Sorcim), noted for its very effective HELP feature.

At this writing, Victor is shipping only one database management program, dBase II (from Ashton-Tate), but Victor promises a second database manager soon. Condor Computer Corporation does offer its Condor Series 20 DBMS for the Victor 9000.

Victor also offers the following software: accounts receivable, accounts payable, general ledger, payroll, order processing, inventory control, purchase-order writing, time-management, project management, pharmacy management, financial and banking, installment lending, and software for managing a Victor dealership. As you can see, Victor is pursuing some "vertical" markets (specialties such as pharmacy) as well as the "horizontal" markets (general applications such as accounting and word processing).

Both bisynchronous and asynchronous communications software are on the way, too.

Performance in BASIC

I was hoping to have a running version of GW-BASIC on the Victor 9000 in time for this review in order to run some of BYTE's benchmark programs. GW-BASIC may be available as you read this. (Microsoft is still adding enhancements.) Rather than wait, I ran the benchmark tests under the version of Microsoft BASIC-86 that Victor was using to write some of its utilities and demonstration programs. While the resultant timings of the Victor 9000 probably give a rough idea of the Victor's capabilities, you have to keep in mind

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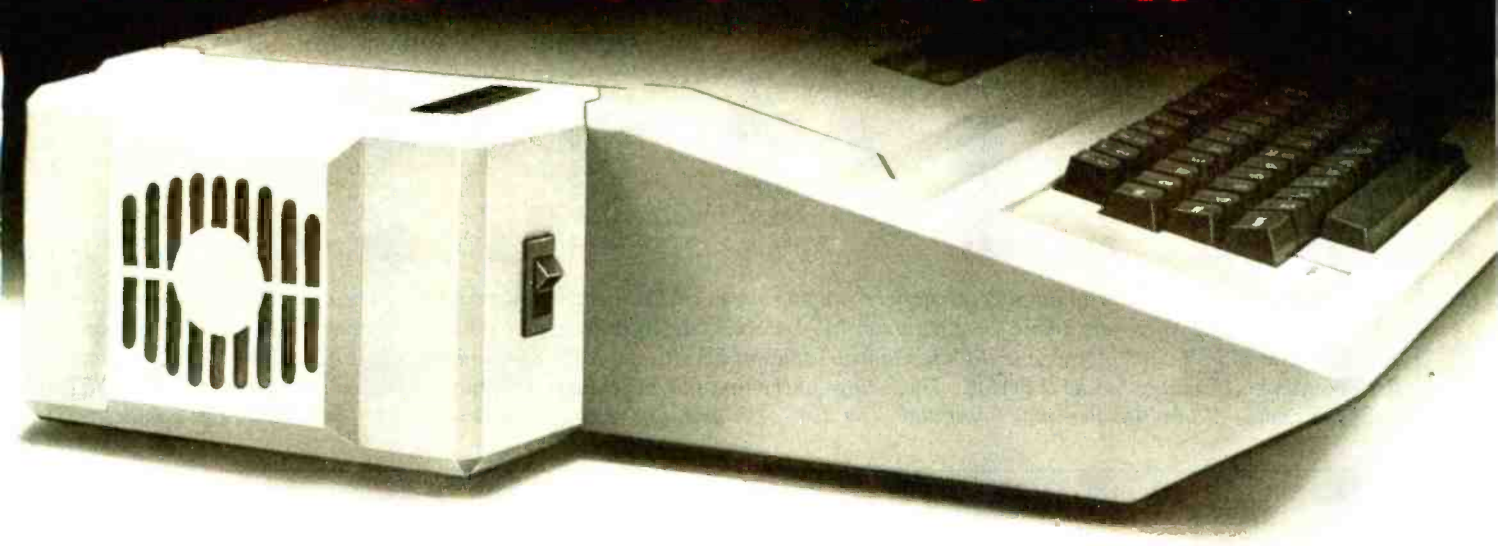
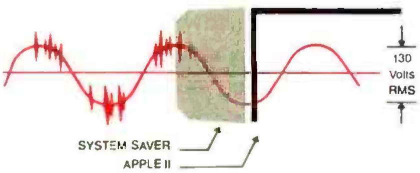


For Line Surge Suppression

The SYSTEM SAVER provides essential protection to hardware and data from dangerous power surges and spikes.



By connecting the Apple II power input through the SYSTEM SAVER, power is controlled in two ways: 1) Dangerous voltage spikes are clipped off at a safe 130 Volts RMS/175 Volts dc level. 2) High frequency noise is smoothed out before reaching the Apple II. A PI type filter attenuates common mode noise signals by a minimum of 30 dB from 600 khz to 20 mhz, with a maximum attenuation of 50 dB.

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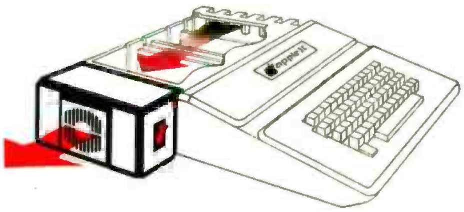
As soon as you move to 64K RAM or 80 columns on your Apple II you need SYSTEM SAVER.

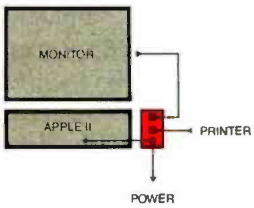
Today's advanced peripheral cards generate more heat. In addition, the cards block any natural air flow through the Apple II creating high temperature conditions that substantially reduce the life of the cards and the computer itself.

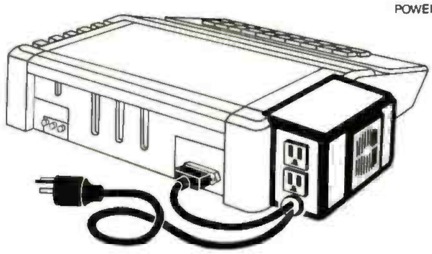


SYSTEM SAVER provides correct cooling. An efficient, quiet fan draws fresh air across the mother board, over the power supply and out the side ventilation slots.

For Operating Efficiency

SYSTEM SAVER contains two switched power outlets. As shown in the diagram, the SYSTEM SAVER efficiently organizes your system so that one convenient, front mounted power switch controls SYSTEM SAVER, Apple II, monitor and printer.





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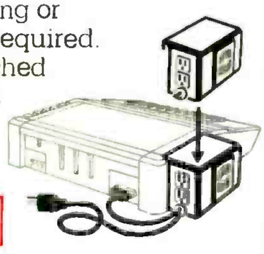

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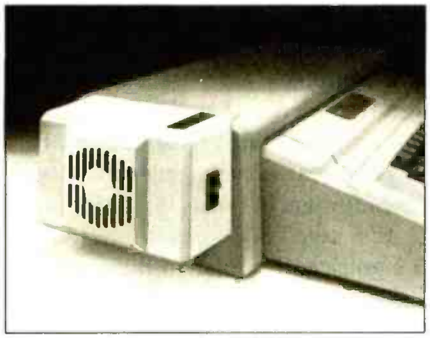

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Benchmark	Victor 9000 BASIC-86 5.21, MS-DOS 1.2	IBM	Applesoft	4-MHz Z80 MBASIC 4.51	Radio Shack TRS-80 Model II
	Times				
Empty do-loop	7.7	6.43	6.66	5.81	7.98
Division	21.8	23.8	29.0	24.9	19.4
Subroutine jump	16.9	12.4	13.9	9.4	17.1
MID$ (substring)	24.6	23.0	32.3	18.6	24.8
Prime-number program	197.0	190.0	241.0	151.0	189.0
Disk-write program	50.3	32.0	175.0	NA	246.0
Disk-read program	21.3	22.9	217.0	NA	96.0

Table 2: *The timings of several microcomputers in running seven BASIC benchmark programs. The computers timed were the Victor 9000 running Microsoft BASIC-86 5.21 under MS-DOS 1.2, the IBM Personal Computer running IBM Personal Computer BASIC under MS-DOS 1.0, the Apple II Plus running Applesoft BASIC, a 4-MHz Z80 running MBASIC 4.51, and a Radio Shack TRS-80 Model II running Model II BASIC. The listings of the first five benchmark programs appeared in the January 1982 BYTE with the review of the IBM Personal Computer. The disk-write and disk-read programs are printed here as listings 1 and 2.*

that the BASIC used was not the standard interpretive BASIC for this machine. Also keep in mind that the timings for the IBM Personal Computer were done with IBM BASIC, a version of GW-BASIC and not the same as the BASIC used on the Victor 9000 in these tests. Both the IBM Personal Computer and the Victor 9000 have 8088 processors; the IBM runs at 4.77 MHz, the Victor 9000 at 5 MHz. The two systems have different disk drives and controllers, which may account for the differences in disk I/O benchmarks. I've run the benchmarks on the Victor 9000 under MS-DOS, since IBM Personal Computer DOS is an installation of MS-DOS, in order to avoid further confusing the issue. Of course, the two different installations of an operating system that is fundamentally the same can also leave room for differences in performance.

Having offered all the foregoing caveats, I can at last refer you to table 2, which shows the Victor 9000's performance, alongside that of several other popular microcomputers, in seven benchmark BASIC programs. The first five benchmark programs are listed in Gregg Williams's article in the January 1982 BYTE. Listings 1 and 2 give the sixth and seventh programs. The Victor 9000 performed comparably to the IBM Personal Computer—a little slower on the empty do-loop, a little faster on division, a little slower on the subroutine jump, about the same on the string operation, and a little slower on the prime-number program. There is no dramatic difference between the IBM Personal Computer, the Radio Shack Model II, and the Victor 9000 in the computational benchmarks. The 4-MHz Z80 system still does best overall!

However, dramatic differences in the disk-write and disk-read benchmarks do exist. The Victor 9000 writes a 64K-byte file in 50.3 seconds, almost 3½ times faster than an Apple II and almost 5 times faster than a TRS-80 Model II. The Victor 9000 reads a 64K-byte file in 21.3 seconds, roughly 10 times faster than an Apple II and 4½ times faster than a TRS-80 Model II. The IBM Personal Computer is even faster than the Victor 9000 in the disk-write test—32.0 seconds compared to 50.3 seconds. But the Victor reads the disk to verify the data after writing to disk; the IBM does not. Subtracting the Victor's read time (21.3) from the write-and-read time (50.3) gives a "write-only" time of 29 seconds, or 3 seconds faster than the IBM Personal Computer. In the disk-read test, the Victor is almost 2 seconds faster than the IBM Personal Computer.

Here is evidence that the IBM Personal Computer and Victor 9000 really do represent a new generation of microcomputer. In terms of computation, the two 8088-based systems don't significantly outstrip their competitors, but in disk I/O, none of the other computers comes close to the Victor or the IBM. Whatever the reason—the direct memory access (DMA), something about the processors, or a generation's experience in design—the Victor 9000 and the IBM Personal Computer leave prominent 8-bit systems shown in the table far behind even though the 8088 does I/O 8 bits at a time, too.

Given the truism that most programs are "input/output bound"—that is, I/O is a more important factor in their overall performance than is speed of computation—the choice narrows to the IBM Personal Computer and the Victor 9000. And then the choice depends on whether greater storage capacity or faster disk output is more important to you. The Victor 9000's verify-after-write disk I/O accounts for its being about a third slower than the IBM Personal Computer in disk output but also helps ensure reliability because the Victor packs almost 4 times the storage of the IBM on disks of the same size.

Marketing and Distribution

Victor is supplementing its own 50 branch offices with many independent Victor 9000 dealers. The existing network of branch offices gives Victor an edge over most of its competitors. Victor has an edge over IBM, ironically because of something that Victor doesn't have—compar-

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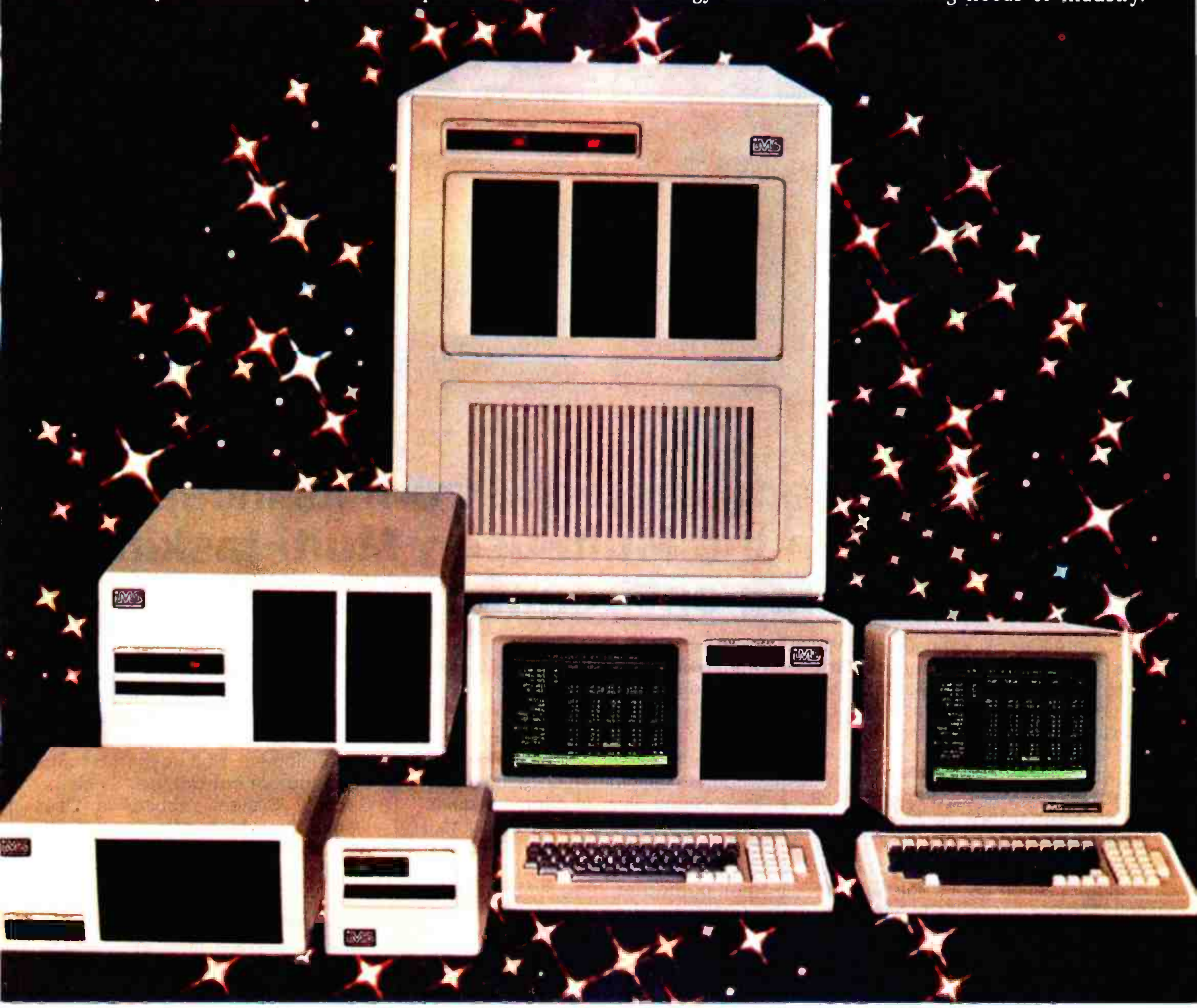

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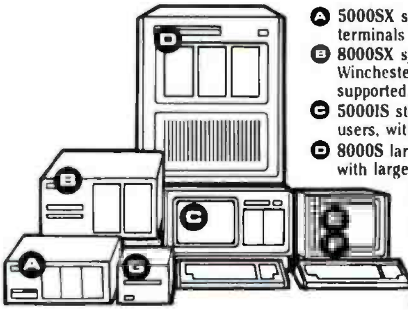

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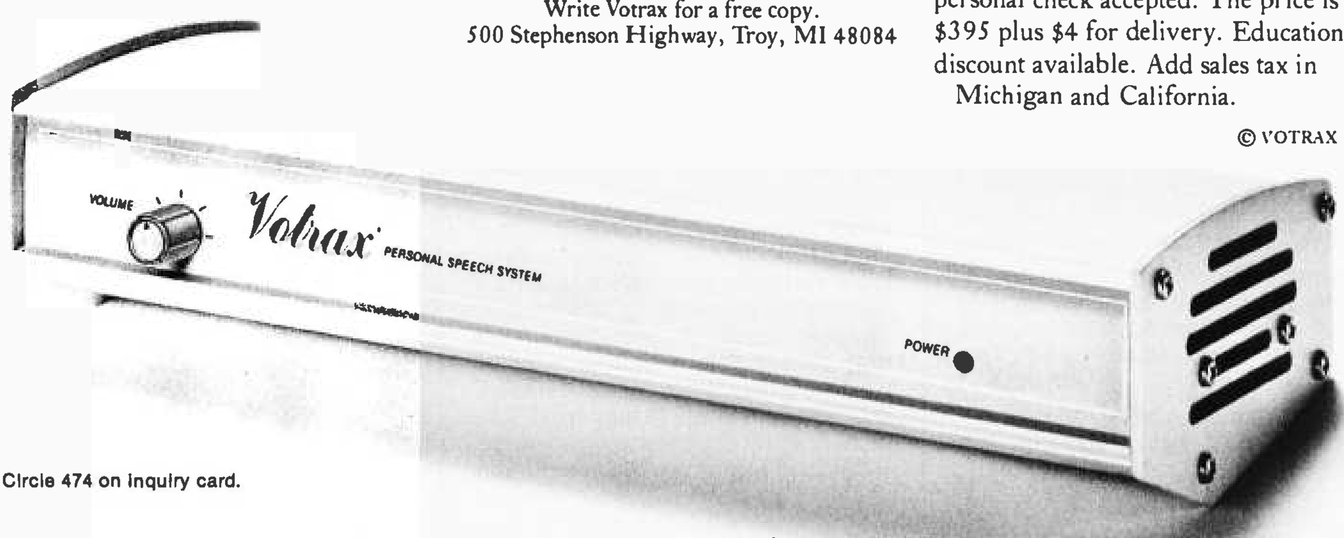

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Listing 1: *A BASIC disk-write benchmark program that writes a 64K-byte file.*

```
10 CLEAR 1000
40 A$="12345678123456781234567812345678"
60 B$=A$+A$+A$+A$
80 NR=500
100 OPEN "R", #1, "TEST"
120 FIELD #1, 128 AS Z$
140 FOR I = 1 TO NR
160 LSET Z$=B$
180 PUT #1, I
200 NEXT I
220 CLOSE #1
240 PRINT "DONE"
```

Listing 2: *A BASIC disk-read program that reads the file generated by the program in listing 1.*

```
10 CLEAR 1000
80 NR=500
100 OPEN "R", #1, "TEST"
120 FIELD #1, 128 AS Z$
140 FOR I = NR TO 1 STEP -1
160 GET #1, I
200 NEXT I
220 CLOSE #1
240 PRINT "DONE"
```

able but more expensive computers whose sales must be protected. While IBM (at least, at the IBM Product Centers where I've asked) tells people to buy a Displaywriter if they want letter-quality output and a first-rate word-processing program, Victor is eager to sell good word-processing programs and to sell and interface a letter-quality printer.

Maintenance and Support

Victor is offering three types of maintenance service: you can carry your system to a Victor service center, have Victor send a messenger to swap a failed component, or have Victor send a technician to repair your system on the spot. This surpasses IBM's service offerings, which had set a new standard for the industry little more than a year ago.

Victor's 50 branch offices are gearing up to provide software support as well as hardware maintenance. Because Victor will be the source of so much software on its own machine, software support should be easier for Victor than for most companies. Furthermore, the soft-tooled design of the Victor 9000 makes it easier for Victor than for any other company at this writing to adapt its system to new software.

The Victor branch offices also sell all the necessary supplies for the computer—paper, print wheels, disks, cables, dustcovers, etc.

Finally, Victor has a toll-free number to help dealers with any problems in Victor-released software and another toll-free number for technical support.

Optional Hardware

Victor is now offering both double-sided floppy-disk drives, increasing storage to 2.4 megabytes, and a separately housed Winchester hard disk, providing 10 megabytes (formatted) of storage.

For those who have too much invested in the 8-bit world to say goodbye, Victor will recommend a Z80 Executive Card that runs CP/M 2.2 (8-bit) programs without modification.

Victor also sells a full range of printers—letter quality (40 characters per second), inexpensive dot matrix (80 cps), and high-speed dot matrix (400 cps).

Reservations

I do have a few reservations about the Victor 9000; there's always something. In principle, I would prefer a computer with an 8086 and a 16-bit data bus. How much difference in performance this would really make we still don't know. [For some indication of the difference, see BYTE's Bits, October 1982 BYTE, page 468. . . . **M. H.**] I would prefer a computer with a standard bus, particularly the S-100 bus so that existing peripherals could be added. Of course, the IBM Personal Computer doesn't use a standard bus either, and Victor, like IBM, is making available technical information about its bus.

As I noted earlier, I would prefer brightness and contrast knobs, and probably a knob for audio volume as well. But these are truly trivial considerations, and I can see the advantage of being able to control these things with software.

I would like a battery-based clock-calendar, but a board could be added to provide that, and someone will probably make such a board if Victor doesn't.

If life without a joystick and light pen is for you without joy and light, then the Victor 9000 is not for you. (On the other hand, if you love these sensory I/O devices, you would probably find the CODEC so fascinating that you wouldn't rest until you'd taught the machine to yodel.)

You might fault the Victor 9000 for not having standard CP/M-format 8-inch floppy disks, but few new systems do, and Victor deliberately chose 5¼-inch drives to keep the system's "footprint" small and packed in the data to provide double the storage of a standard CP/M single-density 8-inch disk.

My only serious reservation about the Victor 9000 concerns the pricing of hardware options and software. The basic system price is better than fair, especially because of the versatility of the standard hardware. But with the double-sided floppy-disk drives, the Victor 9000 costs $5950, almost $1000 more than the price with single-sided drives. The 128K-byte memory expansion board costs $800 if you order it with the machine, and $895 if added later; the 384K-byte board costs $2500 if purchased with the machine, and $2695 if purchased later. The $4495 price for the 10-megabyte hard disk includes the controller but still seems high. So many hard disks are available for the IBM Personal Computer for so much less money. (Of course, none of those is from IBM.) No doubt, if third-party suppliers start offering alternate sources for hardware, these prices will drop.

As to software prices, Wordstar is $500 and Mailmerge is an additional $200; Victorwriter II (Benchmark) is $645, and its mailing-list program is another $245. Victorcalc, Supercalc, and Multiplan each cost $300, which seems reasonable but not aggressive. The price of dBase II is $695, and that seems reasonable but not aggressive. In my opinion, more aggressive marketing through lower software prices

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63K available for program development or execution	NO	NO	✓

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would help Victor gain a wider market and establish itself as a computer company.

The other side of the coin is that Victor does have the cost of maintaining its branch offices and a high level of support. Both Sirius Systems Technology (which, in collaboration with Victor, is marketing internationally the Victor 9000 under the name Sirius I) and Victor have large and busy software staffs installing three operating systems and dozens of applications programs. Who else is doing as much?

Conclusion

The Victor 9000 is an excellent microcomputer. The available service and support and the machine's ability to fit on a typing table make the machine ideal for the business market. The "soft-tooled" hardware makes the machine adaptable to unforeseen external changes (such as your company's home office changing mainframe computers and expecting you to be able to communicate with the new one). The keyboard has a good feel, ample keys, and adaptability that approaches the limit of logical possibility. The video monitor would make your eyes applaud if anatomy permitted. Mass storage is ample and reliable. The Victor 9000's abundance of standard hardware means that your four expansion slots are really free; even with 896K bytes of RAM, two slots remain free. You could have all that memory, a Winchester controller, and a network interface board without the added bulk and expense of an expansion chassis. The company is offering a remarkable range of software, including more than one program for word processing, spreadsheet calculations, and (soon) database management.

You can personalize the computer with the utilities for programming the keyboard and designing character fonts for the display. The CODEC voice-output system stimulates the imagination, especially when and if an input board comes along. Will Victor design software that enables the Victor 9000 to read a letter aloud in a real human voice while you proofread the final copy? Will the Victor 9000 support spoken electronic mail? Will Victor enhance the time-management program with polite spoken reminders?

Given the choice between an IBM Personal Computer with two of its standard floppy-disk drives and a Victor 9000 with two of its standard floppy-disk drives, I would take the Victor 9000. The Victor is clearly superior in quality of display, amount of standard memory, standard number and versatility of I/O ports, and number of available expansion slots. The prices of Victor's memory boards and Winchester disk, however, would give me pause and may hamper Victor's marketing effort.

Finally, two intangible reasons for buying a Victor 9000 deserve mention. First, the Victor 9000 is everything to Victor Business Products, not the "low end" of a long line of computers. Second, owners of the Victor 9000 will have the pleasure of knowing that new products and enhancements for their machine will be coming from a design team headed by Chuck Peddle. ■

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Chuck Peddle

Chief Designer of the Victor 9000

A candid discussion on microcomputer design, marketing, and the industry's future.

Phil Lemmons
West Coast Editor

More than any other person, Chuck Peddle deserves to be called the founder of the personal computer industry. After getting a bachelor of science degree in engineering physics in 1959, he worked for 11 years for General Electric in all aspects of its computer enterprises. In 1970, Peddle started a company to make intelligent terminals. "Too early," he now says. He started a word-processing company in 1972. "Too early," he now says. He then went to work for Motorola, where he participated in the design of the 6800 microprocessor family. Peddle did the architecture for all the peripheral chips of the 6800 and all the I/O (input/output) structure. The 6820, a peripheral interface adapter (a parallel I/O chip), secured several fundamental patents in that area.

Peddle took a team from Motorola to MOS Technology in 1974 to do a low-cost microprocessor and was chief architect in the design of the 6502 microprocessor and its family of chips. By producing the 6502 and selling it for only $25 while other semiconductor houses were saying the price would never fall below $200, Peddle made the personal computer possible.

The 6522, the PIA (peripheral interface adapter) in the 6502 family, extends the concepts in the 6820 by adding some integral timers and shifters as well as other features. The 6522 appears in several places in the Victor 9000 (see "Victor Victorious," page 216 of this issue).

MOS sold 6502s to Atari and Steve Jobs, and then Commodore bought MOS Technology. Peddle transferred to the West Coast and started Commodore's systems business. At Commodore, Peddle developed the world's first personal computer, which he designed to Radio Shack's specifications. In January 1977, Peddle showed the first PET to Radio Shack at the Consumer Electronics Show. Radio Shack and Commodore were unable to make a deal. Radio Shack did its own microcomputer, Commodore brought out the PET, and Steve Wozniak made the 6502-based Apple II. The PET and the Apple II were simultaneously announced to the public in 1977 at the West Coast Computer Faire. Apple shipped Apples first, but Commodore showed the PET first.

Peddle has since left Commodore, founded Sirius Systems Technology, and designed the machine sold in North America as the Victor 9000 and elsewhere as both the Victor 9000 and the Sirius 1. BYTE's West Coast editor, Phil Lemmons, interviewed Peddle late in July 1982 about his goals in designing the Victor 9000/Sirius 1 and about the direction of the microcomputer industry in the next few years.

PL What were your general goals in designing the Victor 9000/Sirius 1?

Peddle I think there were three generations of microcomputer products. The first generation was the board-level computer, like the KIM-1, which was the thing that we did at MOS Technology, the Apple I, the Systems Group—that kind of computer. They were really hobby computers, meant to be used by people looking to develop computer skills.

The second generation—the PET, the Apple II, the TRS-80—were designed as stand-alone, plug-'em-in-and-they-work computers for people who wanted to have computers of their own, for whatever reason. The evolution of that kind of product into high memory, disks, and so forth, leads you to see that those products, which had really been conceived for a different purpose, were starting to be used heavily in business, where they really had a lot of limitations.

PL Forty-column screens, that sort of thing?

Peddle Well, just the whole concept. They were aimed at a different market. If you look at the VIC-20, it is really the original PET repackaged at a lower price—that kind of thing.

We believed that a third generation of microcomputer was coming that would be compiler-oriented, would have multiple high-capacity disks, lots of compute power, synchronous communications, and high-resolution screens, a product that would be designed to be used as a desktop machine in an office network. It was going to be used professionally. It was an office product as opposed to these other products.

Chuck Peddle

We felt that several developments—the new architectures of new micros, the dropping prices of 64K-bit RAM [random-access read/write memory] chips, what had happened in floppy-disk capacities, what was going to happen in hard disks, what was going to happen in networks—basically gave us the opportunity to design a new generation of product. So the goal for the Victor 9000/Sirius 1 was to have a true, very competitive, desktop, entry-level product that could be marketed by the office-products dealers but would also be sold by a sophisticated computer dealer as really a replacement for the higher-end applications of the personal computers and the lower-end applications of the pseudominis and minis. That's a very crisp market definition, a very crisp generation definition.

PL How long did the design of the computer take?

Peddle We fundamentally formed the design team in late December of '80 and started operations in January '81. We showed the first prototype product in April of '81.

PL How many people were on the design team?

Peddle Basically about eight people. It grew after that as we built things.

PL What processors did you consider and why did you choose the 8088?

Peddle We looked at the dual 6502, which was fine except there was no programming base—a small base in Europe, but none in the United States. We looked at 6502 and Z80 combinations, which would have given us an Apple look-alike and a CP/M look-alike. But we concluded that the memory-management problem, while it was solvable, would lead to the sort of machine from which a software base would not naturally evolve. If we were a world leader, like DEC or some firm like that which has its own proprietary software, it might be worthwhile. But these two approaches wouldn't satisfy our software needs.

We then looked at the Motorola 68000. You know, even though I'd been with the Motorola family from almost the beginning, the conclusions were that product was never going to be as cost-effective as the Intel 8086 family was going to be, the support languages were not there at the time, and the 8088 was a very interesting alternative to the 8-bit micros, which we felt we had to compete against from a cost standpoint, but the 8088 also had the ability to migrate upward into 16-bit software.

PL Is there an 80286 [Intel's new very high performance version of the 8086] in your future?

Peddle There's anything that Intel does in our future.

PL The standard memory in the Victor 9000 is 128K bytes. Is that true of the Sirius 1 too?

Peddle Yes, the Sirius and the Victor both. The business strategy for that is very simple. Victor was literally with us from the time we started Sirius Systems Technology. The company was a partnership. We talked to Victor within a week after we formed the company—

PL It's more than the traditional OEM relationship?

Peddle That's right. Victor and Sirius were partners right at the beginning. We talked about the concept. Our business strategy was to compete for Victor's business with Japanese companies, giving Victor the same kind of pricing they would have gotten out of the Japanese. Letting them build a volume base for us in the United States, while we, because of our special knowledge of the international market, would concentrate outside the United States market. We were trading volume for specialized market, in this case, to get higher profit margins. The decisions that went into the computer design were always based on this premise. Therefore, the boards in the Victor 9000 and the Sirius 1 are the same, the power supplies are the same. It's basically the industrial design that's different.

PL The 128K bytes of standard memory was a huge amount a year ago, and it's still a lot, for standard equipment. But now that memory's gotten much cheaper, are you thinking of adding more memory in order to take advantage of the new operating system improvements that I keep hearing about?

The Victor 9000 has the smallest footprint of any word processor.

Peddle Remember two things. First of all, we offer the most memory expansion in the market.

PL Something like three quarters of a megabyte?

Peddle It's more than that, it's really over 900 kilobytes. We have announced a 256K version of the machine that we're currently shipping with a 128K expansion. We're shipping all of that expansion product, and so the answer is that we see an evolution for the development machines almost exclusively to 256K, and some level of application machines to 256K. You've got to watch it. The market's such that when you have to compete against the Z80 and 6502 machines, you've got to be careful not to have too much in your baseline machine when you have to go in—at least on a price-quote basis—against these machines with a lot less capability, and we're able to come close in price.

PL After you decided you wanted to have something in the range of 1.2 megabytes of floppy storage, why did you choose 5¼-inch drives instead of 8-inch?

Peddle Cost, packaging. The Victor 9000 has the smallest footprint of any word processor in the marketplace, much less any personal computer.

Peddle

PL And that couldn't be done with 8-inch thin-line drives?

Peddle No. The form factor on that design was very, very compact. It was designed to sit on the side port of a secretary's desk. Remember our primary market is Europe, and Victor wants to be a factor in that market too, and therefore we had to meet the latest European ergonomic standards. Packaging 5¼-inch drives led much more easily to that. Typically 5¼-inch drives are cheaper by far. We believed that we could pack the 5¼, and we could get enough capacity into that size on the basis of techniques that we'd used previously. And we were able to do so without any sacrifice of system reliability. In fact, we have a more reliable system. We've done some tests on alignment. We're less sensitive to alignment problems than normal 48-tpi (tracks per inch) drives.

PL I had the machine for several months, longer than I intended, for several reasons. I tried to do things with huge files to cause problems, and I haven't been able to generate a single disk error. So I'm convinced.

Peddle Yes, if you look at the way we've done it, the systems concept is much more inherently reliable. We've got a very tuned phase-locked loop, which we're operating very effectively at a single frequency, but we have none of the normal droop and signal-to-noise problems that most disk drives have because we're really recording at constant density all the way across the disk.

PL The constant linear speed is a factor too?

Peddle Right. The combination of the phase-locked loop and the constant linear speed is unique.

PL In order to include these two characteristics, did you have to design your own disk-controller board?

Peddle Perhaps, but quite frankly, the system is optimized for cost as well as performance. We get higher-capacity disks and higher-resolution

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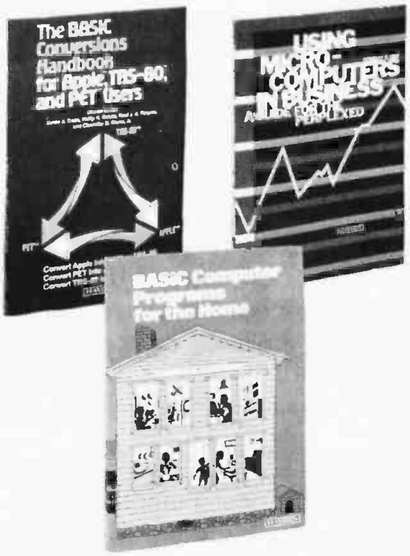

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PL Why did you use the 6522 parallel I/O chips for the disk-controller board and other input/output? Specific design virtues?

Peddle Yes, basically. We used them for some things we do with printers and particularly for our parallel ports. Look at the way we did our IEEE or printer port. We needed to have the ability for our I/O devices to be glitchless when we change states and directions. Intel parts aren't. Motorola parts and MOS Technology parts are, because we designed them that way. By the way, I used Intel parts to begin with. Had to redesign.

PL Why did you choose Group Code Recording [a technique of compressing data by squeezing out zeros] as a method for increasing disk-storage capacity? Were there other options?

Peddle No. We proved to ourselves long ago that Group Code, with the higher bit densities and the kind of recording scheme we had, gave a much more reliable recording. It's a question of reliability as much as it is higher capacity.

PL Is the encoding itself done in the BIOS [basic input/output system]?

Peddle No, it's done in the disk-controller chip that does the speed control, and yeah, there's a small amount in the programming. The system is really a combination of micro- and multiprocessing, if you will. Some pieces of the stuff are done in the chip itself. Some of it's done in a ROM [read-only memory] that's outboard—it's currently being implemented into a gate array—and some of it's done in the outboard micro that's in the controller. So it's —I don't like to overuse the term "systems design," but in fact that's what it is. It really is a totally integrated design. You partition pieces of it but the focus is constantly architecture.

PL The high-resolution monitor is one of the computer's most striking features. A lot of computers now have separate RAM for the screen. Your computer has some screen RAM, but it also gives the monitor access to main memory. Why did you choose that approach?

Peddle First, cost. Second, programming ease—the ability to move

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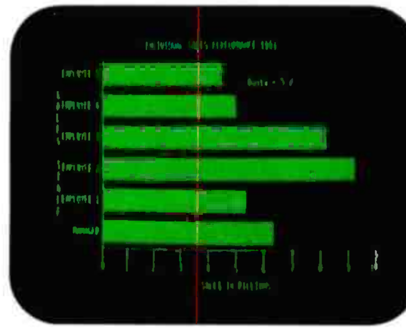

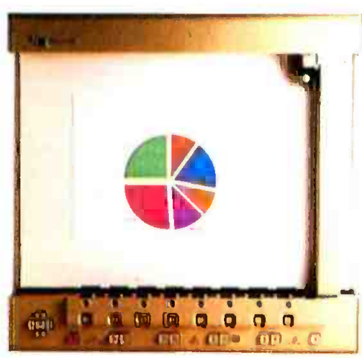

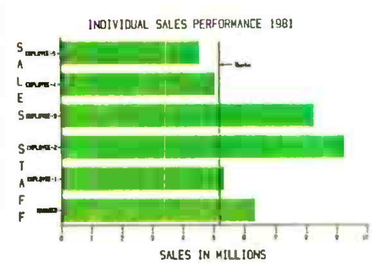

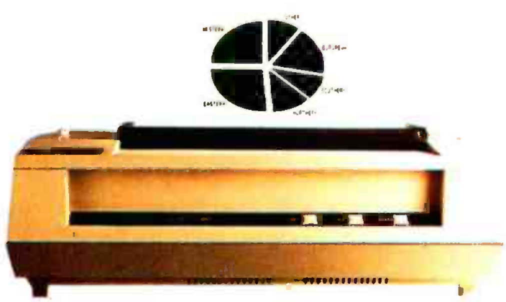

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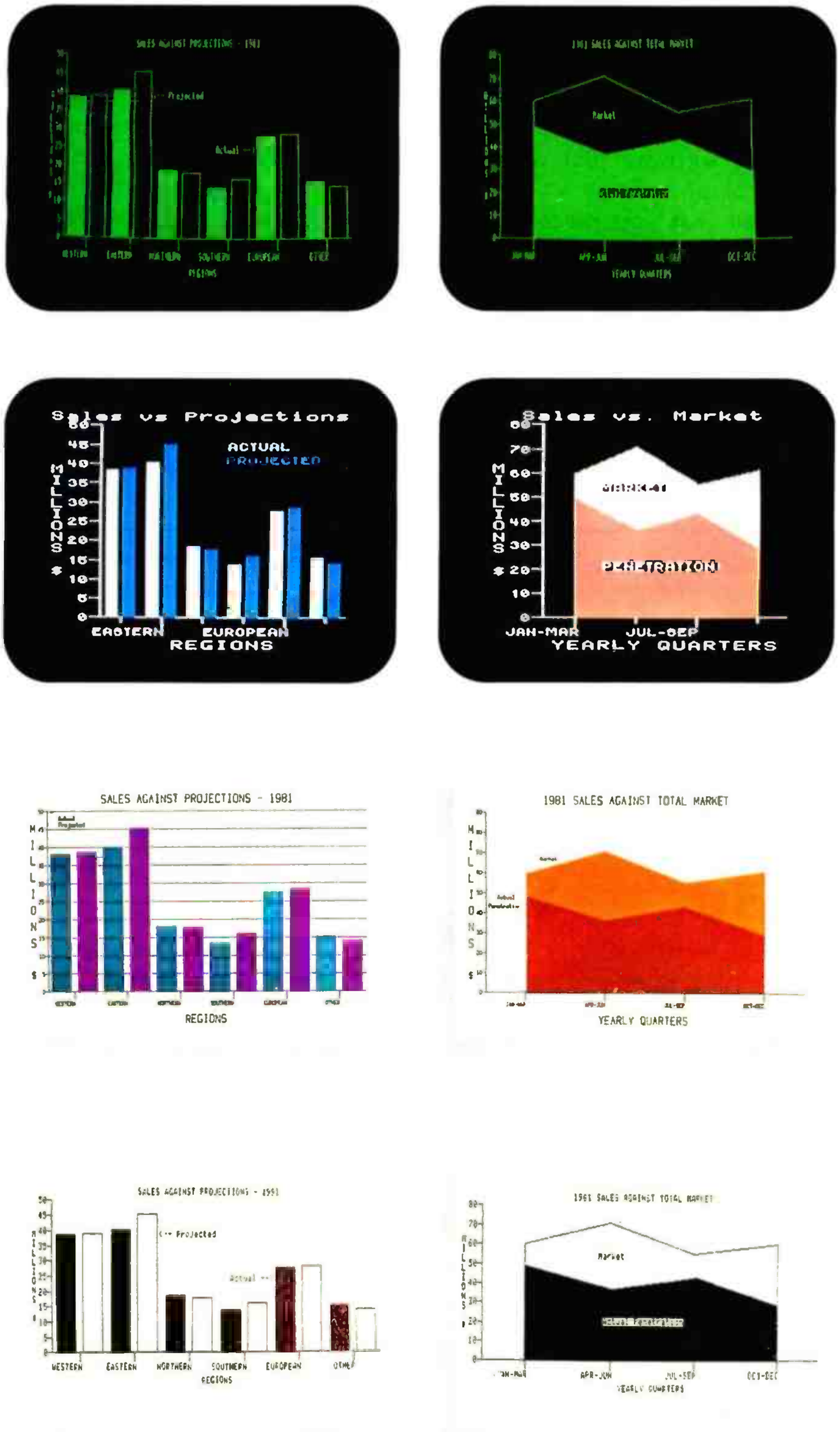

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memory around for some of the high-resolution kinds of things we do. Third, it's a trade-off. You can use character graphics part of the time and give yourself back about 40K of memory. If you want to go into high-resolution mode, you give up that memory. So it's an architectural decision. The only memory we have outboard is there because for timing purposes we needed another memory. We're already really doing a 32-bit fetch for the screen right now. We needed some parallel memory in order to be able to do that.

PL Why the Hitachi 46505 CRT-controller chip?

Peddle It's a third-generation computer. Therefore we were looking at a state-of-the-art product that was just coming out. Look at what we did with the CODEC [coder-decoder for digitized voice]. Look at what we did with the communications chips. We were looking for the thing that was the best product at that point in time, even though the price was high, because we felt that we didn't want to redesign later. So we went with the best ICs we could get, under the assumption that the price would drop.

PL For the RS-232C serial ports, you chose the 7201 programmable communications chip. I know one programmer who's been singing its praises as something to use in writing communications software. But why that particular chip?

Peddle We felt that you needed a channel of synchronous communications. The 7201 gives us two channels, totally under program control.

I want to contrast what we consider different in the third generation from the second generation. Second-generation computers were basically ROM-based machines, right? They were designed to power up, run, and go. They were designed to be used by fairly trivial programmers to write simple programs. What we discovered was that all those architectures kept getting in the way of the more sophisticated programmers. On this machine, we felt that almost all programs would be written by sophisticated applications programmers, and you would have a higher level of operating languages and utilities. And, therefore, we wanted to make the machine absolutely as soft as we could, so that programmers could just get in and do anything. The keyboard is an example of that. The whole concept of the keyboard is to allow universal configurability by the programmer so that you can have a machine that is so personalized that the user buying the product believes he is buying a unique product. What he's really buying is a general-purpose piece of hardware, which we

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built, and a very sophisticated, specialized piece of software written by a creative programmer who's solving that particular problem. But if those are married and properly packaged and presented to a user, he'll believe this machine is tailored for him, whereas you couldn't do that with products from the previous generation.

So the whole idea was to put enough hardware in the machine—the communications chip, programmable data rates, and so on—to stay out of the programmer's way.

PL I guess there's no reason why the keyboard couldn't be switched to a Dvorak format?

Peddle Absolutely. Whatever you want. Have fun.

PL Is anyone doing it yet?

Peddle No, we haven't seen anybody do it, but we're already supporting 31 different keyboard styles. We intend to support as many keyboards as people want to create.

PL The 8048 microprocessor seems to be a popular choice for keyboards, but it's really a general-purpose microprocessor isn't it? What suits it especially to scanning and so on?

Peddle It's available from Intel, and it's quite reasonably priced. You know, there are a couple of others that were probably equally doable, but I think the answer is really that it's an Intel product.

PL What applications did you have in mind for the CODEC voice capability?

Peddle It's our belief that machines in the business environment are going to have to become increasingly user-friendly. That's the reason for the high-resolution screen. If we could do it, voice input would be in the product right now. It will be if it ever becomes available. You could buy a Datsun 280 ZX that has a pretty voice to tell you the door is open. You're going to be able to buy a refrigerator that will talk to you before long. We believe voice is the competition that the Japanese have chosen for the next generation of consumer products. We feel that the use of the voice to personalize training, to interrupt for electronic mail, is something that will be required by customers in the near future. High-resolution graphics on the Apple II showed us something about what this marketplace is all about. On the PET, we put in character graphics because it was cheap and it was available. We won design awards with the PET character graphics because the average programmer could jump all over them and was made happy quickly. In the long run, the Apple graphics won because more creative programmers could do more with that product, to the point that we felt that a next-generation product couldn't *not* have high-resolution graphics. We think voice fits the same category, that by making it available, we will have a whole generation of programmers start to use it.

You know, we showed the concept of what I consider to be the first personal computer to the financial community. The first announcement and demonstration was in New York in early '77. People said, "Why do people buy these things?" Kind of a funny question. I answered them with Edison's concept about the electrical industry: "What use is a baby?" Okay? And in fact, I think my implied prophecy was correct. Fundamentally, we're at that stage with voice. People will find a use for it.

PL What part of the design of this computer gave you the most satisfaction?

Peddle [Laughs] Making the company happen, for me personally, because I got a chance to do only a little bit of the design work this time. I did less on this computer than any of the things I've done over the past few years. I think the fact that we met all our goals, achieved all the things that we set out to do. This is the most sophisticated product that has been done in this kind of a marketplace. We had to bring together several talents who had not worked together before. Making all those talents come together—the guys that understood IBM-compatible communications along with the guy that designed the VIC-20. There's a lot of space between those people. Bringing them all together was satisfying. So I guess the answer to your question about the most satisfying part of the design of the computer was "none of the above."

PL What do you think general-purpose business microcomputers will be like two years from now?

Peddle Network. Lots of memory. Very, very hard-disk-oriented. Sold through a different channel from that which the current marketplace is mostly being sold through.

PL What sort of channel do you see?

Peddle I think that you're going to see more use of the mixture of direct and pseudodirect sales. I think you're

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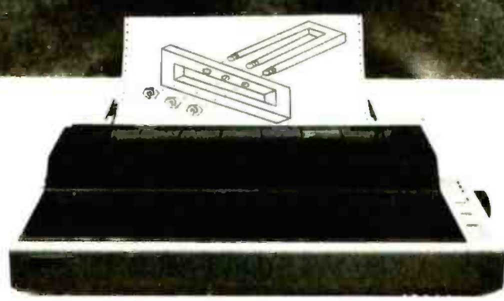

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going to see a lot of follow-on selling. More service-oriented kind of selling. I think you'll see computer retailers change into people who are more market-focused. I think you'll see a lot more vertical markets. Some of the people that others think of as more traditional retailers are going to focus more and more on selling this product in a packaged kind of way. I think you'll see dramatic changes in point-of-sale presentation. I think videodisc will be very important in both applications and point of sale.

PL What do you think home computers will be like two years from now? How many of them do you think will be around?

Peddle Luckily, millions. I think the market for computers split two years ago. I'm going to define two major segments, and there's a smaller middle segment. One major market segment is the throwaway computer, the concept that the Sinclair [ZX81] epitomizes—the kind of computer that nobody should buy but everybody does. Truly disposable. You get the VIC-20, the TRS-80 Color Computer kind of thing, which has meaning and usefulness in terms of computer literacy, games, some form of that kind of activity. And then you get the more serious, third-generation computers that are really aimed at solving problems. They're big, they've got enough disk capacity, and hooked together they really attack. I think what's happened is the guys who started this market find themselves in the middle. They're not powerful enough to compete with the higher-end guys, and they're too expensive to compete with the low-end guys. Other than the education market, which I consider to be a very specialized market and which I expect Atari to dominate—in this country at least, because they've got some real strong leads in that area—I think you're going to see a real dropping out of what I call the middle-range computer buyers. You're going to see a lot of stuff under five hundred dollars, and a lot of stuff in the three- to five-thousand-dollar price range, and relatively little in between.

PL Looking at the other end of the microcomputer market, how much do you expect the superchips, like the Intel 80286 and the National Semiconductor 16032, to cut into the minicomputer market?

Peddle I'm going to not answer the question but give you an answer as to what I think is happening to the minicomputer market. I've been a distributed-intelligence fan and dedicated to making that marketplace happen since 1967, working for General Electric and for several companies that were really all distributed. I think I made a contribution to that marketplace. I think the minicomputer represented, at the beginning, a first step in distributed processing. I think the microcomputer companies are, in fact, representing the next step in that. And I think networked microcomputers are, in fact, a new product. Now, the question is, what benefit do I get out of a 32-bit machine? If I get a bigger language, better memory management, those kinds of things, code that I need to move from some other place, sure, I'll have that. But in fact, if you look at the number of new programmers and the number of people who have the opportunity to really crank out user-friendly and very meaningful programs, I think that's the most exciting thing about the microcomputer marketplace. It's not a given that the kind of programming that has to be done to make computers usable by people has to have that 32-bit power. Price drives people. Software availability drives people. But I think that the mainframe step-up in function is less important than what we do with databases, for instance. Does one of those micros make the generation of very powerful back-end database processing possible? Then it's very exciting.

PL So you think multi-user systems are going to fade away in favor of networking?

Peddle I've believed that for a long time.

PL Will multitasking, then, be an essential feature in single-user systems?

Peddle I think so. Just to run the networks and to do local spooling and all of the things that you want a computer to do. A computer should do what you want it to do. If it's capable of doing several things at one time and not slowing me up, it ought to do those things.

PL Without regard to the limits of current technology, what features would your own dream-machine have?

Peddle Voice in. Video messaging. A total product that allows me to work anywhere in the world and communicate with others anywhere in the world and with databases anywhere in the world.

PL Portable?

Peddle Both. One in my office and one in my briefcase and maybe one in every hotel room. I really want to be able to talk to them. I want to have all kinds of my own private storage. I want to have access to a worldwide network of storage.

PL What competitors do you fear more, the small start-up companies with venture capital or the big computer companies? Is the time past for the small company?

Peddle I felt that we were the last venture-capital start-up company—we're not venture capital, because we're funded by Kidde, but that was alternate venture capital. Fortune seems to be trying to prove me wrong. Grid does also. Grid has a specialized product. If we're not the last, Fortune is, in my opinion. The minicomputer company that I fear the most is DEC. The big computer company I fear the most is IBM. The third company I fear the most is whichever Japan decides to let be the winner.

PL You think they'll decide that?

Peddle I think if they don't, they won't beat either of the other two guys. ■

BYTE Game Contest

JETSET

Eugene Szymanski
693 Rosedale Rd.
Princeton, NJ 08540

JETSET, for those of you whose fantasies include manning a perilous flight, offers the adventure of flying—minus the jet lag and the risk. With the Jet Simulator Electronic Trainer (hence JETSET), you'll maneuver an aircraft through the three stages of flight—takeoff, cruising, and landing—in less than ideal conditions. The program, which runs on the TRS-80 Model II, uses the keyboard and screen to make a personal computer version of a commercial flight simulator. You and the controls, of course, remain firmly planted on the ground.

I designed JETSET with three criteria in mind. I wanted it to be technically sound and complex enough to require a certain amount of skill and judgment at the keyboard. Above all, I wanted the game to hold the player's interest by presenting a challenge. To make JETSET a realistic simulation, everything the pilot does in this program must be coordinated with an instrument panel displayed on the computer screen. In addition, the pilot must follow the actual procedures required when flying in near-zero visibility. A plane flown in such inclement weather must proceed according to Instrument Flight Rules (IFR) established by the government, and the pilot must be specially trained and certified to fly *on instruments*. This information is incorporated into the JETSET program.

Instrument landing is the most complex part of the simulation.

JETSET, which is written in TRS-80 Model II BASIC, requires about 27K bytes of memory after the language is loaded. (See listing 1.) I'll begin by describing how JETSET works and follow with a descriptive series of flight lessons.

Computer-Simulated Flight

The JETSET program lets the pilot activate the control surfaces of the jet aircraft, adjust engine thrust, and tune navigational radio equipment by pressing a set of keys. (See table 1.) The program responds to the keypress commands by adjusting aircraft attitude to match the control surfaces and updating the instrument panel display every four seconds as the trajectory of the jetliner is tracked through space by the computer.

The jet instrument panel gives the pilot all the flight information he needs to take off, navigate, and land an aircraft using standard flight procedures and the radio facilities established for modern-day flying. The panel functions reveal what the aircraft is doing and where it is located, so that after a short period of training the pilot knows instinctively how to scan and interpret the panel data.

Position tracking, a vital ingredient in the simulation, is performed in real time to keep the flight situation up to date. Although the pilot completely controls the motion of the jet, wind forces that vary with altitude can influence the flight. The program uses an analytical combination of jet and wind motion to solve the "wind triangle" that is formed whenever an aircraft is aloft and moving through layers of air. The wind-triangle solution yields the "true" motion of the jet relative to the earth's surface.

When the simulation begins, the jetliner is poised for takeoff on the runway at Philadelphia International Airport. The geographic coordinates of Philadelphia mark the starting point of flight. The computer fixes this initial position in memory and cranks out a new longitude and latitude 15 times a minute. The pilot controls the path of the jet during the takeoff roll down the runway. If everything is done correctly in the cockpit, this path will lead to a takeoff with room to spare.

Once airborne, the jet is tracked against a grid of meridians and parallels, an involved computation that requires the program to use spherical trigonometry because of the earth's curved surface. Because the geographic coordinates of airports and radio beacons are stored in the computer's memory, a comparison of positions yields the information it needs to update the instrument panel the pilot uses to navigate.

An instrument landing, the trickiest part of any actual flight, is also the most complex operation for the computer to simulate. This type of landing requires a programmed geometry to simulate the Instrument Landing System (ILS) pattern formed by special radio beams. These beams, which converge at the landing end of a runway, deflect an indicator on the instrument panel of the landing jet and give the pilot an exact path to follow during the final approach to the airport.

Because JETSET knows precisely where the pilot is telling the plane to go, the program will continue to run until the jet lands safely and rolls to a halt or until the flight ends in disaster. When the simulation has ended, for whatever reason, JETSET provides a complete report of the pilot's performance. The report includes the landing location of the plane—whether on or off the runway—to the nearest foot, and, in case of pilot error, a description of the error and the likely damage to the aircraft.

Listing 1: *The program listing for JETSET.*

```
1 REM:PROGRAM NAME= JETSET
2 REM:IFR FLIGHT SIMULATOR (BOEING 747)
3 REM:CREATED 06-28-81 BY GENE SZYMANSKI
4 REM:REVISED 02-25-82
9 SYSTEM "CLOCK OFF"
10 GOTO10000
23 REM:BEGIN CRUISE MODULE HERE
24 CLS:CLEAR2000:RANDOM
25 DIM M$(20)
26 KR=57.2958:XU=64
27 RS=1:IFRND(0)<0.5THENRS=-1
28 RW=(15-5)*RND(0)+5
29 RW=RS*RW
30 REM:SET UP WIND TABLE
32 DIM WA(10,1)
34 FOR I=0TO7:WA(I,0)=RND(359):NEXT
36 FOR I=8TO10:WA(I,0)=90*RND(0)+225:NEXT
38 A=0
40 FORI=1TO10:WA(I,1)=25*RND(0)+A:A=A+25:NEXT
41 RS$(0)=STRING$(31,"_")
42 RS$(1)=SPACE$(13)+".    ."+SPACE$(13)
43 RS$(2)=SPACE$(11)+".        ."
44 RS$(3)=SPACE$(9)+STRING$(13,"_")
45 REM:VOR STATION FREQS TABLE
46 DIM VF(15)
47 VF(0)=115.9:VF(1)=113.8:VF(2)=112.7
48 VF(3)=117.7:VF(4)=117.8:VF(5)=112.2
49 VF(6)=117.4:VF(7)=115.5:VF(8)=116.4
50 VF(9)=113.6:VF(10)=116.9:VF(11)=117.0
51 VF(12)=112.3:VF(13)=117.9:VF(14)=115.7
52 VF(15)=112.8
62 REM:ILS CONSTANTS FOR AIRPORTS
63 DIMVG(15,1)
64 VG(0,0)=238:VG(0,1)=28
66 VG(2,0)=240:VG(2,1)=30
69 VG(5,0)=90:VG(5,1)=217
71 VG(7,0)=299:VG(7,1)=164
72 VG(8,0)=166:VG(8,1)=42
79 VG(15,0)=341:VG(15,1)=75
100 REM:VOR STATION COORDINATES TABLE
101 DIM VP(15,1)
102 VP(0,0)=40.633:VP(0,1)=73.773
103 VP(1,0)=40.202:VP(1,1)=74.495
104 VP(2,0)=42.358:VP(2,1)=70.993
105 VP(3,0)=41.282:VP(3,1)=70.027
106 VP(4,0)=42.743:VP(4,1)=73.802
107 VP(5,0)=46.412:VP(5,1)=84.315
108 VP(6,0)=38.350:VP(6,1)=81.770
109 VP(7,0)=40.917:VP(7,1)=77.99[illegible]
110 VP(8,0)=42.928:VP(8,1)=78.647
111 VP(9,0)=41.350:VP(9,1)=82.16[illegible]
112 VP(10,0)=42.967:VP(10,1)=83.74[illegible]
113 VP(11,0)=44.555:VP(11,1)=88.195
114 VP(12,0)=41.547:VP(12,1)=88.418
115 VP(13,0)=39.495:VP(13,1)=76.978
116 VP(14,0)=42.048:VP(14,1)=87.490
117 VP(15,0)=39.747:VP(15,1)=75.[illegible]
155 DATA FUEL,LBS.,%,VHF,MHZ,THRUST,MAX,IDLE,REV
160 DATA PITCH," +"," -",DEG,FLAPS,UP,DWN,WHEELS,UP,MID,DOWN
165 DATA COMPASS,AIRSPEED,KTS," VERT",SPEED,FPM
170 DATA ALTITUDE,FEET,CLOCK
175 DIM P$(28)
180 FOR I=0 TO 28:READ P$(I):NEXT
185 DIM S$(25)
190 FOR I=1 TO 25:S$(I)=SPACE$(I):NEXT
192 FOR I=0 TO 9:F(I)=0:NEXT
195 REM:INIT FLITE VARIABLES TO STATE AT LIFTOFF
196 FU=195480:FP=63:CC=75:AS=380:RC=6704:AL=1900
198 MZ=77:TR=4:FL=1:FA=10:BR=10:WH=10
200 RA=0:AS(1)=380:FA(1)=10:CC(1)=75:AL(1)=1900:RP=40
201 DP(4)=39:DP(5)=52:DP(6)=75:DP(7)=15
202 L1=39.8667:G1=75.25:LL(1)=L1:GL(1)=G1:LS(1)=L1:GS(1)=G1
203 VO(1)=0.0:VO$(1)="OUT ":VO(3)=0:VO(4)=999.9
204 GX(0)=0:GY(0)=0
205 XO=36481:YO=0
220 TV$=TIME$:GOSUB 7050:TL=TD
221 TW(1)=TD
222 GOSUB335
224 PRINTCHR$(2):GOSUB600
300 K$=INKEY$:IFLEN(K$)=0GOTO304
302 GOSUB800
304 GOSUB1000
335 REM:DISPLAY PANEL (HEADERS ONLY)
340 PRINT@(0,3),P$(0);S$(4);P$(5);S$(3);P$(9);S$(3);S$(6);S$(3);P$(20)
341 PRINT@(9,54),P$(13);S$(3);P$(16)
342 PRINT@(10,56),P$(14);S$(6);P$(14)
343 PRINT@(12,56),P$(15);S$(5);P$(15)
345 PRINT@(1,13),P$(6);S$(6);P$(10);S$(6)
350 PRINT@(1,68),P$(28)
355 PRINT@(2,1),P$(1);S$(4);P$(2);S$(21);S$(3);S$(13);P$(23)
360 PRINT@(3,22),P$(11);S$(13);P$(21);S$(2);P$(24);S$(2);P$(26)
365 PRINT@(4,0),P$(3)
370 PRINT@(5,39),P$(22);S$(6);P$(25);S$(5);P$(27)
375 PRINT@(6,0),P$(4);S$(10);P$(7);S$(3);P$(12);S$(7)
380 PRINT@(7,13),P$(8)
381 PRINT@(3,68),"VLF OMEGA":PRINT@(4,65),"LAT"
382 PRINT@(5,64),"LONG"
```

Listing 1 continued on page 304

Key	Function	Definition
F	Thrust increase*	increases power applied to jet engines
S	Thrust decrease*	decreases power
Q	Thrust reverse	reverses engine thrust direction during landing
↑	Pitch down*	lowers nose of aircraft by an angle of 5 degrees
↓	Pitch up*	lifts nose by an angle of 5 degrees
→	Pitch cancel	sets nose to level flight (horizontal)
<	Rudder left*	increases rudder angle to left by one increment
>	Rudder right*	increases rudder angle to right
/	Rudder cancel	returns rudder to center position
L	Flaps	raises and lowers wing flaps
W	Wheels	raises and lowers landing gear
B	Brakes	releases wheel brakes for takeoff
M	Missed approach	signals an aborted landing attempt
V	VOR frequency tune	inputs a frequency to VOR receiver
R	VOR radial select	selects a radial value for navigating
A	VOR auto select	automatically rotates the radial selector dial

Notes: 1. The TRS-80 keyboard CAPS key must be engaged throughout the simulation.
2. An asterisk (*) identifies keys that may be typed additional times to increase their control functions.

Table 1: *Keys used for pilot control.*

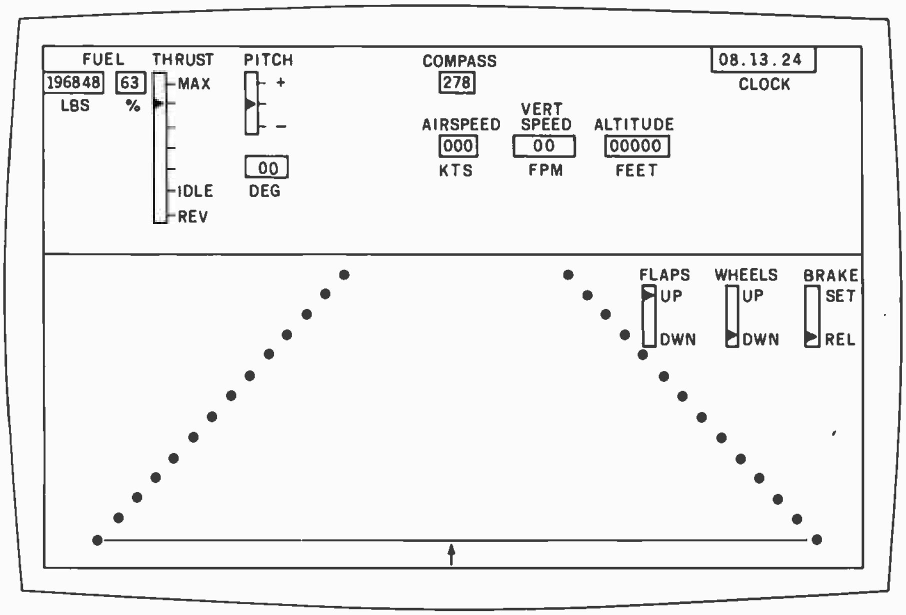

Figure 1: *The instrument panel display during takeoff.*

Flying Lesson #1
Taking Off

When you load JETSET into memory and type RUN, the screen will flash a message authorizing a takeoff from Philadelphia International on runway 9R. The screen will then display the upper section of the jet instrument panel and a perspective view of the runway as it would appear from the cockpit (see figure 1). At this point the jet is parked in the takeoff position with its engines idling, ready to go when its brakes are released. (Note: The "CAPS" key of the TRS-80 keyboard must be engaged and remain on for all key commands used during the simulation.)

To prepare for takeoff, press the L key to lower the flaps and check the panel FLAP indicator. A down position shows that the wing flaps are now extended. The flaps provide the vital extra lift needed during landing and takeoff, when the jet airspeed is marginal. Next, release the wheel brakes (W key). The jet will begin to move slowly because the engines are idling at only a fraction of their rated power or thrust. To apply full takeoff power, press the F key and watch the THRUST lever indicator move to its maximum forward position. The program will now apply acceleration to gradually bring the jet up to its rated takeoff speed, 150 knots (173 mph).

As momentum builds, the AIRSPEED indicator begins to register. The jet begins its takeoff roll down the 10,500-foot runway. Soon afterward, the COMPASS indicator begins to deflect from its 075 degree reading as the jet is hammered by gusts of wind sweeping across the runway. This is a busy time in the cockpit because you must carefully steer the jet along the 200-foot-wide runway strip as you come up to takeoff speed. A sliding arrow at the base of the runway graphic shows how far the jet is wandering from the runway centerline. Use the rudder keys (< and >) to steer the jet via its nosewheel whenever this arrow veers away from the center position. The arrow will shift left or right whenever the compass reading deviates from the 075 degree direction of the runway. Careful steering, then, is an exercise in coordinating both keys with the compass reading and the runway graphic (each press of a rudder key alters the direction of travel by one degree).

Assuming that the jet doesn't veer off the runway (which would end the flight), you must be ready to execute the lift-off maneuver when the airspeed reaches 150 knots, at which point you press the ↓ key once, and once only, to tilt the nose up 10 degrees. The jet will lift off just before the end of the runway moves to the bottom of the screen, and the horizon line will vanish.

Immediately following the lift-off, you must execute a three-step sequence to gain altitude promptly:

1. raise the landing gear (W key) to reduce "drag" (air friction)
2. retract the wing flaps (L key)
3. reduce the thrust (S key) to attenuate engine noise—in accor-

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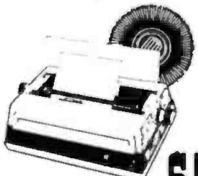

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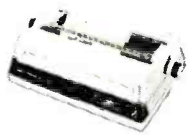

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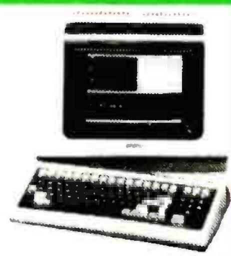

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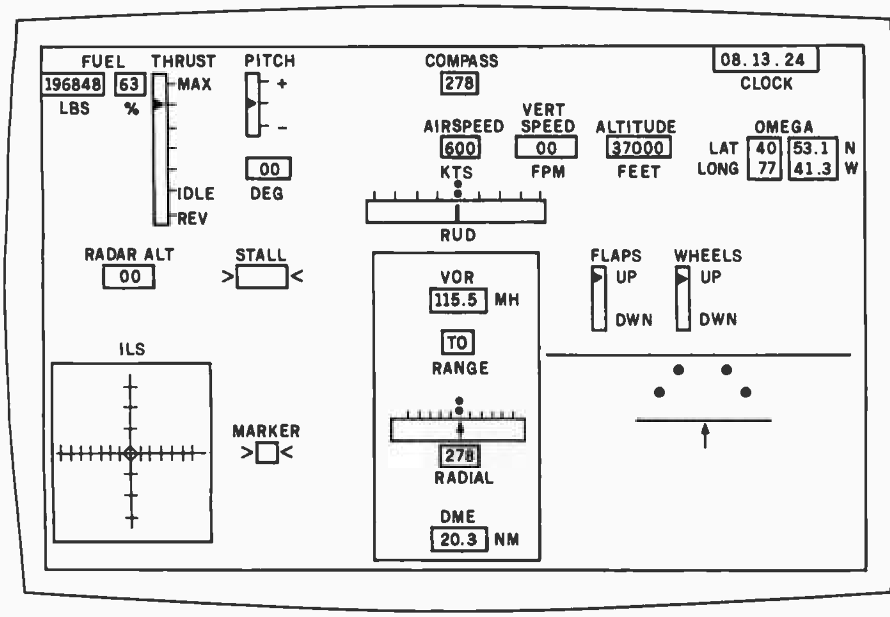

Figure 2: *The full instrument panel display.*

Instrument	Units	Function
FUEL	pounds, %	fuel aboard (in pounds and percentage full)
VHF	MHz	communications channel
THRUST	——	position of engine thrust levers
PITCH	——	attitude of aircraft pitch
DEG	degrees	angle of pitch, measured from horizontal
COMPASS	degrees	compass heading of aircraft (direction of nose)
AIRSPEED	knots	aircraft velocity through the air
VERT SPEED	feet/minute	rate of climb or descent
ALTITUDE	feet	aircraft altitude
CLOCK	hr.min.sec	time of day (local time)
VLF OMEGA	degrees and minutes	aircraft position (latitude and longitude) in degrees and minutes of arc
RUD	——	rudder angle
FLAPS	——	flap position
WHEELS	——	landing gear position
BRAKE	——	position of wheel brakes
VOR	MHz	frequency to which VOR receiver is tuned
RANGE	——	displays status of VOR receiver
RADIAL	degrees	value of selected radial (needle moves along window directly above RADIAL)
DME	nautical miles	distance to VOR ground station
RADAR ALT	feet	aircraft elevation during final approach
MARKER	——	turns on when flying directly over the ILS outer and middle marker beacons
ILS	——	pair of needles that deflect according to aircraft position in ILS radio cone
STALL	——	flashes when aircraft is stalled during final approach

Table 2: *Instrument panel legend.*

dance with federal antinoise regulations—as the jet passes over metropolitan Philadelphia

You must perform this sequence in the above order because the three keys are software-interlocked. In addition, you must complete the three steps before the ALTITUDE indicator reads 1200 feet. If you do everything correctly, the screen will erase to indicate a successful takeoff and a display of the complete instrument panel will appear. (See figure 2.)

Takeoff Mishaps

JETSET doesn't introduce random flight emergencies, but the simulation will abort with a grim message if you mishandle the jet. Using the built-in program specifications of a Boeing 747, the equations of motion dictate that it takes 63 seconds to reach takeoff velocity (150 knots) after full engine thrust is applied. During this interval, the accelerating jet uses up 80 percent of the two-mile runway.

This equation of motion establishes the safe takeoff envelope for the simulation. You must use the ↓ key promptly when the airspeed reaches 150 knots. If you hesitate for another 10 seconds, it will be too late—the jet will simply charge down the runway at 172 knots, plunge into the marshlands beyond, and . . . you get the picture.

The anxious pilot who pulls the nose up too sharply at lift-off time (by pressing the ↓ key more than once) also comes to grief. The abort message will point out that the tail-end of the fuselage has struck the runway; the aft end of a 747 will clear the ground by only a few feet during a normal takeoff. Most important, as pilot you must always remember to lower the wing flaps before you attempt to take off in a 400-ton jet, even in a simulation.

Flying Lesson #2
Maneuvering

Following the takeoff, the jet slowly gains altitude as it passes over central New Jersey and heads toward the Atlantic coast. None of this geography is visible, of course, because of the blanket of clouds below. At this point, you must navigate the jetliner entirely on instruments until it's just a few hundred feet from the point of landing at the destination airport, wherever that may be.

This lesson will give you a "feel" for the controls and show you how they relate to the instrument panel functions. (See table 2 for a list of controls.) The PITCH indicator shows that the nose is tilted upward (positive pitch) at an angle of 10 degrees. With the current position of the THRUST lever, the jet is gaining altitude at the rate of 6704 feet per minute (VERTICAL SPEED). Press the ↑ key twice to level the nose to a zero-degree pitch. The AIRSPEED will now increase, VERTICAL SPEED will become zero, and the ALTITUDE will remain constant. The ↓ and ↑ keys, which correspond

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Instrument Landing

A. *Execute the takeoff procedures.*

B. *Follow the directives given in the Flight Plan (figure 7) for the intended destination (Buffalo, NY or JFK International). This will lead the flight right up to the ILS Outer Marker along the initial approach radial.*

C. *Begin the initial approach, trimming as soon as the DME readout agrees with the value given on the Flight Plan (20 nautical miles for JFK International Airport). Trim as follows:*

- *Reduce airspeed to 300 knots (S key).*
- *Drop the landing gear (W key).*
- *Lower the flaps (L key).*
- *Adjust altitude to between 1700 and 1900 feet (elevator keys).*
- *Keep the VOR needle centered (rudder keys) to stay on the initial approach radial.*

D. *Be alert for the flash of the MARKER lamp (which occurs when the DME=12). At this signal the jet must be maneuvered for the final approach:*

- *Quickly swing the nose until the compass agrees with the localizer direction shown on the Flight Plan.*
- *Use rudder and elevator keys to keep the ILS indicator needles centered as the jet descends along the glidepath.*
- *As soon as the runway graphic appears on the screen, use the graphic arrow as a guide to apply rudder corrections.*

E. *When the MARKER lamp flashes again to announce arrival at the decision-height point, check the runway alignment using the graphic displayed on the screen. If necessary, press the M (Missed Approach) key to abort the landing attempt. Otherwise, if the plane is lined up safely, take all cues from the RADAR ALT from here on in:*

- *At 100 feet, idle the engines (S key).*
- *At 50 feet, flare up the nose (→ key).*
- *At 0 feet, the jet is on the runway. Slow it down by applying reverse thrust to the engines (Q key).*

Takeoff Procedure

A. *Lower flaps (L key).*

B. *Release brakes (B key).*

C. *Apply full throttle (F key).*

D. *Steer along the 075-degree runway using left/right rudder keys (< and >). Coordinate steering with the COMPASS reading and the position of the arrow located at the base of the runway graphic.*

E. *As soon as the AIRSPEED indicates 150 knots, press the ↓ key once to gently lift the jet off the runway.*

F. *After the horizon line drops below the screen, press the W key to raise the landing gear.*

G. *Retract the flaps (L key).*

H. *Throttle back the engines (S key).*

I. *Sit back and relax for a minute or so as the jet gains altitude.*

Practice Flight

A. *Execute the takeoff from Philadelphia.*

B. *Level off at 10,000 feet.*

C. *Steer approximately north.*

D. *Adjust airspeed to 600 knots.*

E. *Tune to the frequency of the Buffalo VOR station.*

F. *Input the reciprocal value of the 115-degree radial into the receiver.*

G. *When the VOR needle moves to center, alter course to 295 degrees (COMPASS).*

H. *Now steer to keep the VOR needle centered. This indicator, not the compass, will provide exact guidance for the remainder of the flight.*

I. *Use the DME indicator to keep track of distance remaining, in nautical miles, to Buffalo. To estimate the remaining flying time (in minutes), simply divide the DME reading by 10.*

J. *When the DME readout reaches zero, the jet has arrived.*

to motion of the pilot's control stick, are used to climb or descend to a new altitude. Each press of the ↑ key pushes the nose down another 5 degrees, causing a rapid loss of altitude as both airspeed and vertical speed build up. Regardless of the maneuver—climbing or diving—you should always use the → key to quickly level off the jet when the ALTITUDE readout reaches the desired value.

You can steer the jet to a new COMPASS course by pressing the keys that control rudder angle. Press the < key once to begin a slow turn to the left and watch both the COMPASS and the rudder-angle indicator (RUD). Each additional push of the rudder key will make the angle more acute, causing the COMPASS to swing faster as the rate of turn increases. Always use the rudder-cancel key (/) to stop further turning as soon as the COMPASS indicates the desired course.

You can adjust AIRSPEED by moving the thrust lever forward or backward (F and S keys) one step at a time. Each tap of the key shifts the position of the arrow displayed on the THRUST indicator and alters the AIRSPEED reading. The 747 normally cruises at 600 knots, and for a given thrust setting the AIRSPEED indication will drop back during a climb and increase during descent.

Because the instrument response time is 4 seconds, you must delay consecutive applications of the stick or rudder keys until the panel instrument readings catch up. The jet will automatically level off when it reaches an altitude of 45,000 feet; a dive to ground level while cruising, however, will abort the flight with a simulated crash.

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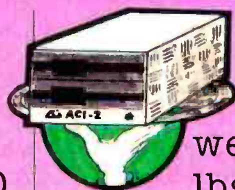

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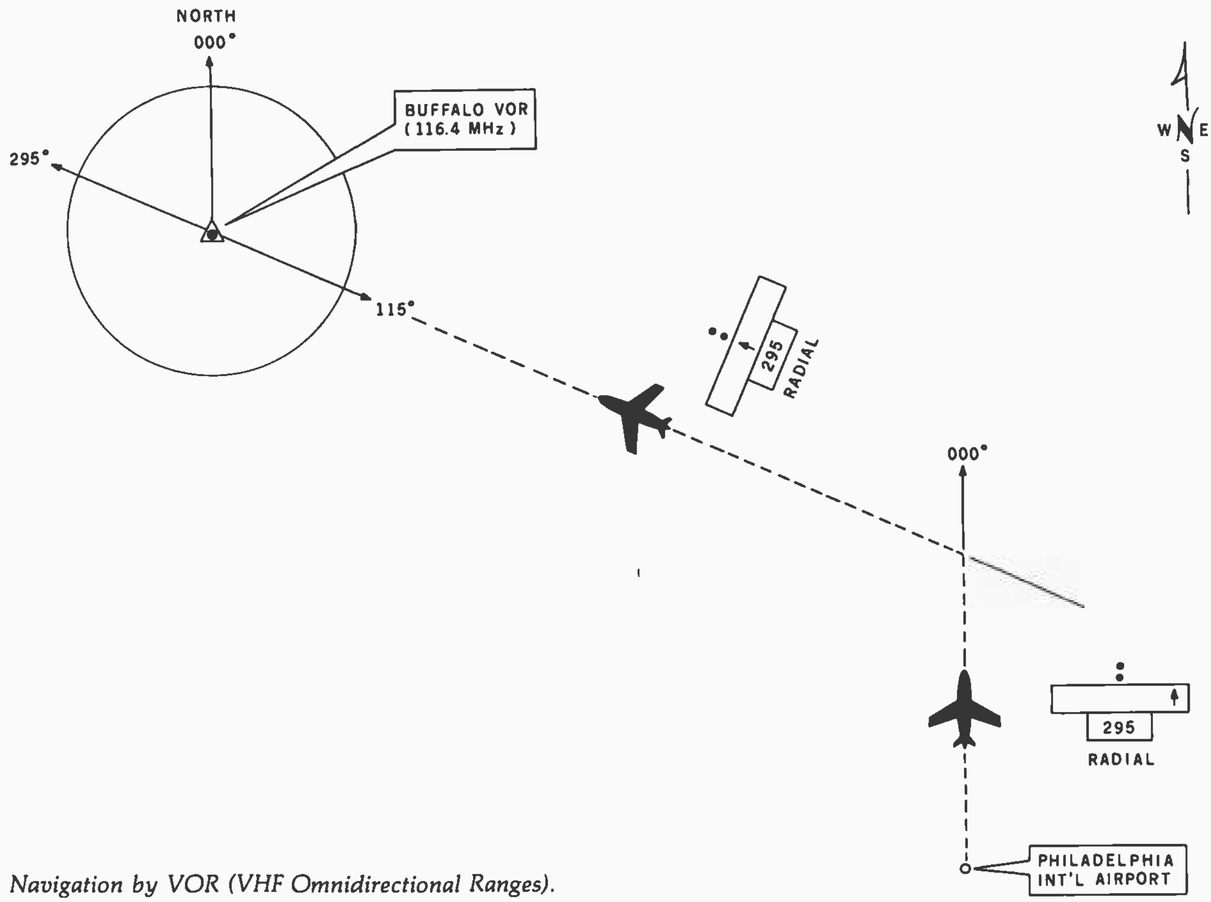

Figure 3: *Navigation by VOR (VHF Omnidirectional Ranges).*

(compass heading and airspeed) and wind movement relative to the earth's surface. As a result of this tracking, the longitude and latitude displayed by the OMEGA readout can fix the exact geographic position of the jet as it is maneuvered through computer-simulated winds. This process results in an effective real-time simulation of the actual OMEGA system.

Although the longitude and latitude displayed on the OMEGA indicator may be used along with any chart or road map to check the progress of the simulated flight, the actual OMEGA system is normally used for flying between continents. For short-range and cross-country flights, most aircraft—and the JETSET simulator—rely on a more convenient system popularly known as VOR (VHF Omnidirectional Ranges).

Flying Lesson #3
Navigating

Most aircraft navigate from point to point using VOR radio facilities. A ground station transmits radio beams that radiate horizontally outward in all directions like the spokes of a wheel. Each spoke or radial (there are 360) is fixed in direction and can be used to provide an accurate and unvarying path to its source, the VOR station transmitter.

In practice, the pilot first tunes the VOR receiver to a ground station located at or near the destination. Each station is assigned a unique frequency. Next the pilot adjusts the receiver's radial selector dial to match the particular radial intended for use as a path (this dial is calibrated in one-degree steps, from 000 to 359 degrees). The pilot then flies while watching the needle of a sensitive meter connected to the VOR receiver. When the needle moves to its center position, the aircraft has intercepted the selected radial. By altering the course to keep the VOR needle centered, the pilot will be able to guide the plane directly along the radial in a straight line toward the VOR transmitter.

Figure 3 shows you how to navigate to Buffalo, New York from Philadelphia International Airport. First tune the VOR receiver to 116.4 MHz (the frequency assigned to the Buffalo VOR station) and select the desired radial, 115 degrees in this example. Rotate the radial dial until it points to 295 degrees, the reciprocal value of 115 (115+180=295). (The reciprocal value is always used when setting the selector dial to match the chosen radial. This process gives the VOR receiver proper internal orientation.)

Once tuning is completed, you fly in an approximate northerly direction and watch the movement of your VOR panel indicator. Initially the needle will be "pegged" to the right side of its travel, but it will slowly begin to move toward the center as the plane nears the 115-degree radial. Once the needle is at center, alter your course to 295 degrees by compass and swing the nose of your jet toward Buffalo. Now you must make minor steering corrections, using the rudder to keep the VOR needle centered.

This needle, rather than the compass reading, provides the guidance for the remainder of the trip. Upper-air winds will generally deflect the heading (compass course) of the jet from its actual track over the earth's surface, but if the plane is flown with the needle centered, the path of travel will remain exactly on the 115-degree radial. The compass reading may differ by a dozen or more degrees when you are flying at upper altitudes in the presence of high-velocity jet streams.

The process of adjusting the steering to keep the VOR needle on center is called "chasing the needle." If the needle (which represents the radial) begins moving to the left, you must apply some left rudder until the needle returns to center. For needle deflection to the right, steer to the right. After a minute or two you should be able to establish a compass heading that keeps the VOR needle centered until the jet arrives in Buffalo.

The VOR system carried aboard a jetliner includes a very useful and important device known as the DME (Distance-Measuring Equipment). Once the VOR receiver is tuned to a station, the DME indicator continuously displays the distance in nautical miles (NM) to that station. In a flight to Buffalo, for example, the DME would read about 180 NM when the northward-flying jet first intercepted the 115-degree radial. From then on, as the pilot steered toward Buffalo the DME value would progressively decrease in step with the aircraft's position until the reading reached zero. A zero reading would indicate that the jet had flown over the VOR station. The DME readout would then slowly begin to increase as the pilot passed by Buffalo.

The simulator VOR receiver is tuned and adjusted from the keyboard. To tune to a station, first press the V key, then type in the station frequency. The typed characters will echo on the screen; to correct them, use the Backspace key. Finally, press Enter to terminate the input. To tune in the Buffalo station, type the 6-key sequence V116.4 followed by the Enter key.

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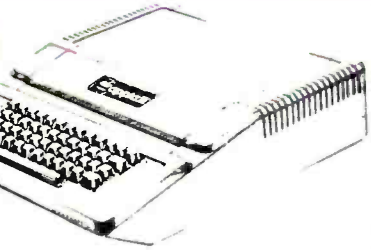

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that you type R first rather than V. To adjust the receiver for the flight to Buffalo, type R295 followed by the Enter key.

The RANGE window of the VOR receiver displays OUT whenever the receiver is not tuned to any station or whenever it is tuned to an incorrect frequency. An OUT also appears if the receiver is tuned to a VOR station whose distance exceeds 300 NM, the maximum range of the VOR signals.

Flying Lesson #4 Practicing VOR

Several practice flights to Buffalo on the JETSET simulator will acquaint you with the simple principle of VOR navigation. Although it isn't necessary, a chart or group of road maps that encompass the Buffalo-Philadelphia area would help you visualize the progress of the jet.

Begin by taking off from Philadelphia, climbing to about 10,000 feet, and leveling off. Then apply the left rudder until the compass reads 000, give or take a few degrees. While you're on this northerly course, adjust the thrust (F and S keys) for an airspeed of 600 knots.

Tune to the Buffalo VOR station by typing V116.4 and the Enter key. Set the receiver for the reciprocal of the 115-degree radial by typing R295 followed by Enter. This completes the tuning procedure. The VOR needle, which is located directly above the RADIAL window on the display, will now remain pegged to the rightmost position for about seven minutes as the jet flies north.

Once the VOR needle begins moving toward the center of the graphic slot, prepare to alter course. When the needle reaches center, apply the left rudder (< key) and bring the jet on a compass course of 295 degrees. Remain on this course for about a minute and watch the motion of the VOR needle. Now you can begin chasing the needle by applying the rudder corrections needed to center the needle and keep it there. You may need to make an occasional steering adjustment if the needle begins to wander, but as long as it remains within one dot of center (each dot represents one degree), your course will be reasonably accurate.

When the Buffalo radial is first intercepted, the DME indicator should read approximately 180 NM, and it should take about 18 minutes for the 600-knot jet to reach its destination. The exact flying time, of course, will depend on the strength and direction of the prevailing winds, but the DME readout will always show the exact remaining distance. If you use a map to keep tabs on the practice flight, remember that DME distances are nautical (not statute) miles. A DME reading of 100 NM corresponds to 115.2 statute miles.

As the jet moves along the radial, the RANGE window of the VOR panel will display TO, indicating orientation toward the VOR station. As soon as the DME reads zero, note the reading of the OMEGA display. Because the jet is passing directly over the ground station, the display should read 42° 55′ North, 78° 38′ West, equal to the geographic coordinates of the VOR station. This reading confirms that the navigation was accurately performed by the VOR system. If you have maintained the course, a FROM will appear in the RANGE window as the jet proceeds in a westerly direction away from Buffalo, New York.

Flying along Airways

Although I used the 115-degree radial for the practice flight to Buffalo, I could just as well have chosen other radials for guidance. For example, a map shows that the 140-degree radial passes directly through Philadelphia and would therefore reduce the flying time if it had been used as a path. I selected 115 degrees instead because it is designated as a jet route by the FAA (Federal Aviation Administration). The FAA has established a network of special radials that high-altitude jets must use when flying on instruments. An aviation chart reveals that radial 115 from Buffalo corresponds to jet route J-95 when the radial direction is adjusted for the earth's magnetism (the JETSET program works with true, not magnetic, directions).

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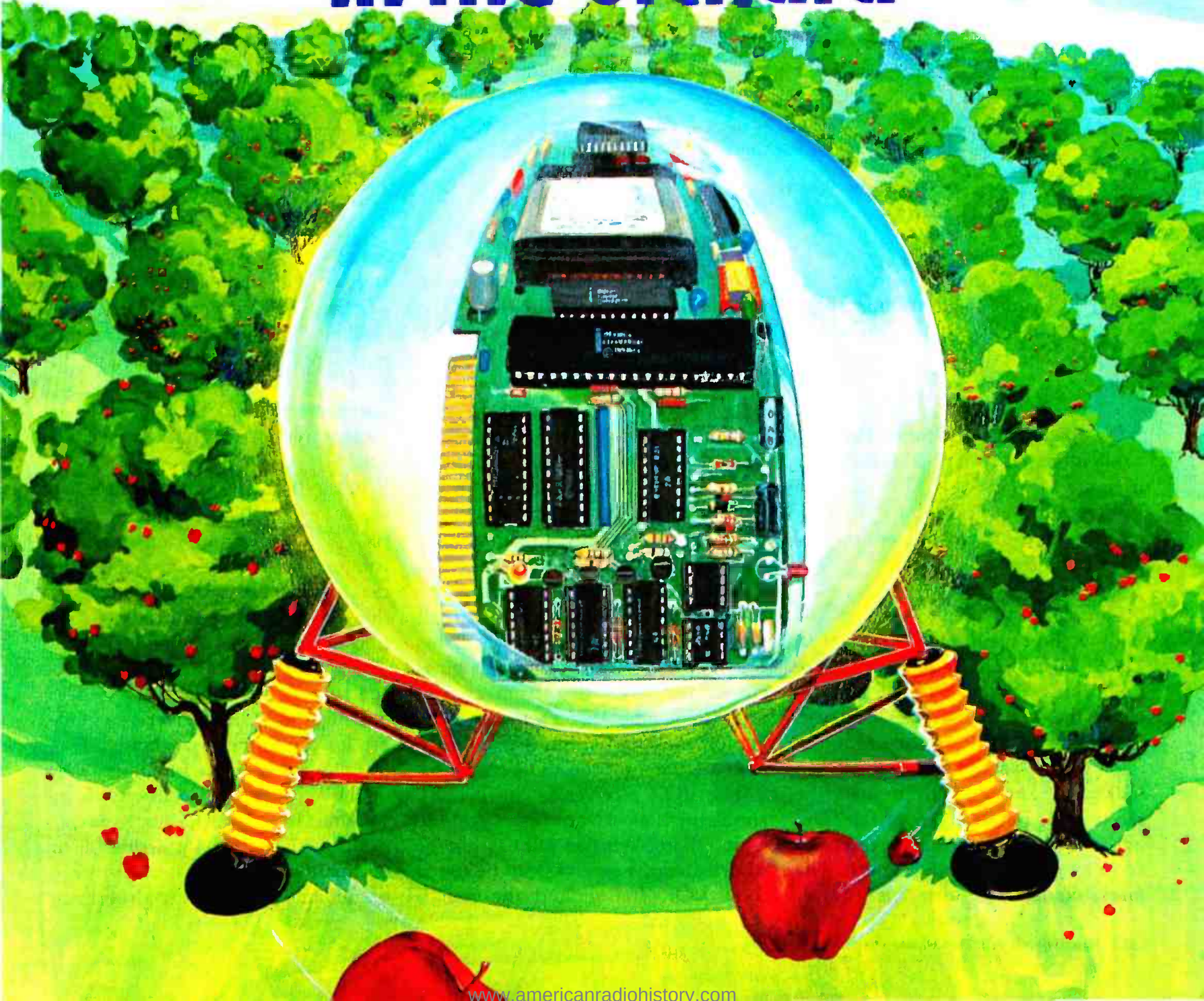


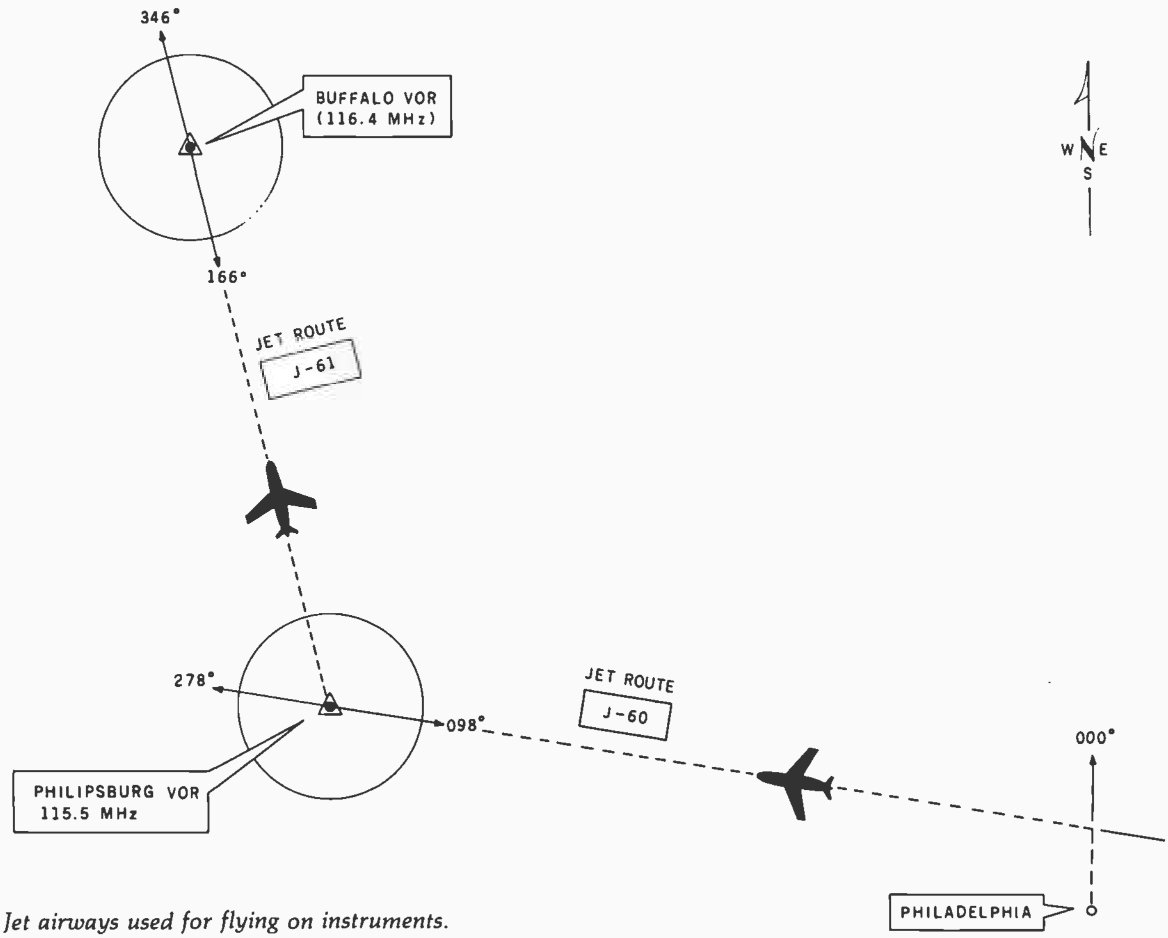


Figure 4: *Jet airways used for flying on instruments.*

In order to comply with regulations, an actual high-altitude flight from Philadelphia to Buffalo might require the pilot to proceed as follows:

- fly toward Philipsburg, Pennsylvania along jet route J-60 (as shown in figure 4)
- alter course at Philipsburg to pick up jet route J-61, which leads directly to Buffalo

During the first leg of the trip, the pilot would tune the VOR receiver to 115.5 MHz, the frequency of the Philipsburg ground station, and fly along the J-60 radial (278 degrees). Just before the pilot reached Philipsburg (as shown by the DME indicator), he would retune the receiver for Buffalo (116.4 MHz) and adjust it to the radial that corresponded to jet route J-61 (346 degrees). The pilot would then alter his course, chasing the needle to follow radial 346 until he arrived at Buffalo.

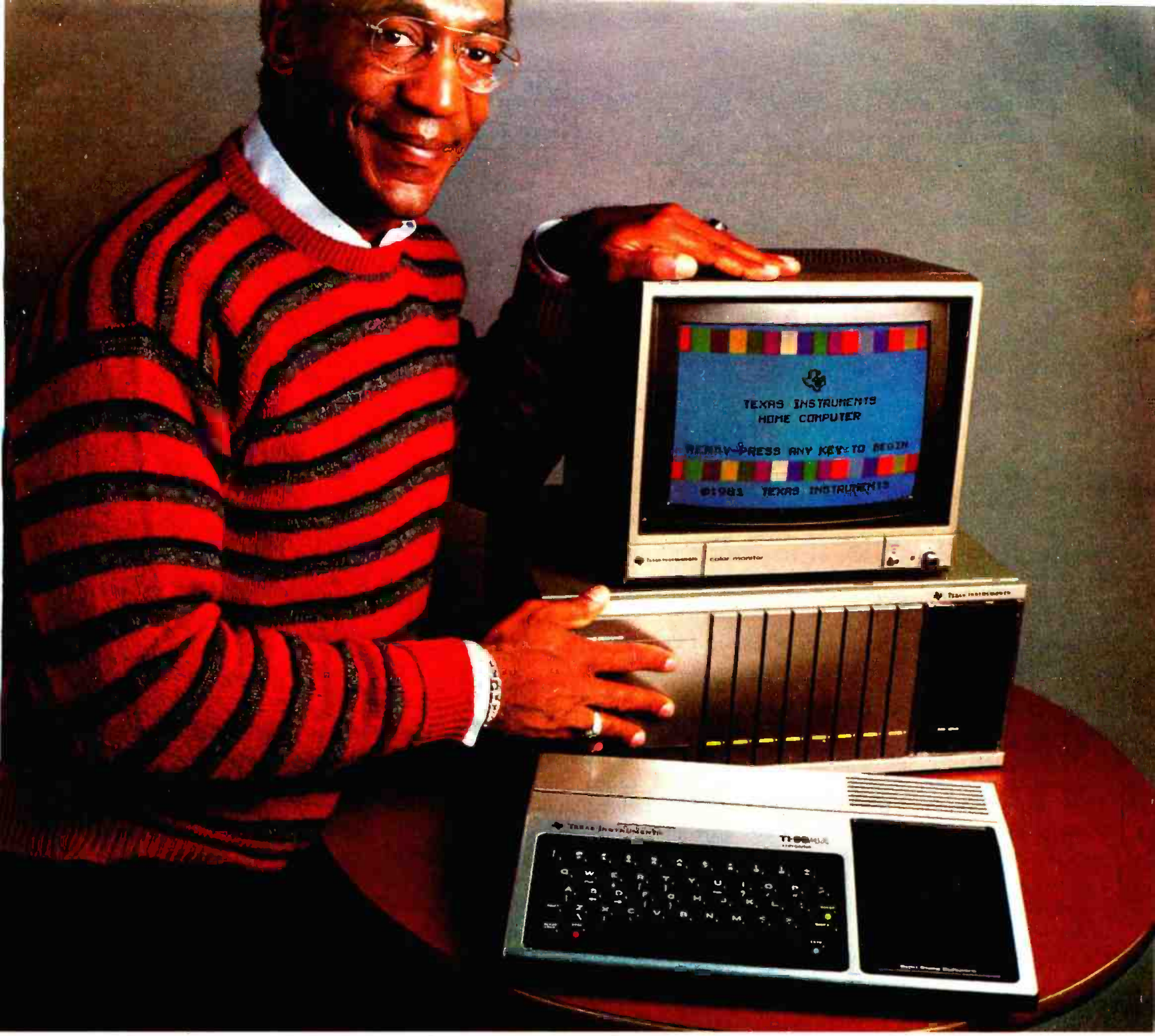
Numerous VOR stations scattered throughout the country enable a pilot to fly extended distances simply by hopping from one station to the next, retuning the receiver to locate the designated jet routes. JETSET, however, needs only a handful of VOR stations to establish a network for instrument flight simulation. Figure 5 shows the frequencies and locations of the VOR stations built into the program. You may use any of these VOR stations for practice flights to the given cities or as stepping-stones for navigating from city to city. (Remember that a tuned-in VOR station must be within 300 miles to activate the airborne VOR receiver.)

The VOR receiver in the JETSET simulator is as versatile as its real-life counterpart. When a pilot is lost or disoriented the receiver can be tuned to a VOR station and the radial-selector dial rotated until the needle of the VOR meter centers. The reading shown on the radial dial then represents the direction from the VOR station. Combining this with the distance read on the DME indicator results in an exact position "fix."

In the JETSET simulator a press of the A key results in an exact position fix. The program automatically rotates the invisible radial-selector dial for the pilot and quickly displays the direction from the tuned-in station in the RADIAL window.

Instrument Landing

Using the VOR receiver as a guide, a pilot can navigate accurately from one city to another without any view of the earth below. VOR radials are suitable for point-to-point navigation, but when a pilot arrives at his destination he needs another system of guidance to get to the airport run-



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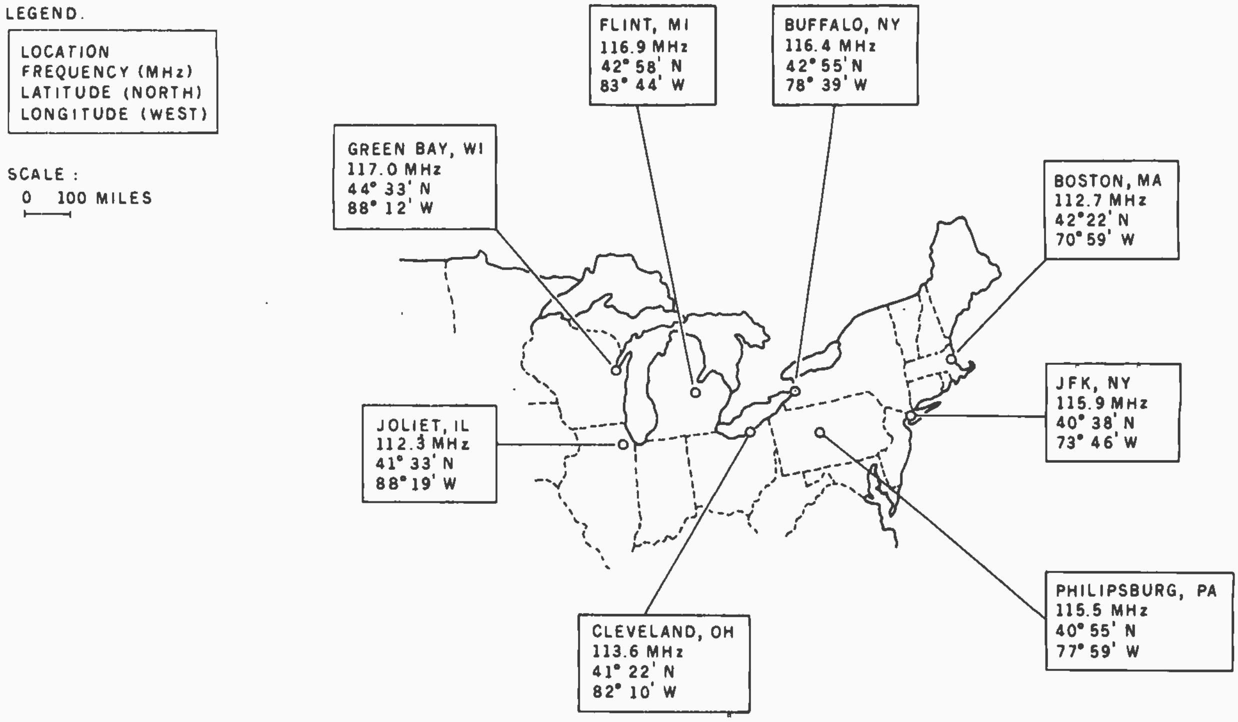

Figure 5: *Locations and frequencies of simulated VOR ground stations.*

way itself. In this case, the pilot must revert to a radio aid, the Instrument Landing System (ILS), a facility designed to make blind landings possible. A trained pilot flying an aircraft equipped with an ILS receiver can locate an airport and safely land on a runway that may not be visible until a minute or so before the actual touchdown.

An ILS installation consists of a group of radio transmitters arranged in the vicinity of the airport where ILS landings are to take place. These transmitters radiate highly directional radio beams that converge at the foot of the runway, forming a cone-shaped pattern like the rays of a searchlight (see figure 6). The pilot first maneuvers the plane into this invisible cone, then uses the ILS receiver to follow the radio waves down until the aircraft is just a few hundred feet above the ground. At this low altitude the runway should be visible, so the actual landing can be completed in the usual way.

The airborne instruments used to locate and follow the cone of radio waves are a marker lamp, an ILS indicator, and a radar altimeter. On the JETSET simulator panel these three components are identified as the MARKER, ILS, and RADAR ALT respectively. The panel MARKER lamp flashes on when the aircraft flies over a point called the "outer marker" (OM in figure 6), telling the pilot that the plane has just entered the ILS cone. The crosshairs (horizontal and vertical needles) of the panel ILS meter will now begin to deflect, and the pilot must maneuver the plane to keep the needles centered in order to follow the path of the ILS radio cone. As the aircraft descends along this narrow path, the radio altimeter (RADAR ALT) gives a continuous display of the exact elevation from the ground (in feet). The radar altimeter is much more sensitive than the conventional altimeter, so it is always used for precision landings.

During the time the aircraft has entered the ILS cone and is heading toward the runway, when the pilot is making the final approach, the plane flies in a direction known as the "localizer" direction of the ILS radio beams. The angle that the radio cone makes with the ground is called the "glideslope" angle, and the descending plane is said to be flying within the ILS "glidepath." The two moving needles of the ILS indicator correspond to the localizer and glideslope axes during the final approach. The pilot chases the vertical needle (which moves left and right) to remain aligned with the localizer direction. The horizontal needle (which deflects up and down) must be chased using the elevator controls to keep the plane within the glidepath.

Once the descending aircraft reaches the ILS "middle marker" (labeled as MM on figure 6), the panel MARKER lamp will flash again, alerting the pilot that the plane is just a fraction of a mile from the runway. This critical location is called the "decision height" of the final approach because the pilot must now decide whether he can safely complete the landing. If the runway appears in view directly ahead, the pilot can make a visual landing. If, however, the plane is not properly lined up with the runway (because the ILS needles were not kept centered), the pilot must abort the landing attempt at once by climbing out of the glidepath. This situation is known as a "missed approach." When a pilot misses the approach, he flies a safe distance away from airport traffic and then returns to the OM point for another try.

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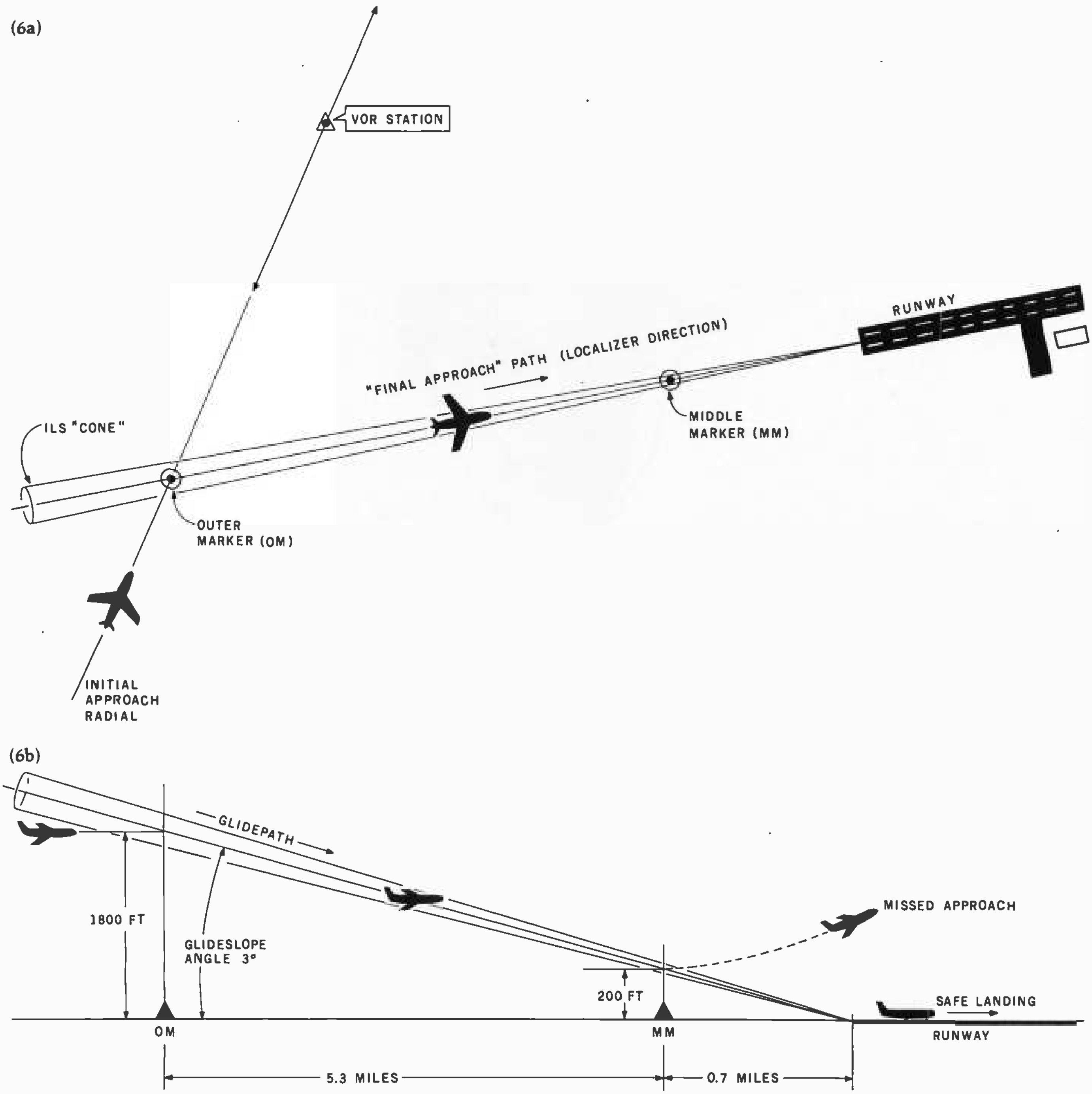

Figure 6: *ILS (Instrument Landing System) geometry showing the localizer direction (a); ILS geometry showing the vertical glideslope angle (b).*

the geometric layouts shown in figure 6 for its instrument landing pattern, with minor variations to suit the terrain. The exact ILS arrangement (localizer direction and glideslope angle) for any given airport is published in a manual of approach diagrams (one for each airport), which the pilot studies well in advance of his instrument landing.

Obviously, an instrument landing is a tricky procedure that airline pilots must practice in large-scale simulators to perfect. The routines that simulate landing are an important part of the JETSET program; they closely follow the sequences that develop when a plane flies into the ILS pattern. You may have to make several attempts at a simulated landing before you can consider yourself qualified to handle a jetliner under bad weather conditions.

Flying Lesson #5 Practicing ILS

Preparing for an instrument landing, even aboard the JETSET simulator, begins when the plane is still

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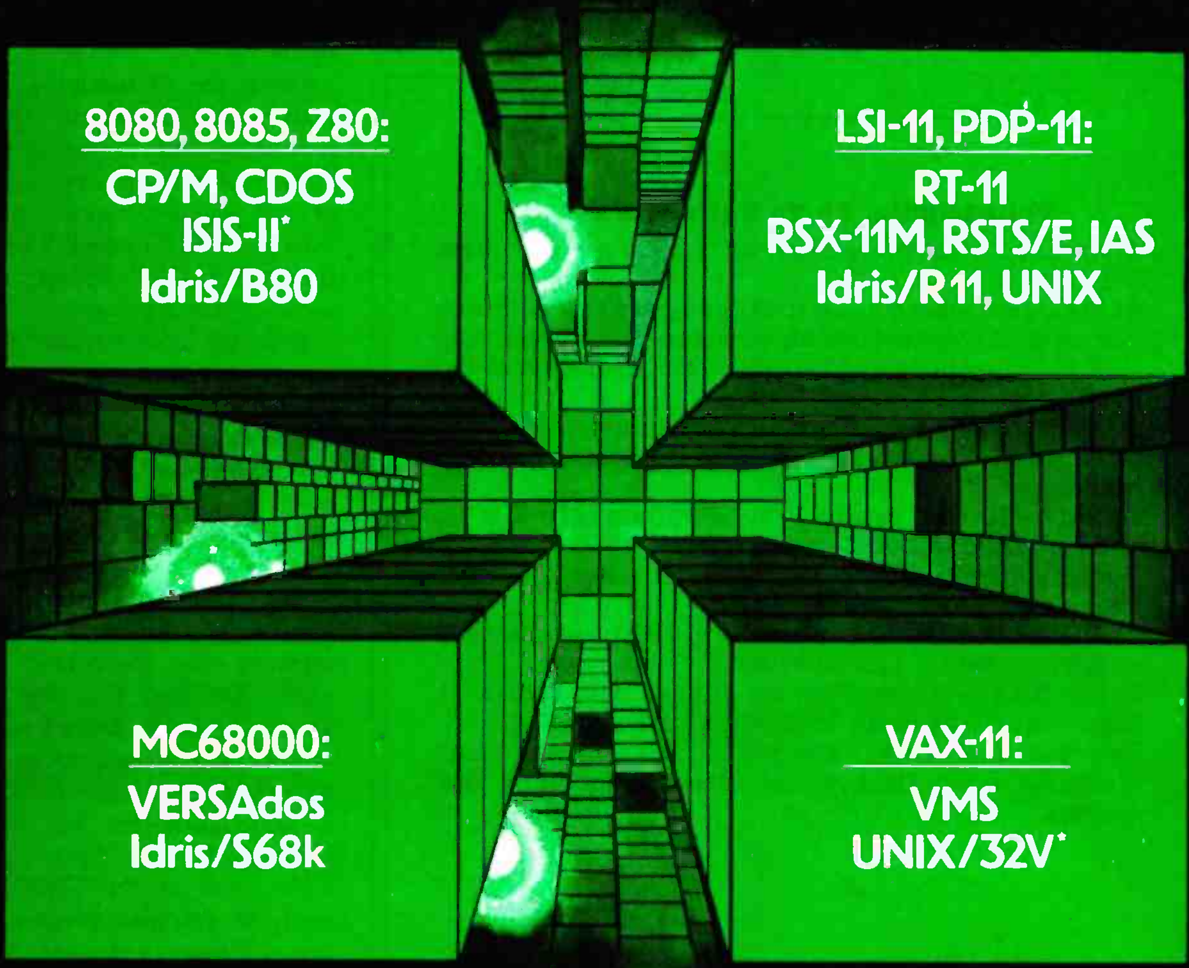

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Parkway Towers, 'B', 485 US Route 1 So., Iselin, New Jersey 08830 (201) 750-9000 Telex: 645592 many miles away from the airport. Because all ILS landing procedures follow a standard pattern, the John F. Kennedy (JFK) International Airport, conveniently located with respect to Philadelphia, can serve as a practice landing site. A simulated flight from Philadelphia to JFK lasts about 20 minutes from takeoff until the jet rolls to a stop on the runway.

Every airline flight must be conducted in accordance with a flight plan, a document that specifies the routes the pilot will fly until he arrives at the destination. An actual flight takes place at standard altitude levels and under close supervision of air traffic controllers, but the flight plan prepared for the practice run to JFK International tells the JETSET pilot exactly how to proceed. (See figure 7.)

Philadelphia, PA To Buffalo, NY

1. After takeoff, continue climbing to 3000 feet on course 075 degrees.
2. At 3000 feet alter course to 000 degrees and continue climbing. Adjust thrust for airspeed 580 knots, tune VOR to Philipsburg station (115.5 MHz), and set radial to 278 degrees.
3. Steer along 278-degree radial when intercepted. Level off at 40,000 feet and proceed to Philipsburg at 600 knots.
4. At DME = 20 NM, retune VOR to Buffalo (116.4 MHz) and set radial to 346 degrees.
5. Upon intercepting 346-degree radial, alter course to follow radial to Buffalo.
6. At DME = 73 NM, begin descent to 1900 feet (descend at approximately 11,000 FPM).
7. Level off at 1900 feet. Remain aligned with radial.
8. Begin initial approach trim when DME = 20 NM.
9. Execute ILS final approach procedures when MARKER lamp flashes. Localizer direction is 042 degrees.

Philadelphia, PA To JFK International, NY

1. After takeoff, continue climbing to 6000 feet on course 075 degrees. While climbing, tune VOR to JFK station (115.9 MHz) and set radial to 058 degrees.
2. Level off at 6000 feet. Steer left to intercept radial, align with it, and proceed toward Long Island, NY at 400 knots.
3. At DME = 38 NM, begin descent to 1900 feet (descend at approximately 7410 FPM).
4. Level off at 1900 feet. Remain aligned with radial.
5. Begin initial approach trim when DME = 20 NM.
6. Execute ILS final approach procedures when MARKER lamp flashes. Localizer direction is 028 degrees.

Figure 7: *Flight plans for a simulated instrument flight.*

Using the Philadelphia-JFK flight plan as a guide, execute the takeoff procedure and climb to 5000 feet while maintaining a compass course of 075 degrees. During the climb, tune your VOR to the JFK ground station (115.9 MHz) and input the radial value of 058 degrees.

Level off at an altitude of approximately 6000 feet. Use the < key for the left rudder to alter the compass course to approximately 000 degrees. Hold this course until the VOR needle nears its center position. Now steer to 058 degrees and begin chasing the VOR needle.

The jet will head directly for JFK as long as you keep the VOR needle centered—the 058-degree radial is used because it's the "initial approach" radial defined for the JFK airport. It will lead to an intercept with the runway outer marker (OM), a prerequisite for the instrument landing.

As soon as the DME indicator reads 38, you must prepare for landing. To begin a descent, adjust the elevators for a pitch of −10 degrees (press the ↑ key twice) and level off at an altitude of about 1900 feet.

Start the "initial approach trim" procedure for the jetliner when the DME distance is 20 NM. First reduce your airspeed to 300 knots (S key), lower the landing gear (W key), and lower the wing flaps (L key). The airspeed will automatically drop back to 120 knots as soon as the flaps are lowered, as required for a proper landing. Complete the trim procedure by adjusting altitude until the ALTITUDE indicator reads between 1700 and 1900 feet.

You must execute this procedure quickly so that the aircraft is in its proper "profile" or flight configuration as it approaches the OM along the initial approach radial. You will

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Circle 198 on inquiry card.

reach the OM when the DME reads exactly 12 NM, so the jet should be in its trim profile and steered to keep the VOR needle centered (to within two graphic dots) as the OM point nears.

If you've done these steps carefully, the panel MARKER lamp will flash when the DME indicator reads 12 NM. This is a signal that the aircraft has just intercepted the ILS radio cone and must be promptly steered to align with the localizer direction (028 degrees) at JFK airport.

Press the left rudder key (<) quickly when the MARKER lamp flashes. It's imperative that you swing the jet to a compass course of 028 degrees before it flies out of the narrow area of the radio cone (this would occur about 15 seconds after the MARKER lamp turns on). A compass reading of 028 degrees (give or take one degree) before the MARKER lamp goes off will ensure that you completed the turn in time for the jetliner to enter the ILS radio cone. Both the ILS indicator and the RADAR ALT meter should be activated. If not, the turn took too long to complete and you need more practice in making a fast turn. For another attempt, you can stop the simulation program and begin again or raise the flaps and wheels and circle back to pick up the initial approach radial for another attempt.

The rapid updating of the ILS indicator means the jet is now beginning its crucial final approach. You have very little margin for error. The program will automatically change the sensitivity of the elevator and rudder keys; each press of the elevator key varies the pitch by one degree and the course changes by one degree each time a rudder key is typed. Quickly press the ↑ key three times to pitch the nose down 3 degrees and turn your full attention to the ILS display.

You must use the rudder keys to chase the vertical needle of the ILS indicator as the jet loses altitude (as shown by the RADAR ALT reading). If the ILS horizontal needle moves from center, chase it by using the elevator keys. Crosswinds blowing across the airport will tend to deflect the jet (and the vertical ILS needle), so you must make every effort to keep the two ILS needles where they belong—exactly on center.

The RADAR ALT indicator, a meter that activates when the final approach begins, shows the elevation of the descending jet (feet above ground level). At an elevation of about 600 feet, JETSET will display the approaching runway on the lower-right portion of the screen to simulate that the ground is now visible. The arrow appearing at the foot of the graphic shows the exact alignment of the jet in relation to the approach end of the airport runway. You must now use this visual reference instead of the ILS indicator to quickly correct any course errors. For example, if the arrow extends too far to the left, beyond the runway base, apply some right rudder to realign the jet's path.

After a few more seconds the MARKER lamp should flash again to

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announce that the plane has just reached the middle marker point along the approach path, the decision-height location. Now a quick decision is vital. If the arrow of the runway graphic extends too far left or right, beyond the runway base, the jet is not properly lined up for a safe landing and you must press the M key immediately to signal a missed approach to the computer. JETSET will comply by announcing that the pilot's decision was a correct one for the landing situation.

If however, the runway arrow shows that the jetliner is safely aligned for a landing, you must bring it down as follows:

1. At an elevation of 100 feet (RADAR ALT reading), press the S key once. This command will "chop the throttle" (abruptly reduce the engine thrust to idle).
2. At 50 feet, press the → key once to "flare up" the nose of the jet. This maneuver automatically tilts the aircraft upward slightly to a positive pitch, causing a controlled stall. The jet will now sink gently down to ground level as it loses aerodynamic lift.
3. At 0 feet the jet has landed and is rolling along the runway. Quickly press the Q key to apply reverse thrust to the engines. Reverse thrust decelerates the aircraft gradually until the AIRSPEED readout reaches zero.

Your JETSET flight concludes with a display of the landing information that tells you how well you handled the jet. This information specifies where ground contact occurred and where the jet finally rolled to a halt. If you made a mistake at the middle marker, the landing report will point out the consequences.■

The author has offered to make copies of his program available to BYTE readers for $8. Send a blank disk, a check, and a self-addressed, stamped envelope to

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Princeton, NJ 08540

← Circle 336 on inquiry card.

Listing 1 continued from page 273

```
383 PRINT@(6,32),". . . . : . . . .":PRINT@(8,39),"RUD"
384 PRINT@(9,32),CHR$(128);STRING$(15,150);CHR$(129)
386 FORX=32TO48STEP16
387 FORY=10TO22
388 PRINT@(Y,X),CHR$(148);
389 NEXTY
390 NEXTX
391 PRINT@(23,32),CHR$(131);STRING$(15,150);CHR$(130);
392 PRINT@(10,39),"VOR":PRINT@(11.44),"MHZ"
393 PRINT@(14,38),"RANGE"
394 PRINT@(16,35),".....:....."
395 PRINT@(19,38),"RADIAL"
396 PRINT@(21,39),"DME":PRINT@(22,44),"NM";
397 FORY=1TO7:PRINT@(Y,12),CHR$(150):NEXT
398 FORY=1TO3:PRINT@(Y,21),CHR$(150):NEXT
400 PRINT@(14,0),CHR$(128);STRING$(15,150);CHR$(129)
402 FORX=0TO16STEP16
404 FORY=15TO21
406 PRINT@(Y,X),CHR$(148);
408 NEXTY
410 NEXTX
412 PRINT@(22,0),CHR$(131);STRING$(15,150);CHR$(130);
414 PRINT@(13,7),"ILS"
416 PRINT@(17,19),"MARKER":PRINT@(18,20),">  <"
418 GX(1)=0:GY(1)=0
420 GOSUB2100
422 PRINTCHR$(26):PRINT@(10,6),"      "
424 PRINTCHR$(25):PRINT@(9,4),"RADAR ALT";SPC(6);"STALL"
425 PRINT@(10,18),">      <"
599 RETURN
600 REM:DISPLAY INSTRUMT READINGS
601 GOTO720
605 YP=1:XP=0:F$="######":V1=FU:GOSUB 9000
610 YP=1:XP=7:F$="###":V1=FP:GOSUB 9000
615 YP=1:XP=39:V1=CC:GOSUB 9000
620 YP=4:XP=39:V1=AS:GOSUB 9000
625 YP=4:XP=46:F$="######":V1=RC:GOSUB 9000
630 YP=4:XP=55:F$="##,###":V1=AL:GOSUB 9000
635 YP=5:XP=0:F$="###":V1=MZ:GOSUB 9000
636 IFF(2)=1THENYP=10:XP=6:F$="#####":V1=AL:GOSUB9000
640 REM:DISPLAY THRUST
650 FOR I=1 TO 7
651 PRINT@(I,11),CHR$(26);" "
652 NEXT
655 PRINT@(TR,11),">";
660 REM:DISPLAY FLAPS
665 FOR I=1 TO 3:PRINT@(I,20),CHR$(26);" ":NEXT
670 PRINT@(FL,20),">"
674 F$="+###"
675 YP=5:XP=20:V1=FA:GOSUB 9000
676 IFF(6)=0THENSX=25:GOTO679
677 IFSX=25THENSX=26:GOTO679
678 SX=25
679 IFF(7)=0THENPRINTCHR$(SX):PRINT@(10,19),"      "
680 REM:DISPLAY BRAKES
690 FOR I=10 TO 12:PRINT@(I,54),CHR$(26);" ":NEXT
695 PRINT@(BR,54),">"
700 REM:WHEELS
705 FOR I=10 TO 12:PRINT@(I,62),CHR$(26);" ":NEXT
710 PRINT@(WH,62),">"
711 IFF(2)=1GOTO723
712 REM:DISPLAY LAT/LONGIT
713 YP=4:XP=69:F$="###":V1=DP(4):GOSUB9000
714 YP=4:XP=73:F$="##.#":V1=DP(5):GOSUB9000
715 YP=5:XP=69:F$="###":V1=DP(6):GOSUB9000
716 YP=5:XP=73:F$="##.#":V1=DP(7):GOSUB9000
717 PRINT@(4,78),"N"
718 PRINT@(5,78),"W"
719 GOTO723
720 REM:DISPLAY RUDDER POSIT
721 PRINT@(7,32),CHR$(26);S$(17)
722 PRINT@(7,RP),CHR$(147);CHR$(25):GOTO605
723 IFF(2)=1THENRETURN
724 REM:DISPLAY VOR VALUES
725 YP=11:XP=38:F$="###.#":V1=VO(1):GOSUB9000
726 PRINT@(13,39),CHR$(26);VO$(1);CHR$(25)
727 YP=18:XP=39:F$="###":V1=VO(3):GOSUB9000
728 YP=22:XP=38:F$="###.#":V1=VO(4):GOSUB9000
729 PRINT@(17,34),CHR$(26);S$(13)
730 IFVO$(1)="OUT "GOTO732
731 PRINT@(17,VO(2)),CHR$(159)
732 RETURN
800 REM:KEY POLL SUBROUT
805 IF K$="F" OR K$="S" THEN KK=1:GOTO 850
810 IF K$="," OR K$="." THEN KK=2:GOTO 850
811 IFK$="/"THENRA=0:GOTO855
825 IF ASC(K$)=30 OR ASC(K$)=31 THEN KK=3:GOTO 850
830 IF K$="W" THEN KK=4:GOTO 850
835 IF K$="V" THEN KK=5:GOTO 850
836 IFK$="R"THENKK=6:GOTO850
837 IFK$="L"THENKK=7:GOTO850
838 IFK$="A"THENKK=8:GOTO850
839 IFK$="Q"THENKK=9:GOTO850
840 IFK$="M"THENKK=10:GOTO850
841 IFASC(K$)=29THENKK=11:GOTO850
850 ONKKGOSUB900,908,914,928,931,935,940,944,946,950,953
855 RETURN
900 REM:THRUST KEY
902 IFK$="F"THENTR=TR-1ELSETR=TR+1
904 IFTR<1THENTR=1:RETURN
906 IFTR>6THENTR=6:RETURN
907 RETURN
908 REM:RUDDER KEYS
909 IFK$=","GOTO912ELSERA=RA+1
910 IFRA>4THENRA=4
911 RETURN
912 RA=RA-1:IFRA<-4THENRA=-4
913 RETURN
914 REM:ELEVATOR KEYS
915 J=5:IFBR=12THENJ=1
916 IFK$=CHR$(31)THENFA=FA+JELSEFA=FA-J
918 IFFA>40THENFA=40
920 IFFA<-40THENFA=-40
922 IFFA>0THENFL=1:RETURN
924 IFFA=0THENFL=2:RETURN
926 FL=3:RETURN
928 REM:WHEELS KEY
929 IFWH=10THENWH=12:RETURN
930 IFWH=12THENWH=10:RETURN
931 REM:SET VOR FREQ
932 PRINT@(14,55),CHR$(1);
933 LINE INPUT"VOR FREQ ";VX$:VO(1)=VAL(VX$)
934 PRINT@(14,55),SPC(16);CHR$(2):RETURN
935 REM:SET VOR RADIAL
936 PRINT@(14,55),CHR$(1);
937 LINE INPUT"VOR RADIAL ";VX$:VO(3)=VAL(VX$)
938 PRINT@(14,55),SPC(14);CHR$(2):RETURN
940 REM:FLAPS KEY
941 IFBR=10THENBR=12:RETURN
942 IFBR=12THENBR=10:RETURN
944 REM:AUTO-OBS KEY
945 F(3)=1:RETURN
946 REM:REV THRUST KEY
947 IFF(7)=1THENTR=7
948 RETURN
950 REM:MISSED APPROACHED KEY
951 IFF(2)=1THENF(5)=1
952 RETURN
953 REM:FLARE KEY
954 IFF(2)=0THENFA=0:FL=2:RETURN
955 FA=1:FL=1:RETURN
1000 REM:SITUATION UPDATE ROUTINE
1002 TV$=TIME$:GOSUB 7050:TJ=TD-TL:TL=TD
1010 GOSUB1100
1012 GOSUB1130
1013 GOSUB1145
1014 IFTR=7THENGOSUB1800ELSEGOSUB1124
1016 GOSUB1106
1018 GOSUB1114
1019 IFF(2)=1GOTO1600
1020 GOSUB1400
1021 GOSUB1500
1030 IFAL<=0THENAF=1:GOTO3000
1031 IFF(2)=0GOTO1099
1032 IFAL>0GOTO1068
1033 IFF(7)=1GOTO1090
1034 F(7)=1
1036 TY=YN
1038 TX=XN-750
1042 IFFA>1THENAF=2:GOTO3000
1044 IFFA<0THENAF=3:GOTO3000
1046 IFF(6)=0GOTO1062
1048 IFAX>100THENAF=4:GOTO3000
1050 IFAX>80THENAF=5:GOTO3000
1052 IFWH=10THENAF=6:GOTO3000
1054 IFTX>0THENAF=7:GOTO3000
1056 IFTX<-10500THENAF=7:GOTO3000
1058 IFABS(TY)>100THENAF=7:GOTO3000
1060 GOTO1099
1062 AF=8:GOTO3000
1068 IFF(5)=1GOTO1082
1070 IFFA>0GOTO1076
1072 IFFA<0THENF(6)=0
1074 GOTO1099
1076 IFF(6)=0THENAX=AL:F(6)=1
1077 IFTR=6GOTO1080
1078 IFFA<2THENRC=-1800:GOTO1099
1079 FA=2:FL=1:RC=-1800:GOTO1099
1080 FA=1:FL=1:RC=-300:GOTO1099
1082 IFAL<20THENAF=9:GOTO3000
1084 TR=3:FA=0:FL=2
1086 AF=10:GOTO3000
1090 IFXN<-9750 OR ABS(YN)>100GOTO1094
1091 IFAS>0GOTO1099
1092 AF=0:GOTO3000
1094 AF=9:GOTO3000
1099 GOTO1700
1100 REM:UPDATE FUEL
1102 FU=FU-(14-TR)*TJ:IFFU<0THENFU=0
1104 FP=FU/3120:RETURN
1106 IFF(7)=1THENRC=0:RETURN
1107 IFF(6)=1THENRETURN
1108 RC=AS*SIN(ABS(FA/KR))*101.6
1110 IFFA<0THENRC=-1*RC
1112 RETURN
1114 REM:UPDATE ALTITUDE
1115 IFF(7)=1THENRETURN
1116 AL=AL+TJ*RC/60
```

Listing 1 continued on page 306

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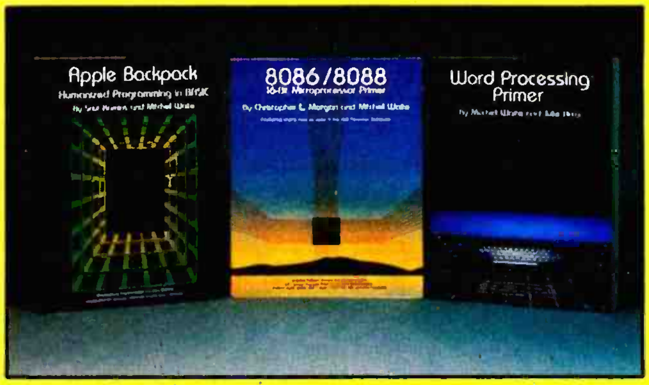

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Listing 1 continued:

```
1118 IFAL<0THENAL=0:RETURN
1120 IFAL>45000THENAL=45000
1122 RETURN
1124 REM:UPDATE AIRSPEED
1125 AS=800-100*TP
1126 AS=AS-2*FA
1127 IFBR=10THENRETURN
1128 AS=AS/3+20:RETURN
1130 IFF(5)=1GOTO1132
1131 IFF(2)=1GOTO1142
1132 IFRA=0THENRT=0:RETURN
1133 IFRA<0THENJ=-1ELSEJ=1
1134 RA=ABS(RA):IFRA=1THENRT=1:GOTO1137
1135 IFRA=2THENRT=10:GOTO1137
1136 IFRA=3THENRT=20ELSERT=30
1137 RT=J*RT:RA=J*RA
1138 CC=CC+RT
1139 IFCC=>360THENCC=CC-360:RETURN
1140 IFCC<0THENCC=360+CC
1141 RETURN
1142 IFRA=0THENRETURN
1143 IFRA<0THENCC=CC-1ELSECC=CC+1
1144 RA=0:GOTO1139
1145 REM:UPDATE RUDDER POSIT VARIABLE
1146 RP=40+RA+RA:RETURN
1200 REM:COMPUTES DIST&BEARING TO A KNOWN POINT LOCATION
1202 VL=ABS(LB-LC):BL(5)=-1:IFLB=>LCTHENBL(5)=1
1204 VG=ABS(GB-GC):BL(4)=1:IFGB=>GCTHENBL(4)=-1
1206 LA=LC:GOSUB2400
1208 M1=MP
1210 LA=LB:GOSUB2400
1212 M2=MP:DM=ABS(M2-M1)
1214 IFDM=0GOTO1220
1216 QQ=VG/(DM/60):IFQQ>114.59GOTO1220
1218 CA=KR*ATN(QQ):DR=VL*(1/COS(CA/KR)):GOTO1222
1220 CA=90:DR=VG*COS(LC/KR)
1222 DR=DR*60:IFBL(5)=-1GOTO1226
1224 IFBL(4)=1THENCR=CAELSECR=360-CA
1225 RETURN
1226 IFBL(4)=1THENCR=180-CAELSECR=180+CA
1228 RETURN
1250 REM:GET WIND VECTOR FOR CURR ALTITUDE
1252 I=FIX(AL/4000):IFI=>10THENI=10
1254 WD=WA(I,0):WV=WA(I,1)
1256 RETURN
1260 REM:SOLVES WIND TRIANGLE
1262 A=CC:L=AJ:GOSUB1300
1264 MX=LX:MY=LY
1266 GOSUB1250
1268 A=WD+180:IFA=>360THENA=A-360
1270 L=WV:GOSUB1300
1272 MX=MX+LX:MY=MY+LY:GOSUB1350
1274 TK=MA:GS=VZ
1276 RETURN
1300 REM:RESOLVES A VECTOR INTO RECTANGULAR COORDINATES
1302 IFA<=90THENQ=1:B=90-A:GOTO1310
1304 IFA<=180THENQ=2:B=A-90:GOTO1310
1306 IFA<=270THENQ=3:B=270-A:GOTO1310
1308 Q=4:B=A-270
1310 LX=L*COS(B/KR):LY=L*SIN(B/KR)
1312 IFQ=1THENRETURN
1314 IFQ=2THENLY=-1*LY:RETURN
1316 IFQ=3THENLX=-1*LX:LY=-1*LY:RETURN
1318 LX=-1*LX
1320 RETURN
1350 REM:COMPOSES X,Y COMPONENTS INTO A POLAR VECTOR
1352 VZ=SQR(MX^2+MY^2)
1354 IFMX<=0GOTO1358
1356 IFMY<=0THENQ=2ELSEQ=1
1357 GOTO1360
1358 IFMY<=0THENQ=3ELSEQ=4
1360 IFMX=0THENMA=90:GOTO1366
1362 MQ=ABS(MY/MX)
1364 MA=ATN(MQ)*KR
1366 IFQ=1THENMA=90-MA:RETURN
1368 IFQ=2THENMA=90+MA:RETURN
1370 IFQ=3THENMA=270-MA:RETURN
1372 MA=270+MA
1374 RETURN
1400 REM:GET POSITION FOR OMEGA DISPLAY
1402 AS(2)=AS:FA(2)=FA:CC(2)=CC:AL(2)=AL
1404 AS=AS(1):FA=FA(1):CC=CC(1):AL=AL(1)
1406 IFAS(2)<>ASORFA(2)<>FAGOTO1440
1408 IFCC(2)<>CCORAL(2)<>ALGOTO1440
1410 F(0)=1:IFTD<TW(1)+60GOTO1442
1412 AJ=AS*COS(ABS(FA)/KR)
1414 GOSUB1260
1416 DN=GS*(TD-TW(1))/3600
1418 CN=TK:L1=LL(1):G1=GL(1)
1420 GOSUB2000
1422 F(0)=0:TW(1)=TD:LL(1)=L2:GL(1)=G2
1424 LS(1)=L2:GS(1)=G2
1426 FORJ=4TO7:DP(J)=CP(J):NEXT
1428 AS(1)=AS(2):FA(1)=FA(2):CC(1)=CC(2):AL(1)=AL(2)
1430 AS=AS(2):FA=FA(2):CC=CC(2):AL=AL(2)
1432 RETURN
1440 TW(1)=TD:F(0)=0
1442 AJ=AS*COS(ABS(FA)/KR)
```

Listing 1 continued on page 308

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Listing 1 continued:

```
1444 GOSUB1260
1446 DN=GS*TJ/3600
1448 CN=TK:L1=LS(1):G1=GS(1)
1450 GOSUB2000
1452 LS(1)=L2:GS(1)=G2
1454 IFF(0)=1GOTO1458
1456 LL(1)=L2:GL(1)=G2
1458 GOTO1426
1500 REM:VOR ROUTINE
1502 IFVO(1)=0GOTO1540
1504 FORJ=0TO15:IFVO(1)=VF(J)GOTO1506
1505 NEXT:GOTO1540
1506 LC=VP(J,0):GC=VP(J,1)
1508 LB=L2:GB=G2
1509 AR=VG(J,0):LL=VG(J,1)
1510 LO=360-LL
1512 GOSUB1200
1514 IFDR>300GOTO1540
1516 IFCR=>360THENCR=CR-360
1517 GOTO1578
1518 VO$(1)="FROM"
1519 VO(5)=CR-VO(3):IFVO(5)<=180GOTO1522
1520 VO(5)=VO(5)-360:GOTO1524
1522 IFVO(5)<-180THENVO(5)=VO(5)+360
1524 IFABS(VO(5))>90THENI1=VO(3):GOTO1536
1526 IFVO$(1)="FROM"THENI=-1ELSEI=1
1527 IFI=1THENVO(3)=I1
1528 VO(2)=40+I*INT(VO(5)):VO(4)=DR
1530 IFVO(2)<35THENVO(2)=34
1532 IFVO(2)>45THENVO(2)=46
1534 GOTO1560
1536 VO$(1)=" TO ":VO(3)=VO(3)+180:IFVO(3)=>360THENVO(3)=VO(3)-360
1538 GOTO1519
1540 VO$(1)="OUT ":VO(4)=999.9:F(3)=0:RETURN
1546 IFDR>12ORDR<10THENMK=0:GOTO1518
1548 IFAL>4000THENMK=0:GOTO1518
1550 IFF(1)=1THENJ=9ELSEJ=2.5
1552 IFCR>AR+JORCR<AR-JTHENMK=0:GOTO1518
1554 F(1)=1:MK=1:GOTO1518
1560 PRINTCHR$(25+MK)
1562 PRINT@(18,21),"   "
1564 PRINTCHR$(25)
1566 IF MK=0THENF(1)=0:RETURN
1570 IFCC>LL+1ORCC<LL-1THENRETURN
1572 IFRA<>0THENRETURN
1574 F(1)=0:F(2)=1
1576 GOTO1540
1578 IFF(3)=1THENVO(3)=CR:F(3)=0
1580 GOTO1546
1600 REM:ILS ROUTINE
1602 ZN=AL:TH=2.82471:MK=1
1603 DW=1.69*RW*TJ:IFF(7)=1THENDW=0
1604 IFF(7)=1THENCC=LL:RA=0
1606 CJ=CC
1608 IFCJ>180THENCJ=360-CJ:CJ=-1*CJ
1610 HA=LO+CJ
1612 DC=360-HA:TS=1:IFHA<180THENDC=HA:TS=-1
1614 IFDC<0THENDC=-1*DC:TS=-1*TS
1616 TL$="W":IFTS=1THENTL$="E"
1618 DD=1.69*AS*TJ
1620 DY=DD*SIN(DC/KR):DX=DD*COS(DC/KR)
1622 XN=XO-DX:IFTL$="E"THENDY=-1*DY
1624 YN=YO+DY+DW
1626 LM=KR*ATN(AL/XN)
1628 BE=KR*ATN(ABS(YN)/ABS(XN)):IFBE>2.5THENMK=0
1630 J=(LM-TH)/0.25:J=FIX(J)
1632 IFJ>3THENJ=3
1633 IFJ<-3THENJ=-3
1636 BE=BE/0.25:BE=FIX(BE)
1637 IFBE<-7THENBE=-7
1638 IFBE>7THENBE=7
1639 IFYN=>0THENBE=-1*BE
1640 IFMK=0GOTO1648
1642 IFXN>34960ANDXN<38000GOTO1648
1644 IFXN>2534ANDXN<5574GOTO1648
1646 MK=0
1648 GX(1)=BE:GY(1)=J
1650 GOSUB2100
1654 PRINTCHR$(25+MK)
1656 PRINT@(18,21),"   "
1658 PRINTCHR$(25)
1662 XO=XN:YO=YN
1664 IFF8=1GOTO1676
1666 IFXN>12000GOTO1676
1668 F8=1
1670 FORI=0TO3
1672 PRINT@(13+I,49),RS$(I)
1674 NEXT I
1676 IFF8=0GOTO1699
1678 PRINT@(17,XQ)," "
1680 YU=FIX(YN/16.7):XC=64+YU
1682 IFXC<49THENXC=49
1684 IFXC>79THENXC=79
1686 PRINT@(17,XC),CHR$(159)
1688 XQ=XC
1699 GOTO1031
1700 GOTO1799
1799 GOTO224
```

Listing 1 continued on page 310

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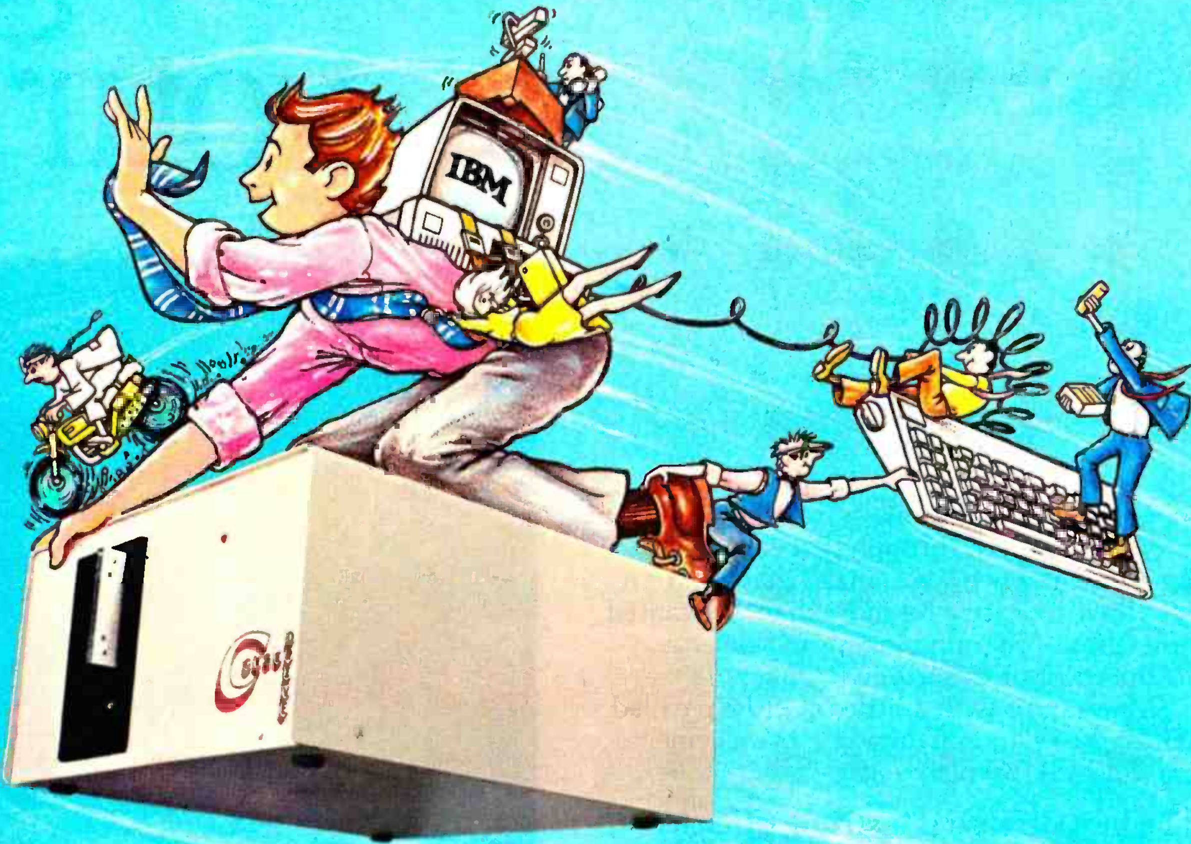
Listing 1 continued:

```
1800 REM:REVERSE THRUST APPLIED
1802 IFF(4)=1GOTO1806
1804 VO=AS*1.152*1.47:F(4)=1
1806 V=VO-(3.23636)*TJ
1808 IFV<=0THENV=0
1810 VO=V
1812 AS=V/(1.152*1.47)
1814 RETURN
2000 REM:COMPUTES NEW POSITION
2004 IF CN=0THENCA=0:LB(5)=1:LB(6)=1:GOTO2014
2006 IFCN>0ANDCN<=90THENCA=CN:LB(5)=1:LB(6)=1:GOTO2014
2008 IFCN>90ANDCN<=180THENCA=180-CN:LB(5)=-1:LB(6)=1:GOTO2014
2010 IFCN>180ANDCN<=270THENCA=CN-180:LB(5)=-1:LB(6)=-1:GOTO2014
2012 CA=360-CN:LB(5)=1:LB(6)=-1
2014 IFCA>89.5GOTO2034
2016 DL=DN*COS(CA/KR):DL=DL/60:LB(3)=LB(5)
2018 IFLB(3)=1THENL2=L1+DL:GOTO2024
2020 L2=ABS(L1-DL)
2024 LA=L1:GOSUB2400
2026 M1=MP
2028 LA=L2:GOSUB2400
2030 M2=MP
2032 DM=ABS(M1-M2):DG=DM*TAN(CA/KR):GOTO2036
2034 L2=L1:DG=DN/COS(L1/KR)
2036 DG=DG/60:LB(4)=LB(6)
2038 IFLB(4)=-1GOTO2046
2040 G2=ABS(G1-DG)
2044 GOTO2050
2046 G2=G1+DG
2050 CP(4)=FIX(L2):CP(5)=(L2-CP(4))*60
2052 CP(6)=FIX(G2):CP(7)=(G2-CP(6))*60
2054 RETURN
2100 REM:PLOT GLIDESLOPE CROSSHAIRS
2101 IFXO<=750THENRETURN
2102 XO=8+GX(0):X1=8+GX(1):YO=18+GY(0):Y1=18+GY(1)
2103 PRINTCHR$(25)
2104 FORY=15TO21:PRINT@(Y,XO)," ":NEXT
2106 PRINT@(YO,1),STRING$(15,32)
2108 FORY=15TO21:PRINT@(Y,X1),CHR$(149):NEXT
2110 PRINT@(Y1,1),STRING$(15,151)
2112 PRINT@(Y1,X1),CHR$(143)
2114 PRINT@(18,8),"O"
2116 GX(0)=GX(1):GY(0)=GY(1)
2118 RETURN
2400 REM:COMPUTES MERIDIONAL PARTS,MP
2404 KM(0)=7915.704468
2406 KM(1)=23.268932
2408 KM(2)=0.0525
2410 KM(3)=0.000213
2414 IFLA=0THENLA=0+1/60
2416 IFLA>(89+59/60)THENLA=89+59/60
2418 S1=SIN(LA/KR)
2420 S2=S1*S1:S3=S1*S2
2422 TM(0)=TAN((45+LA/2)/KR)
2424 TM(0)=KM(0)*LOG(TM(0))/LOG(10)
2426 TM(1)=KM(1)*S1
2428 TM(2)=KM(2)*S3
2430 TM(3)=KM(3)*S2*S3
2432 MP=TM(0)-TM(1)-TM(2)-TM(3)
2436 RETURN
3000 REM:ABORT ROUTINES
3002 M$(1)="---------- A CRASH HAS OCCURRED ----------"
3004 M$(2)="YOU ACCIDENTLY STALLED THE AIRCRAFT DURING FINAL APPROACH."
3006 M$(3)="THE STALL OCCURRED AT AN ALTITUDE OF"
3008 M$(4)="THE AIRCRAFT STRUCK THE GROUND IN A NOSE-HIGH ATTITUDE."
3010 M$(5)="THE IMPACT RUPTURED THE TAIL SECTION OF THE FUSELAGE."
3012 M$(6)="---- LOCATION OF CRASH ----"
3013 M$(7)="---- LANDING POSITION ----"
3016 M$(8)="    PITCH ANGLE="
3018 M$(9)="    AIRSPEED="
3020 M$(10)="YOU FLARED AT TOO HIGH AN ALTITUDE DURING FINAL APPROACH."
3022 M$(11)="THE RESULTING STALL OCCURRED AT AN ALTITUDE OF"
3024 M$(12)="THE IMPACT RUPTURED THE "
3026 M$(13)="YOU FORGOT TO LOWER THE LANDING GEAR."
3028 M$(14)="YOU FAILED TO TOUCH DOWN INSIDE THE RUNWAY."
3030 M$(15)="---------- AN IMPROPER LANDING WAS MADE ----------"
3032 M$(16)="NO DAMAGE OR INJURIES OCCURRED."
3033 RL=0:IFTX>0THENRL=1
3034 RW=0:IFABS(TY)>100THENRW=1
3040 N$(2)="FEET INSIDE OF RUNWAY"
3041 IFTX=>0THENN$(2)="FEET SHORT OF RUNWAY"
3042 N$(3)="FEET TO LEFT OF RUNWAY CENTERLINE"
3043 IFTY=>0THENN$(3)="FEET TO RIGHT OF RUNWAY CENTERLINE"
3044 RX=FIX(TX):RX=ABS(RX)
3045 RY=FIX(TY):RY=ABS(RY)
3050 IF AF=0 GOTO 3600
3055 AX=INT(AX):FA=INT(FA):AS=INT(AS)
3060 ONAFGOTO3100,3150,3200,3250,3300,3350,3400,3450,3500,3550
3100 GOSUB3700
3101 YP=4:XP=55:F$="##,###":V1=AL:GOSUB9000
3102 PRINT@(15,0),M$(1)
3104 PRINT"YOU FLEW INTO THE GROUND."
3106 PRINT"THE INSTRUMENT READINGS AT TIME OF CRASH ARE AS SHOWN ABOVE."
3108 END
3150 CLS
3152 PRINT M$(1)
3154 PRINT M$(2)
```

Listing 1 continued on page 314

Performance Breakthrough...



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With the **CYBERDRIVE,** the average seek time across more than five times as much data is only 33 milliseconds (incl. head settling).

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CRT![1] from Cybernetics (COBOL Reprogramming Tool!)-Program generator for **RM/COBOL** to ease program development and maintenance . . . an alternative to a Data Base System.

CBASIC2[5] **& CBASIC86**[5] compilers... for aficionados of a useful BASIC.

The software is available on a variety of industry-standard Operating Systems including CP/M[5]-MP/M[5] (both -80 & -86), OASIS[6], PCDOS, and UNIX[7]. Inquire for specific details and prices.

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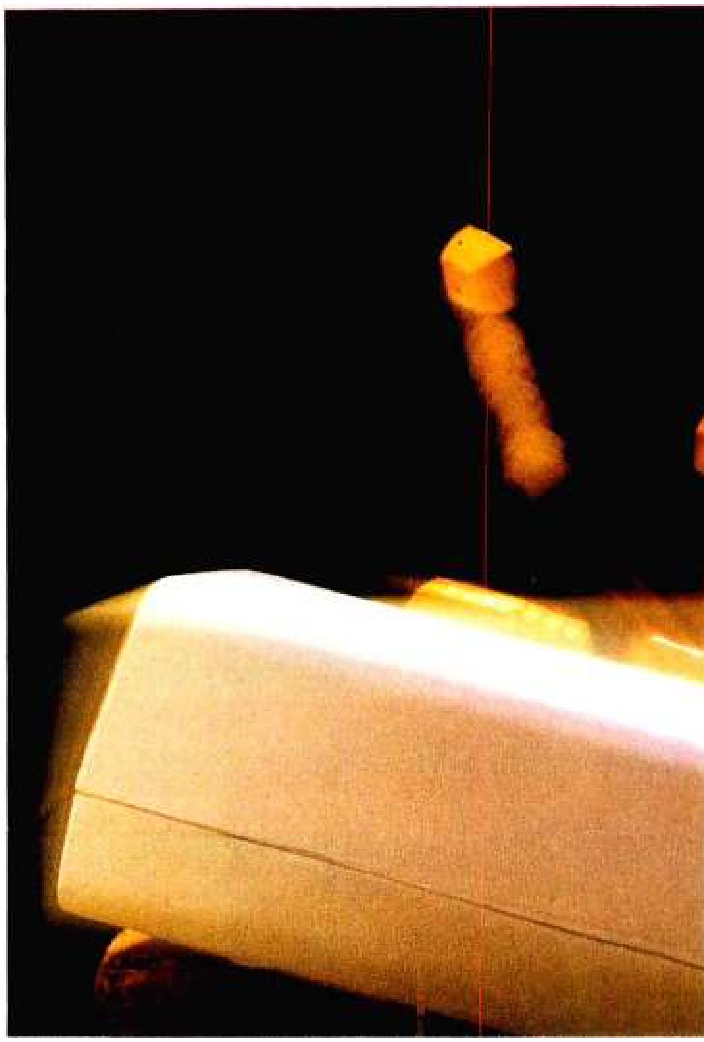
How to get your fi



You're not alone, you know.

We've all been through that same excruciating moment when we realized that we were going to have to learn a lot more than we wanted to know about programming, in self-defense.

But most of us survived.

Many of us with a little bit of help called dBASE II, the relational database management system (DBMS) for micros.

The best defense is a strong offense.

Don't get seduced by BASIC, because basically BASIC is weak. And to make it do anything useful can take 10 times as much programming (and time) as with dBASE II.

dBASE II is much easier because it's a <u>relational</u> DBMS, and you control your information with powerful, English-like commands.

With a word or two, you CREATE databases, APPEND new data, UPDATE, MODIFY and REPLACE fields, records and entire databases. DISPLAY some or all of your data for any conditions you want to apply. Organize months worth of data in minutes with REPORT.

You can prepare your forms and formats precisely the way you want them. Do calculations on fields, records and entire databases with 10-place accuracy.

And do even more with dozens of other commands.

Here's the catch.

With any language, you'll need to understand relational operators ("less than," "greater than," "equals") and a bit of logic ("or," "and," "not").

With dBASE II, you'll also get an easy way to make choices (IF..THEN..ELSE) and a powerful way to perform repetitive tasks (DO WHILE..).

With these tools, you're ready to tackle your accounting and time billing, project management, and any other data handling and record keeping. You can work interactively and get your answers right now. Or save your instructions and repeat everything with two words: DO Manhours, DO ProjectX, DO whatever has to be done.

Use dBASE II to help make your choice.

If you've got a 48k CP/M micro with a disk drive (96k IBM PC), send us $700 ($400 for a 56k Apple). We'll send you a copy of dBASE II to use free for 30 days.

Listing 1 continued:

```
3156 PRINT M$(3);AX;"FEET."
3158 PRINT M$(4)
3160 PRINT M$(5)
3162 N$(1)=M$(6)
3164 GOSUB 3800
3166 END
3200 CLS
3202 PRINT M$(1)
3204 PRINT"YOU FLEW INTO THE GROUND DURING FINAL APPROACH."
3206 PRINT"AT TIME OF CRASH, THE AIRCRAFT PROFILE WAS AS FOLLOWS :"
3208 PRINT M$(8);FA;"DEGREES"
3210 PRINT M$(9);AS
3212 N$(1)=M$(6)
3214 GOSUB3800
3216 END
3250 CLS
3252 PRINT M$(1)
3254 PRINT M$(10)
3256 PRINT M$(11);AX;"FEET."
3258 PRINT M$(12)+"FUSELAGE."
3260 N$(1)=M$(6)
3262 GOSUB 3800
3264 END
3300 CLS
3302 IF WH=10THEN PRINT M$(1)
3304 IF WH=12THEN PRINT"---------- A MINOR CRASH HAS OCCURRED ----------"
3306 PRINT M$(10)
3308 PRINT M$(11);AX;"FEET."
3310 IF WH=10THEN PRINT M$(13)
3312 IF WH=10THEN PRINT M$(12)+"FUSELAGE."
3314 IF WH=12THEN PRINT"THE IMPACT DAMAGED THE LANDING GEAR."
3316 IF WH=12THEN PRINT"ALL PASSENGERS HAVE BEEN SAFELY EVACUATED."
3318 N$(1)=M$(6)
3320 GOSUB 3800
3322 END
3350 CLS
3352 PRINT M$(1)
3354 PRINT M$(13)
3356 PRINT"THE AIRCRAFT LANDED ON ITS BELLY, CAUSING MODERATE DAMAGE."
3358 PRINT"ALL PASSENGERS HAVE BEEN SAFELY EVACUATED."
3360 N$(1)=M$(6)
3362 GOSUB 3800
3364 END
3400 CLS
3402 PRINT M$(15)
3404 PRINT M$(14)
3406 N$(1)=M$(7)
3408 GOSUB 3800
3410 END
3450 CLS
3452 PRINT M$(15)
3454 PRINT"YOU FAILED TO EXECUTE A FLARE PRIOR TO TOUCHING DOWN."
3456 PRINT"THIS IS A VIOLATION OF COMPANY PROCEDURES."
3458 PRINT M$(16)
3460 N$(1)=M$(7)
3462 GOSUB 3800
3464 END
3500 CLS
3502 PRINT M$(15)
3504 PRINT"YOU ROLLED OFF THE RUNWAY AFTER TOUCHING DOWN."
3506 PRINT M$(16)
3508 N$(1)=M$(7)
3512 GOSUB 3800
3513 PRINT
3514 IFXN<-9750THENPRINT"YOU ROLLED PAST FAR END OF RUNWAY"
3516 IFABS(YN)>100THENPRINT"YOU ROLLED THRU RUNWAY SIDE BORDERS"
3518 END
3550 CLS
3552 PRINT"----- YOUR MISSED APPROACH SIGNAL IS ACKNOWLEDGED -----"
3554 PRINT"YOU HAVE FOLLOWED PROPER PROCEDURES."
3556 END
3600 CLS
3602 PRINT"----- YOU HAVE SUCCESSFULLY COMPLETED THE FLIGHT -----"
3604 PRINT"ALL PROCEDURES WERE PROPERLY EXECUTED."
3606 N$(1)=M$(7)
3610 PRINT"CONGRATULATIONS ON A SUCCESSFUL FLIGHT."
3612 GOSUB 3800
3613 PRINT
3614 XN=ABS(XN):JN=FIX(XN+750)
3615 YN=ABS(YN):YN=FIX(YN)
3616 PRINT"YOUR AIRCRAFT CAME TO REST AT THE FOLLOWING POSITION:"
3617 PRINT"      ";JN;"FEET INSIDE THE RUNWAY"
3618 PRINT"      ";YN;"FEET FROM RUNWAY CENTERLINE"
3620 END
3700 REM:SUBROUTINE TO CLEAR LOWER PART OF DISPLAY
3702 FOR I=9TO23
3704 PRINT@(I,0),SPC(79);
3706 NEXT I
3708 RETURN
3800 REM:LANDING STATISTICS
3802 PRINT
3804 PRINT SPACE$(26);N$(1)
3806 PRINT
3808 IFRL=0THENPRINT RX;N$(2)
3809 IFRL=1THENPRINTCHR$(26);RX;N$(2);CHR$(25)
3810 PRINT
3812 IFRW=0THENPRINT RY;N$(3)
3813 IFRW=1THENPRINTCHR$(26);RY;N$(3);CHR$(25)
```

Listing 1 continued on page 316

Circle 282 on Inquiry card.

Listing 1 continued:

```
3814 PRINT
3816 PRINT"--- SIZE OF RUNWAY IS 10,500 FEET  X  200 FEET ---"
3818 RETURN
5085 REM:TIME DELAY PAD
5090 FOR I=1 TO TQ
5095 NEXT I
5099 RETURN
7050 REM:CONVERT RTC TO TIME OF DAY IN SECONDS ABSOLUTE.
7055 J=7
7060 FOR I=0 TO 2
7065 TC$(I)=MID$(TV$,J,2)
7070 J=J-3
7075 TC(I)=VAL(TC$(I))
7080 TD=(3600*TC(2))+(60*TC(1))+TC(0)
7085 NEXT I
7090 RETURN
9000 REM:PLOTS VARIABLE ON REVERSE BACKGROUND
9005 PRINT@(YP,XP),CHR$(26);
9010 PRINT USING F$:V1;
9015 PRINT CHR$(25)
9020 RETURN
9999 END
10000 REM:BEGIN TAKEOFF MODULE HERE
10020 CLS:CLEAR 1000:RANDOM
10025 KR=57.2958
10030 DIM XM(13),WM(13)
10031 DIM P$(31)
10035 DATA 37,35,32,30,27,25,22,20,17,15,12,10,7,5
10040 DATA 6,11,16,21,26,31,36,41,46,51,56,61,66,71
10041 FOR I=0 TO 28:READ P$(I):NEXT
10045 FOR I=0 TO 13:READ XM(I):NEXT
10050 FOR I=0 TO 13:READ WM(I):NEXT
10055 M$(1)="_":M$(2)="_":M$(4)="_"
10060 DIM XE(13),WE(13)
10065 K1=29:K2=23
10070 FOR I=0 TO 13
10075 XE(I)=K1:WE(I)=K2
10080 K1=K1-2:K2=K2+4
10085 NEXT
10090 IO=40
10095 RN=RND(0)
10100 RS=1:IF RN<0.5 THEN RS=-1
10105 W1=75:IF RS=-1 THEN W1=255
10110 W2=RND(20):W3=RS*W2
10115 DIM XL(14),XR(14)
10120 J=31:K=49
10125 FOR I=0 TO 14
10130 XL(I)=J:XR(I)=K
10135 J=J-2:K=K+2
10140 NEXT
10145 DATA FUEL,LBS,%,VHF,MHZ,THRUST,MAX,IDLE,REV
10150 DATA PITCH," +"," -",DEG,FLAPS,UP,DWN,WHEELS,UP,MID,DOWN
10155 DATA COMPASS,AIRSPEED,KTS," VERT",SPEED,FPM
10160 DATA ALTITUDE,FEET,CLOCK,BRAKE,SET,REL
10170 FOR I=0 TO 31:READ P$(I):NEXT
10175 DIM S$(25)
10180 FOR I=1 TO 25:S$(I)=SPACE$(I):NEXT
10185 FOR I=0 TO 9:F(I)=0:NEXT
10190 REM:INIT VARIABLES FOR TAKEOFF MODE
10195 FU=200000:FP=0:CC=75:AS=0:RC=0:AL=0
10200 MZ=77:TR=6:FL=2:FA=0:WH=13:IX=40:HY=9:BR=11:BK=11
10205 AB=0
10215 PRINT@(8,17),"UNITED 312    CLEARED AS FILED"
10217 PRINT:PRINT
10218 PRINT"         SURFACE WINDS VARIABLE, GUSTING TO 15."
10219 PRINT"         MINIMUM CEILING CONDITIONS ARE IN EFFECT."
10230 PRINT"         SKY CONDITIONS AT 20,000 SCATTERED."
10235 PRINT"                            AT 30,000 BROKEN."
10240 PRINT:PRINT
10245 PRINT"UPON TAKEOFF, MAINTAIN HEADING 075 TO 3000, THEN PROCEED AS FILED."
10248 PRINT:PRINT:PRINT"         STANDBY FOR TAKEOFF CLEARANCE"
10255 TQ=7000:GOSUB 11535
10260 CLS
10265 PRINT@(10,17),"UNITED 312":PRINT:PRINT
10270 PRINT"YOU ARE CLEARED FOR TAKEOFF AT 0800 HOURS"
10275 TQ=3000:GOSUB 11535
10280 CLS
10285 SYSTEM "TIME 07.59.00":SYSTEM "CLOCK":CLS
10290 TV$=TIME$:GOSUB 11555:TL=TD
10295 GOSUB 10330
10300 GOSUB 10410
10305 GOSUB 10480
10310 PRINT CHR$(2);:GOSUB 10615
10315 K$=INKEY$:IF LEN(K$)=0 GOTO 10325
10320 GOSUB 10790
10325 GOTO 10945
10330 REM:DISPLAY PANEL (HEADERS ONLY)
10335 PRINT@(0,3),P$(0);S$(4);P$(5);S$(3);P$(9);S$(3);S$(6);S$(3);P$(20)
10340 PRINT@(10,59),P$(13);S$(3);P$(16);S$(2);P$(29)
10345 PRINT@(11,61),P$(14);S$(6);P$(14);S$(6);P$(30)
10350 PRINT@(13,61),P$(15);S$(5);P$(15);S$(5);P$(31)
10352 IFF(9)=1THENRETURN
10355 PRINT@(1,13),P$(6);S$(6);P$(10);S$(6)
10360 PRINT@(1,68),P$(28)
10365 PRINT@(2,1),P$(1);S$(4);P$(2);S$(21);S$(3);S$(13);P$(23)
10370 PRINT@(3,22),P$(11);S$(13);P$(21);S$(2);P$(24);S$(2);P$(26)
10375 PRINT@(4,0),P$(3)
```

Listing 1 continued on page 318

10 MEGABYTES FOR $2495.

Only Davong Systems provides so much hard disk memory for your Apple III.®

Choose a low-cost, high quality Davong hard disk to fit your storage needs:

> DSI-A306 5 Mb (6 Mb unformatted) $1995*
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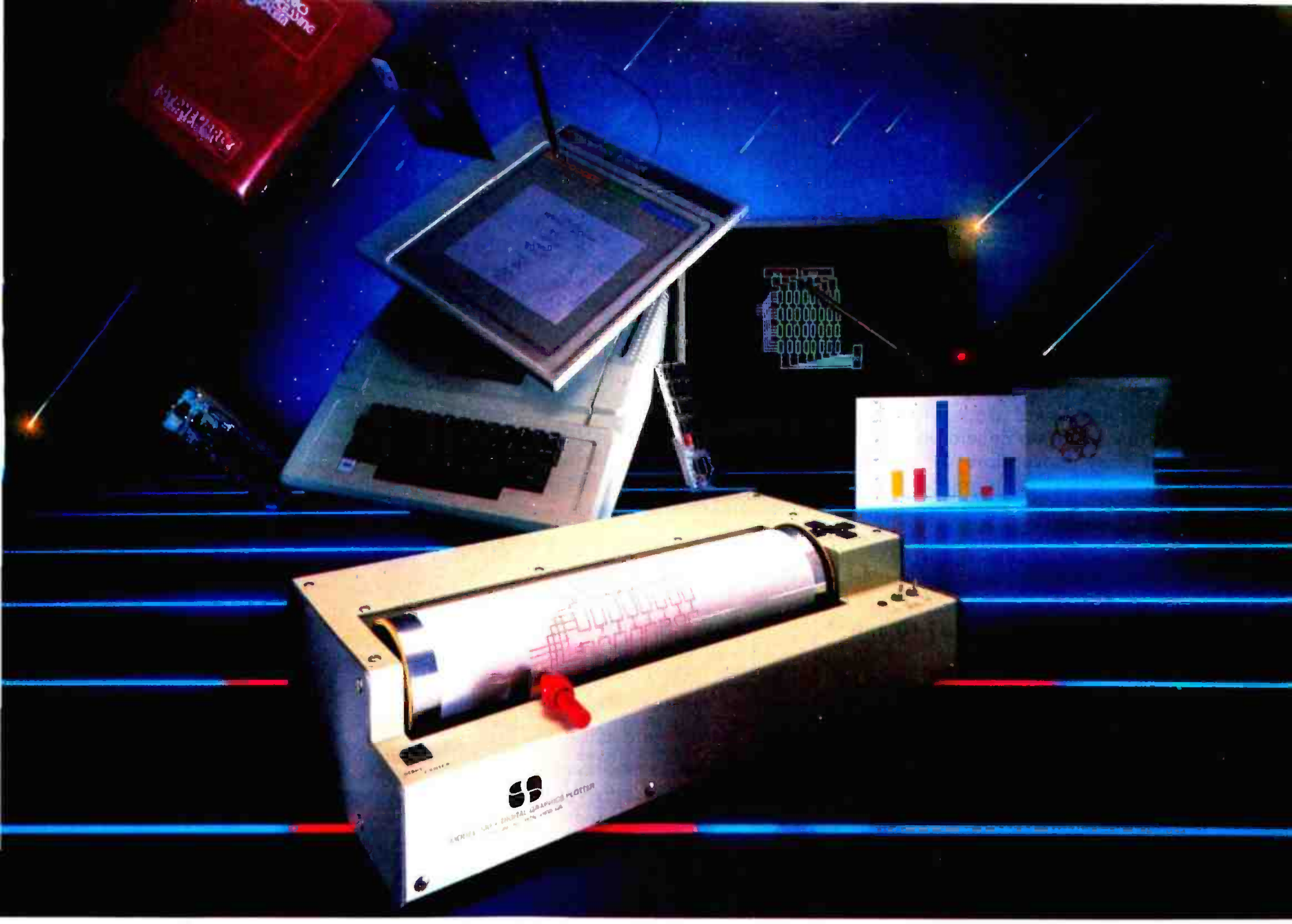
Circle 425 on inquiry card.

Listing 1 continued:

```
10380 PRINT@(5,39),P$(22);S$(6);P$(25);S$(5);P$(27)
10385 PRINT@(6,0),P$(4);S$(10);P$(7);S$(3);P$(12);S$(7)
10390 PRINT@(7,13),P$(8)
10395 FORY=1TO7:PRINT@(Y,12),CHR$(150):NEXT
10400 FORY=1TO3:PRINT@(Y,21),CHR$(150):NEXT
10405 RETURN
10410 REM:DISPLAY HORIZON LINE
10415 IF F(9)=0 GOTO 10430
10420 PRINT@(9,0),SPACE$(80);
10425 IF HY=20 GOTO 10440
10430 PRINT@(HY,0),STRING$(80,"_")
10435 RETURN
10440 OH=9:HY=10
10445 FOR I=HY TO 22
10450 PRINT@(OH,0),SPACE$(80);
10455 PRINT@(I,0),STRING$(80,"_");
10460 OH=I
10465 NEXT I
10470 PRINT@(23,IO)," ";
10475 RETURN
10480 REM:DISPLAY RUNWAY
10485 IF F(4)=1 GOTO 10525
10490 S=10:X=29
10495 FOR Y=10 TO 22
10500 PRINT@(Y,X),".";SPACE$(S);" ";SPACE$(S);".";
10505 X=X-2:S=S+2
10510 NEXT
10515 S$=S$(13)
10520 RETURN
10525 REM:PRINTS RUNWAY GRAPHICS
10530 IF N>3 GOTO 10600
10535 PRINT@(OY,OX),SPACE$(WM);
10540 PRINT@(NY,NX),MK$;
10545 OY=NY:OX=NX
10550 WM=FW
10555 RETURN
10560 REM:ENTRY WHEN SHIP IN FINAL ZONE
10565 PRINT@(OY,OX),SPACE$(WM):IF F(9)=1 THEN RETURN
10570 FOR I=10 TO NY-1
10575 PRINT@(I,XE(J)),SPACE$(WE(J))
10580 NEXT I
10585 IF N>4 THEN RETURN
10590 PRINT@(NY,NX),MK$;
10595 RETURN
10600 IFF(2)=1GOTO10560ELSEF(2)=1
10605 FORI=10TO13:PRINT@(I,59),SPACE$(21):NEXT
10610 GOTO10560
10615 REM:DISPLAY INSTRUMT READINGS
10620 YP=1:XP=0:F$="######":V1=FU:GOSUB 11600
10625 YP=1:XP=7:F$="###":V1=FP:GOSUB 11600
10630 YP=1:XP=39:V1=CC:GOSUB 11600
10635 YP=4:XP=39:V1=AS:GOSUB 11600
10640 YP=4:XP=46:F$="######":V1=RC:GOSUB 11600
10645 YP=4:XP=55:F$="##,###":V1=AL:GOSUB 11600
10650 YP=5:XP=0:F$="###":V1=MZ:GOSUB 11600
10655 REM:DISPLAY THRUST
10660 FOR I=1 TO 7
10665 PRINT@(I,11),CHR$(26);" "
10670 NEXT
10675 PRINT@(TR,11),">";
10680 REM:DISPLAY PITCH
10685 FOR I=1 TO 3:PRINT@(I,20),CHR$(26);" ":NEXT
10690 PRINT@(FL,20),">"
10695 F$="+###"
10700 YP=5:XP=20:V1=FA:GOSUB 11600
10705 REM:DISPLAY FLAPS
10710 IFF(2)=1GOTO10760
10715 FOR I=11 TO 13:PRINT@(I,59),CHR$(26);" ":NEXT
10720 PRINT@(BR,59),">"
10725 REM:WHEELS
10730 FOR I=11 TO 13:PRINT@(I,67),CHR$(26);" ":NEXT
10735 PRINT@(WH,67),">"
10740 REM:BRAKES
10745 FORI=11TO13:PRINT@(I,75),CHR$(26);" ":NEXT
10750 PRINT@(BK,75),">"
10755 PRINTCHR$(25)
10760 REM:DISPLAY RUNWAY ALIGNMT INDEX
10765 IF F(9)=1 THEN RETURN
10770 PRINT@(23,IO)," ";
10775 PRINT@(23,IX),CHR$(159);
10780 IO=IX
10785 RETURN
10790 REM:KEY POLL SUBROUT
10795 IF K$="F" THEN KK=1:GOTO 10820
10800 IF K$="," OR K$="." THEN KK=2:GOTO 10820
10805 IF K$="B" THEN KK=3:GOTO 10820
10810 IF ASC(K$)=30 OR ASC(K$)=31 THEN KK=4:GOTO 10820
10815 IF K$="L" THEN KK=5:GOTO 10820
10817 IFK$="W"THENKK=6:GOTO10820
10818 IFK$="S"THENKK=7:GOTO10820
10820 ON KK GOSUB 10830,10845,10865,10880,10925,10941,10826
10825 RETURN
10826 REM:THRUST KEY (DECREASE)
10827 IFF(7)=1ANDBR=11THENTR=4
10829 RETURN
10830 REM:THRUST KEY (INCREASE)
10831 IFF(7)=1THENRETURN
10835 IF F(0)=0 THEN RETURN
```

Listing 1 continued on page 320



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Circle 426 on inquiry card.

Listing 1 continued:

```
10840 F(1)=1:TR=1:RETURN
10845 REM:RUDDER KEYS
10846 IFF(7)=1THENRETURN
10850 IF AS<=50 THEN RETURN
10855 IF K$="," THEN CC=CC-1 ELSE CC=CC+1
10860 RETURN
10865 REM:BRAKES
10870 IF F(0)=1 THEN RETURN
10875 F(0)=1:BK=13:RETURN
10880 REM:PITCH
10881 IFF(7)=1THENRETURN
10885 IF AS<=50 THEN RETURN
10890 FD=-10:IF K$=CHR$(31) THEN FD=10
10895 FA=FA+FD
10900 IF FA>60 THEN FA=60
10905 IF FA<-60 THEN FA=-60
10910 IF FA>0 THEN FL=1:RETURN
10915 IF FA=0 THEN FL=2:RETURN
10920 FL=3:RETURN
10925 REM:FLAPS
10926 IFF(7)=1ANDWH=11THENBR=11:RETURN
10930 IF F(3)=1 THEN RETURN
10935 IF F(3)=0 THEN F(3)=1: BR=13:RETURN
10940 RETURN
10941 REM:WHEELS
10942 IFF(7)=1THENWH=11
10944 RETURN
10945 REM:SITUATION UPDATE ROUTINE
10950 TV$=TIME$:GOSUB 11555:TJ=TD-TL:TL=TD
10955 IF F(9)=1 GOTO12000
10960 IF F(0)=1 GOTO 10970
10965 GOSUB 11130:GOTO 10310
10970 IF F(4)=1 GOTO 10990
10975 F(4)=1
10980 XX=0:YY=0
10985 TX=TD:VO=0:N=1:OY=23:OX=5:WM=71
10990 REM
10995 A=(118-18*TR)*0.04028
11000 GOSUB 11190
11005 IF AL>0 GOTO 11060
11010 IF YY>10500 OR ABS(XX)>100 GOTO 11390
11015 IF FA<=0 GOTO 11100
11020 IF AS<150 GOTO 11385
11025 IF FA>10 GOTO 11385
11030 IFF(3)=0GOTO11100
11035 AL=25
11040 GOSUB 11130
11045 GOSUB 11150
11050 GOSUB 11300
11055 GOTO 10305
11060 F(9)=1
11065 GOSUB 11130
11070 GOSUB 11150
11075 GOSUB 11170
11080 FOR I=10 TO 22:PRINT@(I,0),SPACE$(80);:NEXT
11085 HY=20
11090 GOSUB10410
11095 GOTO11115
11100 GOSUB 11130
11105 GOSUB11300
11110 GOTO10305
11115 REM:NOW DO DEPARTURE PROCEDURES
11120 GOTO10310
11130 REM:UPDATE FUEL
11135 FU=FU-40*TJ
11140 FP=FU/3120
11145 RETURN
11150 REM:UPDATE RATE OF CLIMB
11155 RC=AS*SIN(ABS(FA/57.3))*1.693*60
11160 IF FA<0 THEN RC=-1*RC
11165 RETURN
11170 REM:UPDATE ALT
11175 AL=AL+TJ*RC/60
11180 IF AL<=0 THEN AL=0
11185 RETURN
11190 REM:EQUATIONS OF MOTION
11195 T=TJ
11200 V=VO+A*T
11205 VB=(V+VO)/2:VO=V
11210 S=VB*T
11215 IF TD<(TX+18)GOTO 11235
11220 TX=TD
11225 WB=RS*RND(2)
11230 CC=CC+WB
11235 DA=(CC-75)/57.3
11240 DY=S*COS(ABS(DA))
11245 DX=S*SIN(ABS(DA))
11250 IF DA<0 THEN DX=-1*DX
11255 YY=YY+DY
11260 XX=XX+DX
11265 AS=V/1.69278
11270 IF AS>20 THEN AS=AS+WS
11275 IX=40+FIX(XX*7/20):IFIX>79THENIX=79
11280 IFIX<0THENIX=0
11285 ZP=FIX(YY-2500*(N-1))
11290 IF ZP>2500 THEN N=N+1:GOTO 11285
11295 RETURN
11300 REM:VARIABLES FOR RUNWAY GRAPHICS
```

Listing 1 continued on page 322

Listing 1 continued:

```
11305 MP=FIX(10+(13*ZP)/2500)
11310 IF N>3 GOTO 11350
11315 NY=MP
11320 J=NY-10
11325 NX=XM(J)
11330 FW=WM(J)
11335 S$=SPACE$(J)
11340 MK$=M$(N)+S$(J)+"_"+S$(J)+"_"+S$(J)+"_"+S$(J)+"_"+S$(J)+"_"
11345 RETURN
11350 REM:IN ZONE 4-MARKER IS RUNWAY EDGE
11355 NY=MP
11360 J=NY-10
11365 NX=XE(J)
11370 IF N>4 THEN RETURN
11375 MK$=STRING$(WE(J),"_")
11380 RETURN
11385 AB=1:GOTO11415
11390 AB=2:IF YY<10500 GOTO 11415
11395 FOR I=10 TO 22
11400 PRINT@(I,0),SPACE$(80);
11405 NEXT I
11410 GOTO 11415
11415 REM:ABORT
11420 FOR I=10 TO 22
11425 PRINT@(I,0),CHR$(26);SPACE$(80);
11430 NEXT I
11435 PRINT@(10,29),"*** TAKEOFF FAILED ***":PRINT:PRINT
11440 ON AB GOSUB 11455,11480
11445 PRINT@(19,34),CHR$(25);"END OF PROGRAM";
11450 END
11455 PRINT" YOU PULLED BACK ON THE STICK AT TOO SLOW A SPEED, OR YOU"
11460 PRINT" PULLED BACK THE STICK TOO FAR WHEN AT PROPER SPEED."
11465 PRINT" AS A RESULT THE TAIL END OF THE FUSELAGE SCRAPED THE RUNWAY"
11470 PRINT" AND THE AIRCRAFT SPUN OUT OF CONTROL."
11475 RETURN
11480 IF YY>10500 GOTO 11505
11485 PRINT" YOU FAILED TO STAY WITHIN THE RUNWAY BOUNDRIES."
11490 PRINT" AS A RESULT YOU VEERED OFF THE RUNWAY AND COLLIDED WITH"
11495 PRINT" THE RUNWAY LIGHTS."
11500 RETURN
11505 PRINT" YOU RAN OUT OF RUNWAY. AS A RESULT YOU ROLLED INTO THE
11510 PRINT" MARSHLANDS LOCATED";FIX(YY)-10500;"FEET PAST THE END OF THE RUNWAY.
"
11515 IFF(3)=1THENRETURN
11520 PRINT:PRINT:PRINT" YOU FORGOT TO LOWER THE FLAPS."
11525 PRINT" AS A RESULT THE AIRCRAFT COULD NOT DEVELOP SUFFICIENT LIFT."
11530 RETURN
11535 REM:TIME DELAY PAD
11540 FOR I=1 TO TQ
11545 NEXT I
11550 RETURN
11555 REM:CONVERT RTC TO TIME OF DAY IN SECONDS ABSOLUTE.
11560 J=7
11565 FOR I=0 TO 2
11570 TC$(I)=MID$(TV$,J,2)
11575 J=J-3
11580 TC(I)=VAL(TC$(I))
11585 TD=(3600*TC(2))+(60*TC(1))+TC(0)
11590 NEXT I
11595 RETURN
11600 REM:PLOTS VARIABLE ON REVERSE BACKGROUND
11605 PRINT@(YP,XP),CHR$(26);
11610 PRINT USING F$;V1;
11615 PRINT CHR$(25)
11620 RETURN
12000 REM:DEPARTURE ROUTINE
12010 IFF(7)=1GOTO12025ELSEF(7)=1
12015 GOSUB10340
12020 F(2)=0
12025 IFWH<>11GOTO12040ELSEAS=AS+5
12030 IFBR<>11GOTO12040ELSEAS=AS+5
12035 IFTR=4ANDAL>1800GOTO24ELSEGOTO12090
12040 IFAL<1200GOTO12090
12042 PRINT@(12,0),"********** FLIGHT ABORTED **********"
12044 PRINT:PRINT
12046 PRINT"YOU FAILED TO PERFORM CRUCIAL TRIM MANEUVERS FOLLOWING LIFTOFF."
12048 PRINT"THE PROPER TRIM SEQUENCE,WHICH MUST BE COMPLETED BELOW 1200 FEET,IS
AS FOLLOWS:"
12050 PRINT"   1-RAISE LANDING GEAR"
12052 PRINT"   2-RETRACT FLAPS"
12054 PRINT"   3-REDUCE THRUST"
12056 PRINT
12058 PRINT"---------- END OF PROGRAM ----------
12060 END
12090 GOSUB11130
12092 GOSUB11150
12094 GOSUB11170
12099 GOTO10310
13000 REM:END OF LISTING
```

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Colonial Data Services' SB-80

A single-board business computer that runs CP/M software.

Arthur A. Little
Technical Editor

Now that the microcomputer industry boasts 16-bit systems with megabytes of user memory and 8- and 10-MHz clock rates (with 32-bit microprocessors lurking on the horizon), why would anyone want to purchase a "vanilla" 8-bit, Z80 CP/M computer? Probably because that person has work to do and wants to use existing CP/M software. Why then would someone buy an integrated, "black box" system rather than one based on the more flexible S-100 bus? Two reasons: one, as with home stereo equipment, an all-in-one unit is usually less expensive than a component system; and two, many users can do without the excitement and challenge of configuring a microcomputer system, which may even result in flexibility that's never used.

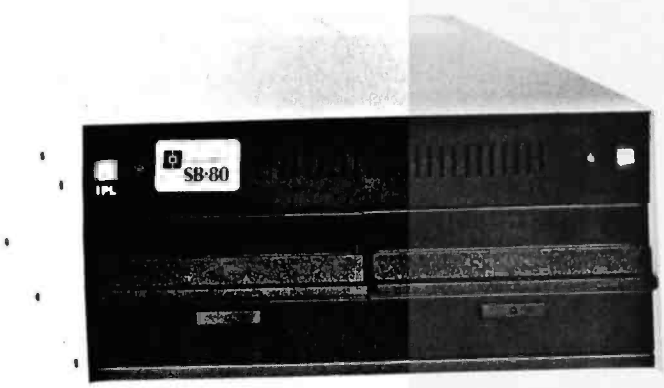

Photo 1: *The SB-80 microcomputer from Colonial Data Services.*

Acknowledgment
Thanks to John Steer of S and M Systems, Haverhill, Massachusetts, for making the system available for review.

The SB-80 is one of a family of microcomputers intended for the business and professional customer rather than the computer hobbyist. The circuit board is housed in a beige metal cabinet with two 8-inch disk drives and a switching power supply (see photo 1). The front-panel controls are simple; an on/off switch, Reset button, Power indicator, and Parity Error indicator. On the back panel are the connectors for two serial ports, two parallel ports, and the power cord. To set this single-board computer up, you simply attach a standard serial video terminal to the DB-25 connector and plug the AC line cord into a wall socket.

One especially nice characteristic of the SB-80 is its silence. The system is quiet because it does not use a fan for cooling but, instead, depends on air moving through slots on the front and top of the cabinet. (This convection cooling has worked well, with no indication of overheating.) The floppy-disk drives are so quiet that you must pay special attention to hear them in a normal office environment.

The Heart of the System

The computer's circuit board is mounted in a tray above the horizontally positioned disk drives. This tray not only protects the board but also forms part of the front panel (see photo 2). The system uses a Zilog Z80A microprocessor running at a clock rate of 4 MHz. It has 64K bytes of user RAM (random-access read/write memory) and uses 200-nanosecond dynamic memory devices (4116 type). As with the IBM Personal Computer, the SB-80's memory is 9 bits wide, rather than the more

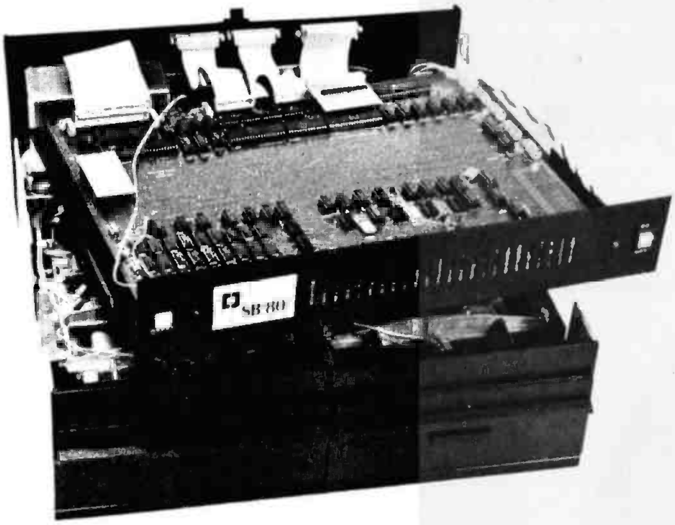

Photo 2: *Inside the SB-80. The single-board computer rests in a tray that is mounted above the disk drives.*

At a Glance

Name
SB-80

Manufacturer
Colonial Data Services Corporation
105 Sanford St.
Hamden, CT 06514

Price
(double-density, dual-disk system) $2995

Features
Width 17¼ inches, depth 18¼ inches, height 8 inches; Z80A, 4-MHz clock-rate microprocessor; 64K bytes of RAM; two 8-inch floppy-disk drives, 600K bytes each (or 243K bytes, IBM format); two RS-232C serial ports, two parallel ports (one for printer), floppy-disk controller; four programmable counter/timers; one 50-pin expansion connector

Hardware Options
Double-sided floppy-disk drives, 1.2 megabytes each; Winchester hard disk, 10 to 40 megabytes

Software
CP/M 2.2 operating system; HELP documentation system; 14 macro-assembler libraries; four utility programs; two business-oriented demonstration programs

Documentation
Two sets of manuals in 3-ring binders: six manuals from Colonial Data, 364 pages, and seven manuals from Digital Research, 245 pages

Audience
Business and professional users

common 8-bit width. The additional bit is used for parity checking, so that any memory errors can be caught immediately. If an error (e.g., a hardware malfunction) is detected, the system halts, and the LED (light-emitting diode) on the front panel signals a parity error.

The SB-80 has an impressive number of features built into its single circuit board:

- The floppy-disk controller uses the Western Digital 1793 integrated circuit (IC). This device can support up to four 8-inch soft-sectored drives. The controller supports both IBM's 3740 single-density format and a double-density format that yields 600K bytes of storage per disk side. With two single-sided drives, you'll have a storage capacity of 1.2 megabytes. The SB-80 is also available with double-sided drives that offer a total of 2.4 megabytes of disk storage.
- The parallel I/O (input/output) ports use Zilog's Z80A PI/O (parallel I/O) chip. There are two 8-bit bidirectional ports, one of which is normally configured for a Centronics-compatible printer. The other parallel port is set up for "handshake" data control; you can use it for industrial applications, such as process control, or—with the right equipment—you could have it in the home to control lights and appliances.
- Two serial ports are available from the dual-channel Z80A SIO/0 (serial I/O) chip. This versatile device can operate in three serial data-transfer formats: asynchronous, bisynchronous (BISYNC), or SDLC (synchronous data-link control, IBM's preferred mode of communication). Essentially, the SIO/0 does everything a UART (universal asynchronous receiver/transmitter) can—and more. It offers the two synchronous protocols that are fully under program control.
- A Z80A CTC four-channel counter/timer IC provides four independent counters (or timers) that are fully programmable. They can be used to count events, to measure real-time intervals, or to interrupt another device after a preset delay.
- The 50-pin expansion connector allows for future expansion of the system. All address and data lines can be accessed from this connector, which is located directly on the circuit board. Colonial Data Services is currently offering hard-disk systems (10 to 40 megabyte capacity) that attach directly to the expansion connector.

The Software

As mentioned earlier, this system was designed to run the CP/M operating system. It comes with a copy of CP/M 2.2 configured for the SB-80. All of the usual Digital Research CP/M commands and utilities are available, as well as some additions from Colonial Data. Colonial Data BIOS (basic input/output system) is set up for a 63K-byte CP/M. This BIOS requires a 9600-bps (bits per second) serial terminal and a Centronics-compatible printer. If you wish to run a smaller CP/M, a 61K-byte BIOS is provided as an ASM (assembly-language) file.

CP/M is loaded by a 256-byte boot ROM (read-only memory) located on the circuit card. This ROM performs

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And it's smart. An extensive set of firmware routines makes life easier for the user. A small sampling of the built-in talent inherent in the DMP-29 includes character generation, circle, arc and elipse synthesis, line type variations, viewport/windowing, clipping and scaling.

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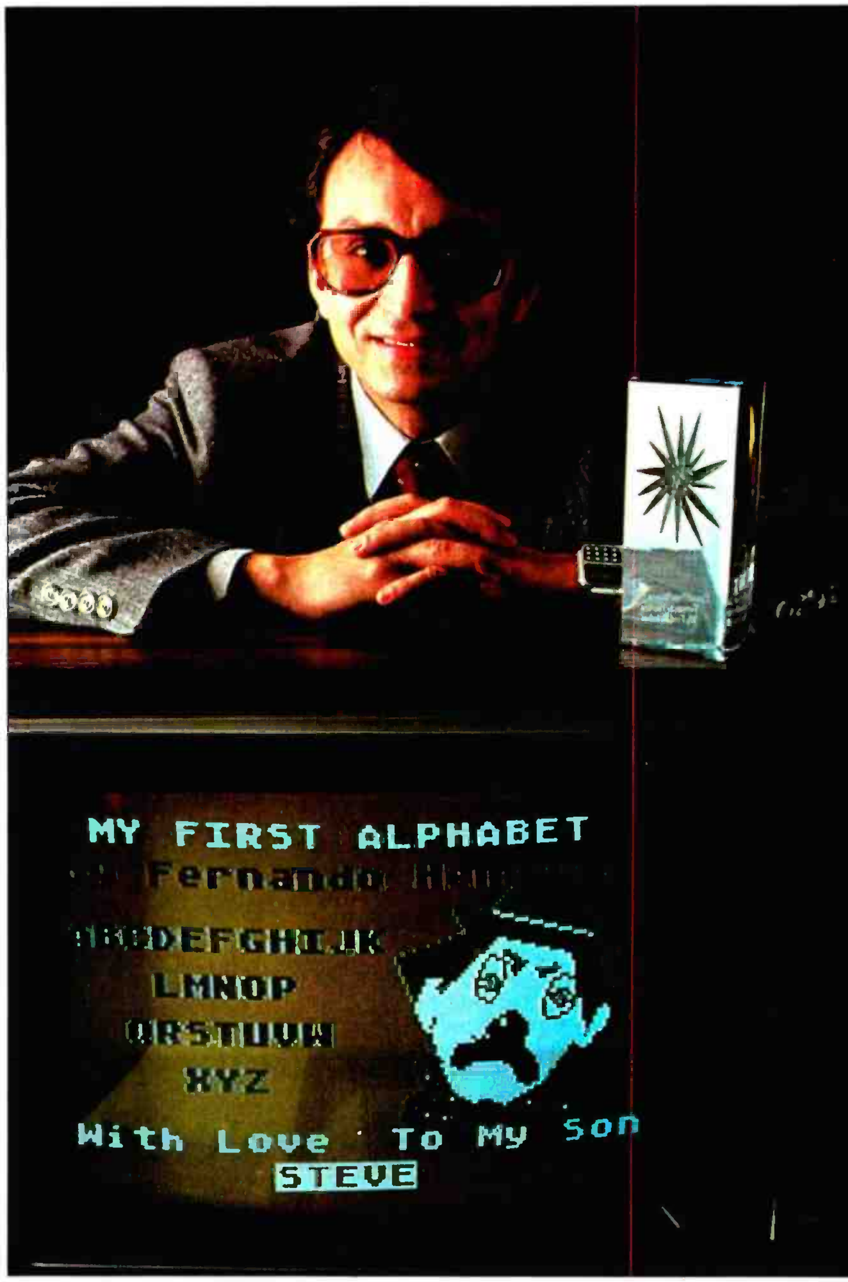


Fernando Herrera became the first grand prize winner of the ATARI Software Acquisition Program (ASAP) competition because he believed in computers, his son and himself.

The story of Herrera's success began with his son's sight problems. Young Steve Herrera had been born with severe cataracts in both eyes and, naturally, his father was concerned. Herrera reasoned that the boy's learning abilities could be seriously affected by growing up in a world he could not see.

Having just purchased an ATARI 800 Home Computer, it occured to Herrera that this could be the perfect tool for testing Steve's vision. So he wrote a program simply displaying the letter "E" in various sizes.

Success! It turned out that 2-year-old Steve could see even the smaller "E's" without special lenses. Herrera was first relieved, and then intrigued when he discovered that not only could his son see the "E's," but he would happily play with the computer-generated letters for hours. So Herrera added a picture of an elephant to go with the "E," and then more letters and pictures. Thus, "My First Alphabet" was born, a unique teaching program for children two-years and older consisting of 36 high resolution pictures of letters and numbers.

Herrera submitted the program to the ATARI Program Exchange, where it became an instant best-seller. ATARI was so impressed with the outstanding design, suitability and graphic appeal of "My First Alphabet," that the program is being incorporated into the ATARI line of software.

In addition to his grand prize winnings of $25,000 in cash and an ATARI STAR trophy, Herrera also automatically receives royalties from sales of his program through the ATARI Program Exchange.

But Fernando Herrera wasn't the only software "star" that ATARI discovered. Three other ATARI STARS were awarded at the ASAP awards ceremony for software submitted to the ATARI Program Exchange and

```
  HELP File Selections are --
A. Welcome to the HELP Command
B. How to Use the HELP Command
C. Moving Around within the HELP Command
D. HELP Command Prompts
E. HELP Error Messages
F. How to Write HELP Files
G. An Explanation of the Tree Structure of the HELP Command
H. Sample HELP Files Illustrating Use of Tree Structure
I. Help on CP/M in general

Type  ↑C=CP/M or Enter Selection
```

Figure 1: *An example of an indexed file (menu) available from within the HELP subsystem.*

a RAM test prior to loading CP/M into memory. Colonial Data Services provides additional software designed specifically for the SB-80, and these programs are of special note.

HELP: The HELP subsystem is used to explain hardware or software operations to less sophisticated users. Because HELP files are intended to be read on screen, they are in ASCII (American Standard Code for Information Interchange) format and are usually created with a text editor or word processor. The HELP subsystem consists of the command file HELP.COM, which calls in text files of the format

filename.HLP

and displays them to the user page by page. To use the system, you would type

HELP *filename*

(e.g., HELP SB80 would call a file named SB80.HLP). The information is then presented to the user.

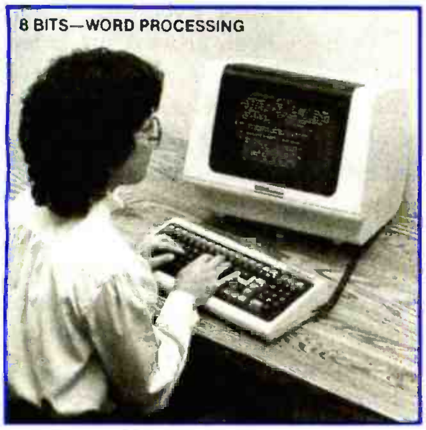
The HELP subsystem explains the structure and design of the HELP (and .HLP) files so that you can create your own, either indexed (menu-driven) or not indexed (block text). For an example of an indexed HELP file, see figure 1. Furthermore, HELP files may be linked, either serially or as branches of a "tree." The latter case provides users with a hierarchy of HELP levels through which they can travel, typically moving from general to specific information. These levels begin at level 0, the root, and extend as far as needed. Users may explore other branches of the tree by invoking the command Root (descend to starting point) and then climbing other branches. Alternately, the Up Level command moves closer to the root, one level at a time.

Because the HELP files are primarily concerned with teaching the structure and use of the HELP subsystem, they provide many examples.

The information sections in the HELP subsystem are organized as "frames," that is, each contains the amount of information that makes up one page of information on the terminal's screen. At the end of each frame, the user is shown a mini-menu of the possible responses.

Libraries: There are 14 libraries supplied on the CP/M system disk. These files are macroinstructions provided

Finally, a MULTI-USER micro for professionals by G&G Engineering



Shown: WordStar™ from MicroPro

EXPANDABLE

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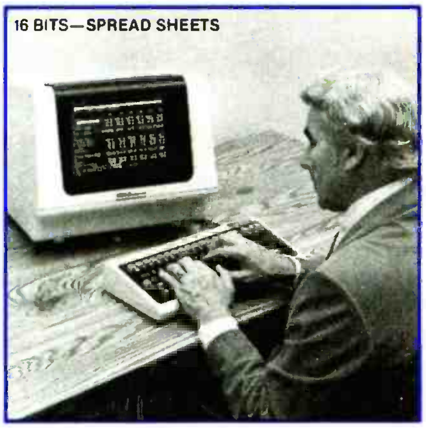

Shown: SuperCalc 86™ from Sorcim

Hard Disk Based Multi-User Systems start at $10,500

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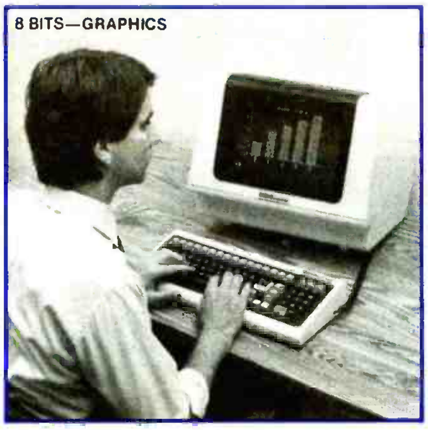

Shown: CompuPlot™ from G&G Engineering

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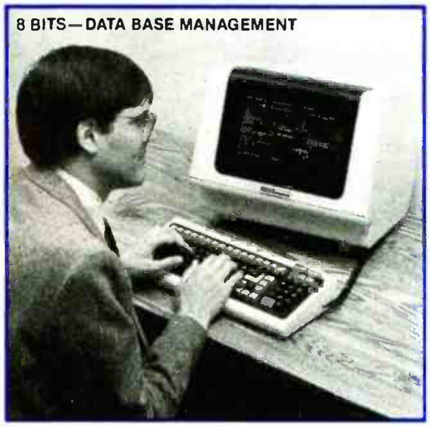

Shown: dBASE II™ from Ashton-Tate

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for the convenience of assembly-language programmers. (For a complete listing of the software supplied with this system, see table 1.)

SB-80 utilities: Four utility programs from Colonial Data Services add to the capabilities of CP/M 2.2. They are DSKTEST, a disk verification program; FORMAT, a combination disk-format and disk-backup program (single or double density); MEMTST, a series of memory diagnostics; and XDIR, an extended-directory command.

Demonstration programs: Finally, two examples of business-oriented programs (SMDEM01 and SMDEM02) are available from S and M Systems (2 Washington St., Haverhill, MA 01830), which is affiliated with Colonial Data.

"Benchremarks"

Because the SB-80 is a 4-MHz Z80 system, its benchmark results (see table 2) are similar to those obtained in other tests of 4-MHz Z80 systems—though the SB-80 proved to be slightly faster than our "generic" Z80 test system through the first four iterative benchmarks. These benchmark programs consisted of an empty do-loop (or FOR. . .NEXT loop), a division operation (using single-precision real numbers), a subroutine jump/return operation, a MID$ (substring) operation, and a prime number program.

More details about the "generic" Z80 can be found in the review "A Closer Look at the IBM Personal Computer," (January 1982 BYTE, page 36), wherein Gregg Williams compared five benchmark programs written in Microsoft BASIC version 4.51 on both IBM's machine and an unidentified Z80 microcomputer running at 4 MHz.

Documentation

The makers of the SB-80 seem to be eager to inform the system's owners about the computer. In fact, one is almost overwhelmed with material—two 3-ring binders full. The first binder contains seven manuals from Digital Research covering the CP/M disk operating system. These reference manuals have been around for several years and have, in fact, been the basis of several books dedicated to explaining CP/M to novice users. The second binder contains Colonial Data's SB-80 user's manual. This manual is divided into six sections and is really a collection of six separate references.

The first section of the user's manual is the 24-page "Operator's Guide." According to the introduction, it is directed to the novice user and states that "no prior knowledge of computers is required." Unfortunately, it tries to cover too much ground too fast; by page 5, the discussion of serial I/O becomes fairly technical. The subsection called "Getting Started" is better oriented to the first-time user and is in a step-by-step, "cookbook"

BIOS.ASM	Source listing for 63K BIOS with parameters set up for 9600 bps terminal, 300 bps modem, and standard Centronics parallel printer
BIOS61.ASM	Source listing for 61K BIOS with parameters set up for 9600 bps terminal, 300 bps modem, and standard Centronics parallel printer
BIOS.HEX/ BIOS.REL	Assembled BIOS.ASM file for 63K BIOS
BIOS.PRN	Listing file of BIOS.ASM (assembled)
LIBRARIES	TREADLES.LIB, COMPARE.LIB, STACK.LIB, NCOMPARE.LIB, SELECT.LIB, WHEN.LIB, BUTTONS.LIB, I8085.LIB, DISKDEF.LIB, Z80.LIB, SIMPIO.LIB, DOWHILE.LIB, SEQIO.LIB, INTER.LIB
DUMP.ASM DUMP.COM DUMP.PRN	Sample assembler program, which will print a hexadecimal file dump of any file which has been assembled (DUMP.ASM), producing a listing file (DUMP.PRN) and an executable program file (DUMP.COM)
CPM.COM	CP/M image file using SYSGEN utility for 63K machine
BOOTROM.PRN	Listing of SB-80 boot ROM
BOOT.ASM	SB-80 Boot Loader Source file
DISKTST.COM	SB-80 Disk Verify program
FORMAT.COM	System Utility program, which formats, verifies, and copies the contents of one disk to another
MEMTST.COM	SB-80 memory diagnostics
XDIR.COM	Extended Directory program
TERM.COM TERM	Program and Data file for S and M Systems' demo terminal selections
Digital Research utilities	PIP.COM, XSUB.COM, STAT.COM, LOAD.COM, ASM.COM, SYSGEN.COM, ED.COM, SUBMIT.COM, DDT.COM
SMDEM01.COM SMDEM02.COM	S and M Systems Accounting Demonstration programs
HELP.COM	Universal HELP system for online documentation
*.HLP	Various HELP files on the most popular CP/M and SB-80 microcomputer functions

Table 1: *An annotated list of all the software distributed with the SB-80 CP/M 2.2 disk.*

Benchmark Description	SB-80 (4 MHz) Seconds	Generic Z80 (4 MHz) Seconds
empty do-loop	5.74	5.81
division	24.87	24.90
subroutine jump	9.17	9.40
MID$ (substring)	18.50	18.60
prime number program	151.00	151.00

Table 2: *Benchmark results for the SB-80 versus a Z80 S-100 system. Both computers ran identical BASIC programs written in MBASIC 4.51. For listings of the benchmarks, see page 54 of the January 1982 issue of BYTE in "A Closer Look at the IBM Personal Computer" by Gregg Williams.*

format that explains plugging in a terminal and orienting the floppy disk properly. The Operator's Guide also introduces microcomputers, software, terminology, disks and drives, and how to make a backup. The guide goes on to explain prompts, Control keys, and introduces CP/M.

The second section, titled the "Technical Manual," is 60 pages long and describes the hardware: the processor, memory, I/O ports, counter/timers, disk controller, expansion circuitry, power supply, and miscellaneous items. The manual then goes into the operation(s) of these various components.

The third section is a commented listing of the bootstrap ROM used in the SB-80, while the fourth section is made up of the full schematics of the system. There are 12 pages of circuits, parts placement, and component descriptions. The fifth and sixth sections consist of the Shugart OEM and maintenance manuals for the 800-series 8-inch floppy-disk drives. Overall, more than 360 pages of information are included with this microcomputer.

Conclusions

- The SB-80 system is not an exotic machine but rather an example of the refinement of an existing concept—in this case, a Z80-based, CP/M-compatible computer. Aspects of the system reflect the careful planning that went into the design (e.g., the expansion connector and the jumper-programmable RS-232C ports). The price for a fully configured machine is $2995, which places the system in the low-to-middle section of the market. Even so, the manufacturer appears not to have cut corners in production. For example, all of the ICs are socketed so that repairs and replacements can be done in the field. Also, the serial ports are controlled by a Z80 SIO/0 rather than a less expensive UART.
- I was favorably impressed with the 9-bit memory width used for parity checking. In a business environment, an undetected dropped bit could create some interesting results in the Accounts Receivable department. The HELP subsystem shows a great deal of potential for both OEMs who may be packaging this system with proprietary software and end users who might want to set up mini-tutorials for less experienced operators.
- On the debit side, the user's manual becomes too technical for the intended audience of novice users. (Documentation is forever the downfall of computer manufacturers.) Still, the SB-80's documentation is above average. Also, a switched AC outlet for the terminal would be a nice touch.
- In summary, the system worked well, was totally reliable (no resets due to static or line surges), and did the job of running CP/M software. With its excellent price/performance ratio, its rock-solid hardware, and the tremendous amount of software available, the SB-80 should become a real competitor in the 8-bit market. ■

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BYTE Game Contest

The Game of Rat and Dragon

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Have you ever looked at a microcomputer game and thought you could do a better job if only you knew where to start? In this article I'll show you where to start and how to apply certain important elements of game design. After briefly describing the Game of Rat and Dragon in its final form, I'll explain how its evolution was shaped by those design elements.

Rat and Dragon is an animated chase game for the Apple II in which you try to earn a high score within a limited amount of time. You use game paddles to move the rat (represented by a brown square) to find and eat a piece of cheese (a yellow square). When the rat eats the cheese you score points, and a new cheese appears somewhere else on the screen. To keep the game from being too simple, two dragons (red and green) chase the rat. The dragons will eat the rat if they catch it, and that ends the game. As your skill improves and your score gets higher, both the cheese and the dragons move faster, making it harder to score points.

Implied in this description of the Game of Rat and Dragon are four factors important to computer game design:

- goals and objectives (you score points by causing the rat to eat the cheese)
- complications (the dragons want to eat the rat)
- timing (time is limited and things keep moving faster)
- display (colored objects move about on the screen)

The level of implementation of these factors can make the difference between rave reviews and brickbats for a game. If you're planning to write a computer game of your own, don't try to make it too elaborate—the best games are simple, absorbing, and visually attractive. To illustrate how to bring all these factors together in a successful game, I'll start with the initial question, Where do you begin?

Goals and Objectives

All great games, not just computer games, start with very simple ideas, typically involving a goal and objectives. The goal is the ultimate purpose of the game. It might be to make a specific type of move, as in chess, or simply to score as many points as possible, as in Space Invaders. Anything accomplished on the way to the goal is an objective. In chess, the object of the game is to capture game pieces by moving onto the squares they occupy. The goal of the game is to capture the king, or rather to put the king in such a position that he can't avoid being captured.

An objective can contribute directly to the effort to reach the goal, it can be indirectly related, or it can have no relation at all. In chess, capturing pieces other than the king contributes indirectly to the goal; it is still possible to lose even if you have taken more pieces than your opponent. The purpose of the objective is to keep players interested in the game by giving them a way to mark their progress.

How does this apply to computer games? The game starts with a simple idea such as hitting a ball with a paddle (Pong), shooting at a target

(Space Invaders), or gobbling up dots (Pac-Man). Your game should be simple, too. Resist the temptation to make up goals and objectives that take a lot of practice to achieve. Whet the player's appetite by making the first few points easy to score. Give people an easy-to-understand game that they can start playing immediately, and they'll keep coming back for more.

It's possible for a game to go in many directions from a simple idea. Breakout, Asteroids, and Rat and Dragon evolved from the same basic ideas as Pong, Space Invaders, and Pac-Man, respectively. Rat and Dragon in particular began as a program to simulate the workings of the Etch-a-Sketch toy. I added the cheese for an objective and a dragon and a time limit to make the game interesting. The first, very simple version of the program is shown in listing 1. It took about half an hour to program, and I immediately spent the following hour trying to get a score higher than 15 points.

Usually it's a good idea to write a quick program containing the basic idea of your goal and objectives to see if the game will be playable. The flowchart in figure 1 is a guide to the organization of the program. The sequence of events is simple: initialize the program; initialize the game; execute a loop to move the rat, cheese, and dragon until the time limit is reached or the dragon catches the rat; and then end the game.

Once I finished programming the game, I applied the playability test. The action was fast and I became very involved in trying for a high score. From this experience I decided that the idea was basically sound, and I began to think about making the game more complicated.

Complications

One problem with games in general and computer games in particular is that people get better at tasks they practice. If you make a game too simple, players will soon master it and subsequently lose interest. Tic-tac-toe is a good example of this effect.

On the other hand, if you make the game difficult enough to keep their

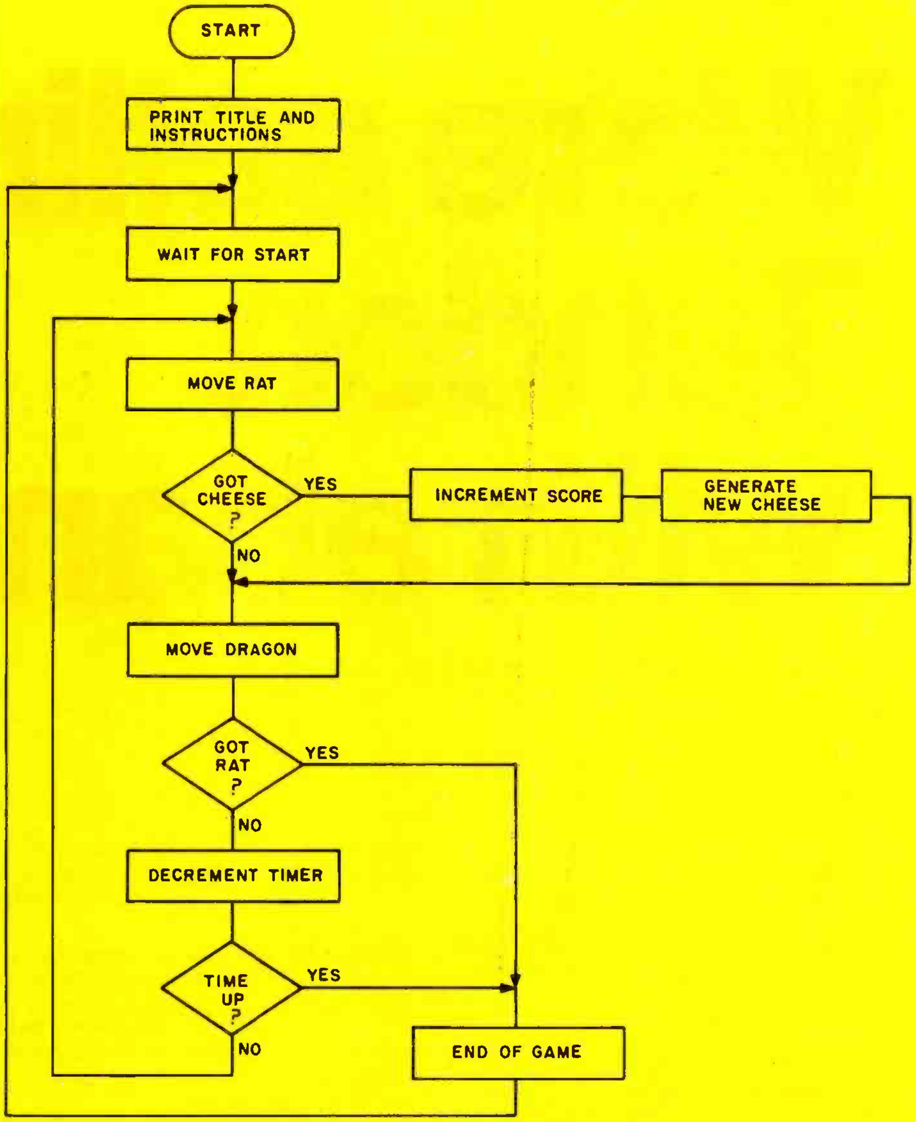

Figure 1: *A flowchart of the Rat and Dragon program that is organized like a polling loop for I/O requests.*

Listing 1: *A simple version of Rat and Dragon that serves to test the basic idea.*

```
1000 REM ------------------------------
1010 REM  THE GAME OF RAT & DRAGON
1020 REM  SIMPLE VERSION
1030 REM  TRUCK SMITH 9/22/81
1040 REM ------------------------------
1050 REM INITIALIZE PROGRAM------------
2000 RC=8
2010 BG=0
2020 DC=1
2030 CC=13
2100 TEXT
2110 CALL -936
2120 PRINT "THE"
2130 PRINT "GAME"
2140 PRINT "OF"
2150 PRINT "RAT"
2160 PRINT "&"
2170 PRINT "DRAGON"
2180 PRINT
2190 VTAB 21
2200 PRINT "PUSH EITHER BUTTON TO BEGIN"
3000 REM INITIALIZE GAME---------------
3010 IF PEEK (-16287)>127 THEN 3100
3020 IF PEEK (-16286)>127 THEN 3100
3030 GOTO 3000
3100 GR
3110 CALL -936
3120 TM=400
3130 DX=19
3140 DY=19
3150 CX= RND (40)
3160 CY= RND (40)
3170 COLOR=CC
3180 PLOT CX,CY
3190 SC=0
3200 VTAB 21
3210 PRINT "SCORE",SC
3220 PRINT "TIME",TM
3230 RX=0
3240 RY=0
```

Listing 1 continued on page 339

Listing 1 continued:

```
4000 REM MAINLOOP------------------------
4010 REM RAT............................
4020 COLOR=BG
4030 PLOT RX,RY
4040 RX= PDL (0)/6
4050 IF RX>39 THEN RX=39
4060 RY= PDL (1)/6
4070 IF RY>39 THEN RY=39
4080 COLOR=RC
4090 PLOT RX,RY
4100 REM SCORE..........................
4110 IF RX<>CX OR RY<>CY THEN 4200
4120 SC=SC+1
4130 VTAB 21
4140 PRINT "SCORE",SC
4150 CX= RND (40)
4160 CY= RND (40)
4170 COLOR=CC
4180 PLOT CX,CY
4200 REM DRAGON.........................
4210 IF DX=RX AND DY=RY THEN 4400
4220 COLOR=BG
4230 IF DX=CX AND DY=CY THEN COLOR=CC
4240 PLOT DX,DY
4250 DX=DX+ SGN (RX-DX)
4260 DY=DY+ SGN (RY-DY)
4270 COLOR=DC
4280 PLOT DX,DY
4300 REM TIMER..........................
4310 TM=TM-1
4320 VTAB 22
4330 PRINT "TIME",TM;" "
4340 IF TM>0 THEN 4000
4400 GOTO 3000
```

interest for a long time, you may find that some people won't even try the game. Others may give up after a few tries because it's too difficult for them. A classic example is chess. I refuse to play my computer chess game because I can't win even when the program is set to the lowest skill level. I can't even beat the computer by asking it where I should move next.

You can avoid the extremes of too simple and too difficult and sustain the players' interest in two ways. One solution is to make some objectives easy but allow only a few points for them. The goal of such a game would be to amass a huge number of points, which must be achieved by satisfying a more difficult objective. The other solution is to start with easy objectives and make them harder as players score more or as playing time increases.

In practice, many computer games use both methods. The Pac-Man game, for instance, grants a small score for eating a dot (which is easy) and a greater score for eating a monster. The game also gets complicated and more difficult with time as the monsters escape from their pen, one by one, to chase the Pac-Man. The Pac-Man then has to find and eat a special dot to be able to eat the monsters.

Space Invaders also uses both methods. It's fairly easy to shoot a single invader, and the score reflects it. You have to shoot down the flying saucers, a considerably harder task, to score higher totals. One elegant feature of the game is the way scoring becomes more difficult as your score gets higher. When you shoot the invaders, the remaining ones move faster, becoming harder targets for you to hit.

In Rat and Dragon, some complications were easy to program, such as having the dragon wait to appear until the player reached a certain score or having the cheese move around, slowly at first, then faster. However, at this stage it was still too easy to score points.

I puzzled over this problem for quite some time. I could have the dragon stay near the cheese, but then you could easily avoid the dragon by staying out of its range and then swooping in for a score. For lack of a better choice, however, I used that complication in the game's second revision, shown in listing 2.

When I ran that version of the program, the game reached the absolute limit of slowness that I could tolerate. My wife then suggested the perfect complication—another dragon. To add a second dragon I would have to use machine language, a solution that would allow increased game speed and the added complications. (For the machine-language version of the program, see listing 3.)

Timing

Good timing is essential to the creation of a believable illusion. Theoretically, some games, such as Space Invaders, can go on forever, while others may impose a definite time limit. I have never seen a game that timed individual points, but that doesn't mean that such a game doesn't exist or that you can't create one.

If I set a time limit for a game, I tend to start it off at roughly 30 seconds. Then I lengthen or shorten the time until I get a game that leaves me wanting to play more but is still long enough to score a reasonable

Continued on page 343

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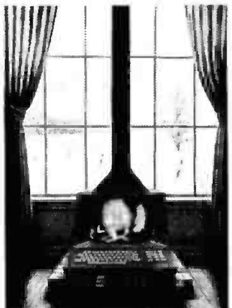

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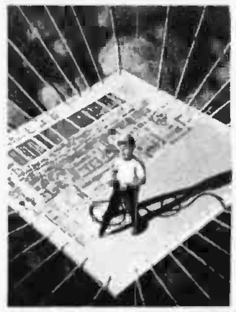

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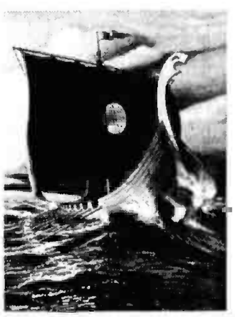

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Programming a Game

The Game of Rat and Dragon exists in three versions: the first attempt in BASIC, a needed revision in BASIC, and the final edition in machine language. The general organization depicted in figure 1 applies to all three versions.

The inner loop is similar to a polling loop that checks for I/O (input/output) requests. This organization is very common in games where several characters move about in real time. For example, in the machine-language version each character has a counter that tracks the number of iterations of the loop since the character last moved. When the counter reaches a predetermined value, the character moves again. By adjusting that value, the character's speed can vary from very slow to very fast.

An alternative to the polling approach is the simulated-interrupt method. Although I didn't use this for Rat and Dragon, several games have incorporated it. With this approach, each character maintains a constant speed regardless of what the other characters are doing. Using the simulated interrupt, each routine is called by a monitor program. The routine then returns to the monitor with the amount of time it has taken and the value that the clock should be when the routine is to be called again. The monitor updates the clock and searches for the next routine to run—the one with the lowest clock value. If the clock has not reached that value yet, the monitor loops until it does. By using this method, you can avoid the Space Invaders syndrome of increasing speed as individual invaders are shot down.

Along with a common organization, all three versions of Rat and Dragon share the chase algorithm for the dragon, embodied in the following two statements:

```
4250 DX = DX + SGN(RX - DX)
4260 DY = DY + SGN(RY - DY)
```

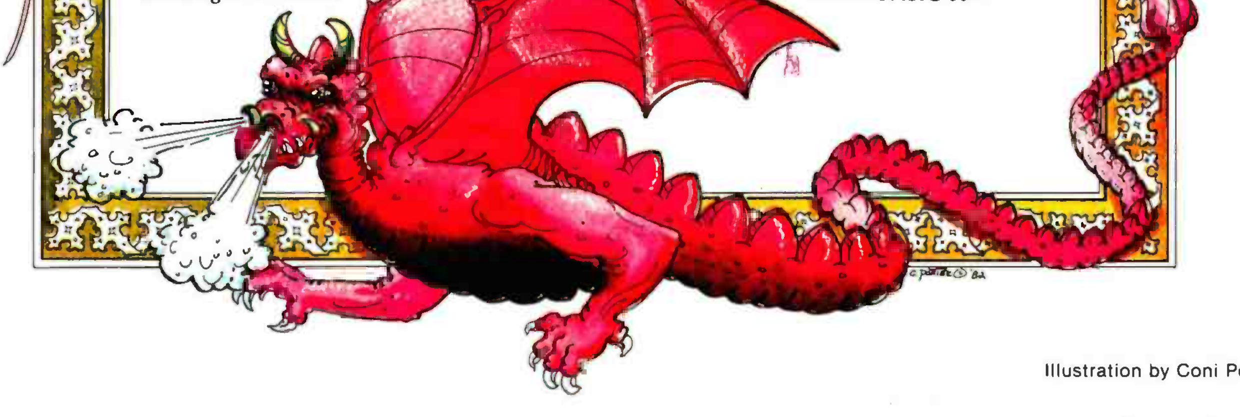
No matter where the rat and dragon are on the screen, the dragon will move one step closer both horizontally and vertically. The program doesn't have to check whether the dragon is still on the screen because in following the algorithm the dragon cannot leave the screen. Another common element is that the cheese is always replotted at two random coordinates whenever the rat gets to it.

The program in listing 1 served its purpose as a quick-and-dirty version to test the playability of the game idea. When I made the initial revisions, the game was well on its way to a final form (listing 2). One of the primary changes was to the dragon; I wanted the dragon to become an extended, worm-like thing, able to expand and contract. I used the following logic to determine whether or not the tail pointer would move:

```
2790 AF = DK = DT
2800 NP = DX(DH)< >D0
  OR DY(DH)< >D1
2810 OC = DH = DT
2820 IF NOT AF AND
  (NP OR OE)
  THEN 2890
```

I outsmarted myself. That logic is evaluated every time the program cycles through the inner loop, making the action slower. The alternative, which I used in the machine-language version, is to initialize the entire array at once, making the programming easier and the action faster.

One instance where the versions of my program differ greatly from one another is in the implementation of complications. Although I decided to introduce the complications as the score mounts in both the second BASIC ver-



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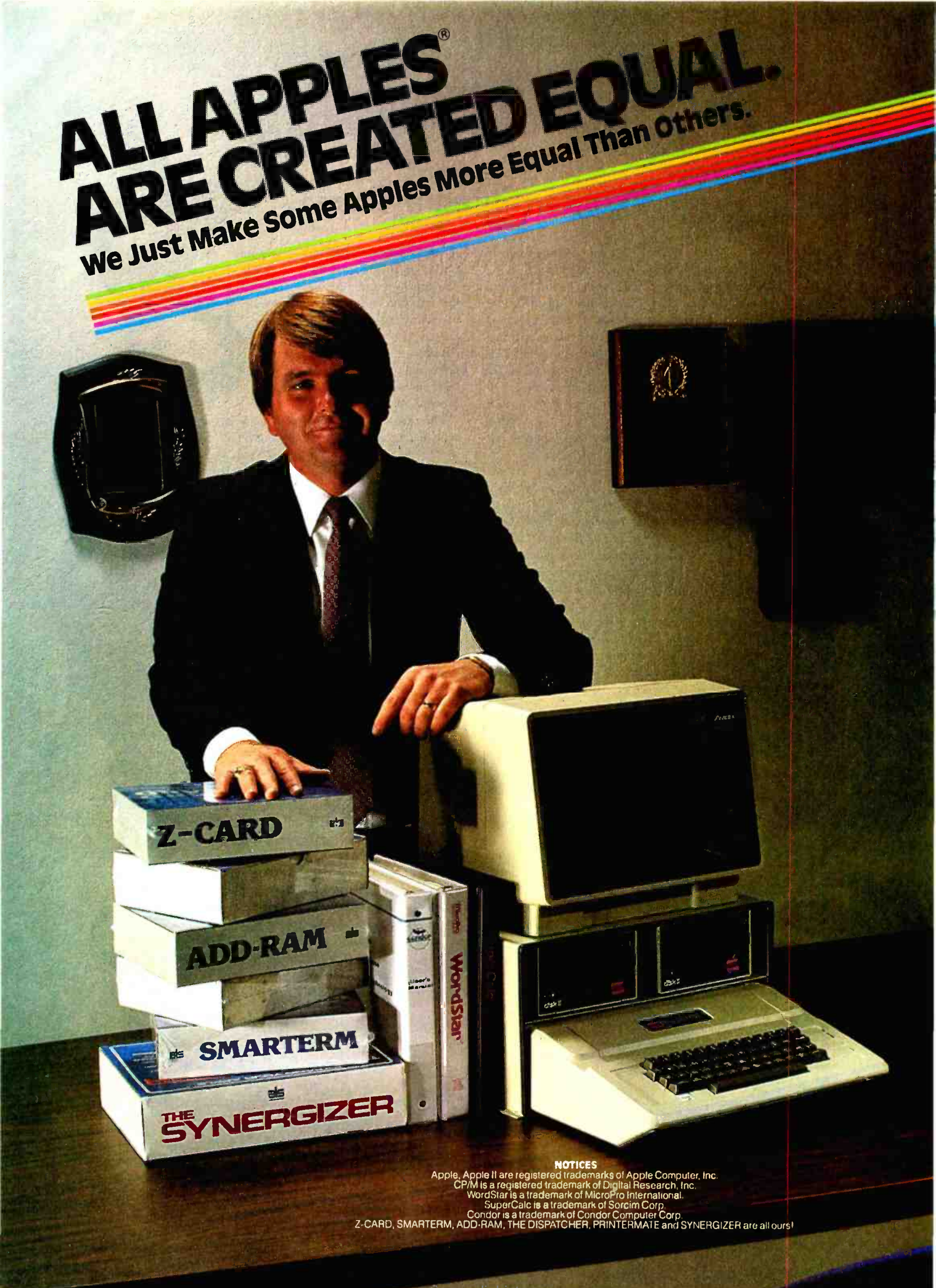
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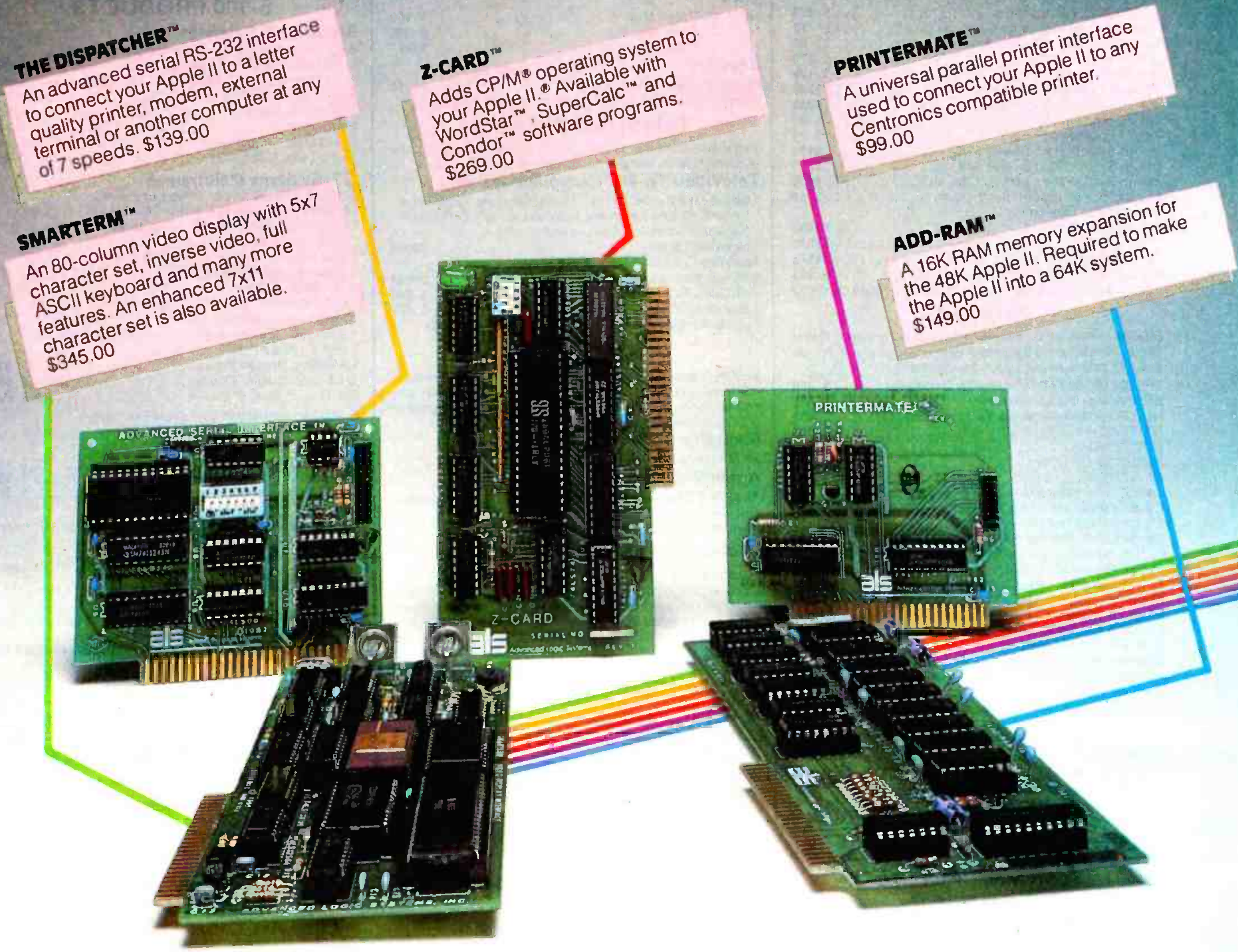

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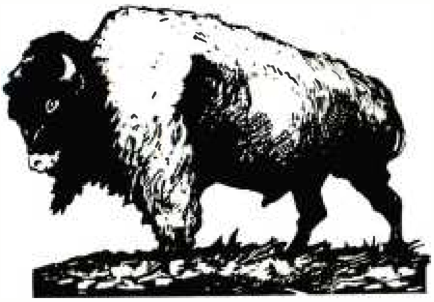

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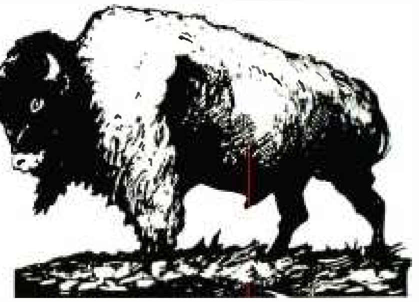

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sion and the machine-language version, the method of handling that procedure varied. In the BASIC program the decision points for the complications are scattered IF. . .THEN statements throughout the program. In the machine-language version I put all the complications in a table and let a scorekeeping subroutine keep track of them. Each complication becomes active when the variable associated with it is no longer equal to zero. The scorekeeping subroutine uses the table to determine which variables should be changed from zero at a particular score (decision point). A table is especially useful when you are uncertain as to how or in what order the complications should come.

Another difference between the BASIC and machine-language versions of my program is in the implementation of a timing sequence. The program in listing 2 uses the BASIC variable TK to count loop iterations and the variable TG to count seconds. About a third of a second is used for each iteration of the loop so there isn't much leeway for adjustments. The adjusting is done primarily by introducing compensating delays for alternate program paths. When I finally decided I needed an accurate real-time clock, increased speed, and another dragon, it was time for version 3—an excursion into the world of machine language.

For the clock I set up a counter that tracks time in units of one ten-thousandth of a second. Each subroutine or section of the program calls a timer subroutine and passes the amount of time the subroutine or section has taken. The timer subroutine decrements the counter and, if the counter goes through zero, ticks the speaker and updates the real-time clock. In the final version I combined most of the invariant times into one count near the end of the loop.

The test for the time-out condition is not done by the timer but is accomplished at the bottom of the loop. The reason for putting the test at the end of the loop was good programming practice; I wanted to avoid dropping out of the loop from the middle of a nested subroutine call.

Initially I determined subroutine times by either counting cycles or actually timing the routine. When I got the entire program running I adjusted the counts, combining some of them, until I got an accurate clock. I chose units of one ten-thousandth of a second because that gave me a counter that took two bytes and routine times that took one byte, making my calls to the timer easier.

On the Apple the paddles are read by counting the elapsed time it takes a triggered impulse to return to the computer. This means that the time it takes to read a paddle value of zero differs from the time it takes to read the maximum paddle value of 255. I timed the paddle-read subroutine and determined that it took approximately 1.5 times the paddle-value after adjustment to fit within the screen limits of 0 to 39. Rather than include a generalized multiplication subroutine that would consume considerable time, I used the machine-language shift and add instructions to calculate the paddle time.

The machine-language version gave me more than the tenfold increase in speed I was hoping for. The game was so fast that I had plenty of room to tailor the rat, dragon, and cheese to my needs. In fact, even with the addition of the second dragon, I finally had to slow many things down to keep the game playable.■

number of points. The first program (listing 1) runs a bit too long, but the program in listing 2 is limited to 60 seconds, which seems to work very well for this game.

I chose to simulate real time for two reasons. A clock gives players a subtle sense of tension, and a real-time clock makes explanations of rules easier. For example, I don't have to explain the timing procedure; I just say that the time limit is 60 seconds. And when the players hear the clock ticking, they are more likely to rush after points and make an error.

Once you have the basic game, the complications, and the timing under control, you proceed to make the game attractive.

Display

Chess can be played on a dime-store checker board with cardboard pieces. One reason most people don't play chess this way is that it is difficult to maintain a high quality of illusion with cardboard pieces. In a well-designed game, the players participate in a believable illusion.

If you want to produce a good game, it's important to pay attention to the details that create a believable

Text continued on page 373

Listing 2: *A revised version of the game, still in BASIC, that runs too slowly to play well.*

```
1000 REM --------------------------------
1010 REM  THE GAME OF RAT & DRAGON
1020 REM  TRUCK SMITH 8/1/81
1030 REM --------------------------------
1040 REM TITLE AND INSTRUCTIONS---------
1050 TEXT
1060 CALL -936
1070 VTAB 3
1080 PRINT "THE"
1090 PRINT "GAME"
1100 PRINT "OF"
1110 PRINT "RAT"
1120 PRINT "&"
1130 PRINT "DRAGON
1140 GOSUB 10100
1150 POKE 32,12
1160 POKE 33,28
1170 VTAB 15
1180 PRINT "TRUCK SMITH"
1190 PRINT "8/1/81"
1200 GOSUB 10100
1210 VTAB 22
1220 PRINT
1230 PRINT "THIS IS A CHASE GAME"
1240 GOSUB 10100
1250 PRINT "INVOLVING A RAT, A DRAGON,"
1260 GOSUB 10100
1270 PRINT "AND AN UNLIMITED SUPPLY OF"
1280 GOSUB 10100
1290 PRINT "CHEESE."
1300 GOSUB 10100
1310 PRINT
1320 GOSUB 10100
1330 PRINT "YOU CONTROL THE RAT (THE"
1340 GOSUB 10100
1350 PRINT "BROWN SQUARE) WITH THE"
1360 GOSUB 10100
1370 PRINT "GAME PADDLES."
1380 GOSUB 10100
1390 PRINT
1400 GOSUB 10100
1410 PRINT "THE DRAGON (WHICH IS RED)"
1420 GOSUB 10100
1430 PRINT "IS CHASING YOU."
1440 GOSUB 10100
1450 PRINT
1460 GOSUB 10100
1470 PRINT "YOUR OBJECTIVE IS TO EAT"
1480 GOSUB 10100
1490 PRINT "AS MUCH CHEESE (YELLOW"
1500 GOSUB 10100
1510 PRINT "SQUARES) AS YOU CAN WHILE"
1520 GOSUB 10100
1530 PRINT "AVOIDING THE DRAGON."
1540 GOSUB 10100
1550 PRINT
1560 GOSUB 10100
1570 PRINT "YOU HAVE 60 SECONDS TO EAT"
1580 GOSUB 10100
1590 PRINT "AS MUCH CHEESE AS YOU CAN."
1600 GOSUB 10100
1610 PRINT
1620 GOSUB 10100
1630 PRINT "A WARNING - AS YOU GET"
1640 GOSUB 10100
1650 PRINT "BETTER, THE CHEESE BEGINS"
1660 GOSUB 10100
1670 PRINT "TO MOVE AROUND, AND THE"
1680 GOSUB 10100
1690 PRINT "DRAGON GETS SMARTER."
1700 GOSUB 10100
1710 PRINT
1720 GOSUB 10100
1730 PRINT "IF YOU FEEL YOU ARE READY,"
1740 GOSUB 10100
1750 PRINT "PUSH EITHER ONE OF THE"
1760 GOSUB 10100
1770 PRINT "PADDLE BUTTONS."
1790 REM INITIALIZE PROGRAM------------
1800 TM=60
1810 DN=5
1820 DIM DX(DN),DY(DN)
1830 HS=0
1840 REM NEWGAME-----------------------
1850 IF PEEK (-16287)>127 THEN 1900
1860 IF PEEK (-16286)>127 THEN 1900
1870 GOTO 1850
1900 REM INITIALIZE GAME---------------
1910 GR
1920 CALL -936
1930 TG=TM
```

Listing 2 continued on page 350

Listing 2 continued:

```
1940 TK=3
1950 VTAB 22
1960 TAB 7
1970 PRINT "TIME ";TG
1980 SC=0
1990 VTAB 22
2000 TAB 25
2010 PRINT "SCORE ";SC
2020 REM BACKGROUND.....................
2030 BG=5
2040 COLOR=BG
2050 GOSUB 10200
2060 REM RAT............................
2070 RC=8
2080 R0= PDL (0)/6
2090 IF R0>39 THEN R0=39
2100 R1= PDL (1)/6
2110 IF R1>39 THEN R1=39
2120 COLOR=RC
2130 PLOT R0,R1
2140 RX=R0
2150 RY=R1
2160 REM CHEESE.........................
2170 CC=13
2180 CX= RND (40)
2190 CY= RND (40)
2200 COLOR=CC
2210 PLOT CX,CY
2220 REM DRAGON.........................
2230 DC=1
2240 DH=0
2250 DT=0
2260 DX(DH)=19
2270 DY(DH)=19
2275 DR=10
2280 REM CLICK..........................
2290 POKE -16336,0
2295 POKE -16336,0
2300 REM MAINLOOP-----------------------
2310 REM CHEESE.........................
2320 IF SC<12 THEN 2460
2330 IF SC<20 AND TK<>0 THEN 2460
2340 COLOR=BG
2350 PLOT CX,CY
2360 CX=CX+ SGN (CX-RX)
2370 IF CX>39 THEN CX=39
2380 IF CX<0 THEN CX=0
2400 CY=CY+ SGN (CY-RY)
2410 IF CY>39 THEN CY=39
2420 IF CY<0 THEN CY=0
2430 COLOR=CC
2440 PLOT CX,CY
2450 GOTO 2470
2460 FOR T=0 TO 15: NEXT T
2470 REM RAT............................
2480 R0= PDL (0)/6
2490 IF R0>39 THEN R0=39
2500 R1= PDL (1)/6
2510 IF R1>39 THEN R1=39
2520 IF R0=RX AND R1=RY THEN 2590
2530 COLOR=BG
2540 PLOT RX,RY
2550 COLOR=RC
2560 PLOT R0,R1
2570 RX=R0
2580 RY=R1
2590 IF RX<>CX OR RY<>CY THEN 2690
2600 SC=SC+1
2610 VTAB 22
2620 TAB 31
2630 PRINT SC
2640 CX= RND (40)
2650 CY= RND (40)
2660 POKE -16336,0
2665 POKE -16336,0
2670 COLOR=CC
2680 PLOT CX,CY
2690 REM DRAGON.........................
2700 IF SC<4 THEN 2970
2710 D0=RX
2720 D1=RY
2730 IF SC<8 THEN 2760
2735 IF SC=16 THEN DR=5
2740 IF ABS (D0-CX)>DR THEN D0=CX+ SGN (D0-CX)*DR
2750 IF ABS (D1-CY)>DR THEN D1=CY+ SGN (D1-CY)*DR
2760 DK=DH+1
2780 IF DK>DN THEN DK=0
2790 AF=DK=DT
2800 NP=DX(DH)<>D0 OR DY(DH)<>D1
2810 OE=DH=DT
2820 IF NOT AF AND (NP OR OE) THEN 2890
2830 REM ERASE TAIL. . . . . . . . . . .
2840 COLOR=BG
2850 IF DX(DT)=CX AND DY(DT)=CY THEN COLOR=CC
2860 PLOT DX(DT),DY(DT)
2870 DT=DT+1
2880 IF DT>DN THEN DT=0
2890 REM MOVE HEAD . . . . . . . . . . .
2900 D2=DX(DH)
2910 D3=DY(DH)
2920 DH=DK
2930 DX(DH)=D2+ SGN (D0-D2)
2940 DY(DH)=D3+ SGN (D1-D3)
2945 IF DX(DH)=RX AND DY(DH)=RY THEN 3100
2950 COLOR=DC
2960 PLOT DX(DH),DY(DH)
2965 GOTO 2975
2970 FOR T=0 TO 50: NEXT T
2975 REM TIMER..........................
2980 TK=TK-1
2990 IF TK>0 THEN 2300
3000 POKE -16336,0: POKE -16336,0
3010 TG=TG-1
3020 VTAB 22: TAB 12: PRINT TG;" "
3030 TK=3
3040 IF TG>0 THEN 2300
3050 REM GAME END-----------------------
3060 REM TIME UP........................
3070 CALL -936
3080 PRINT "THE TIMER RAN OUT"
3090 GOTO 3140
3100 REM DRAGON BITE...................
3110 CALL -936
3120 PRINT "THE DRAGON GOT YOU AT ";TG;" SECONDS"
3140 PRINT "YOUR SCORE ";SC;", PREVIOS HIGH ";HS
3150 PRINT "PUSH EITHER BUTTON TO PLAY AGAIN"
3160 IF HS<SC THEN HS=SC
3170 GOTO 1840
9000 END
10100 FOR T=0 TO 1000: NEXT T: RETURN
10200 REM SCREEN CLEAR------------------
10210 FOR I=0 TO 39 STEP 2
10220 VLIN 0,39 AT I
10230 VLIN 0,39 AT 39-I
10240 HLIN 0,39 AT I
10250 HLIN 0,39 AT 39-I
10260 NEXT I
10270 RETURN
```

Listing 3: *The final machine-language version of Rat and Dragon.*

```
SOURCE FILE: RAT & DRAGON 2/13/82 1342
----- NEXT OBJECT FILE NAME IS RAT & DRAGON
0800:                    ORG  $800
          ****************************************
0800:     *
0800:     * THE GAME OF RAT & DRAGON
0800:     *
0800:     *   COPYRIGHT 1982 TRUCK SMITH
0800:     *
          ****************************************
0800:     *
0800:     * PARAMETERS
0800:     *
0005:     LOG      EQU  5
0800:     *
0800:     * MONITOR REFERENCES
0800:     *
0020:     WNDLFT   EQU  $20
0021:     WNDWDTH  EQU  $21
0024:     CH       EQU  $24
0025:     CV       EQU  $25
0030:     COLOR    EQU  $30
004E:     RND      EQU  $4E
C000:     KBD      EQU  $C000
C010:     KBDSTRB  EQU  $C010
C030:     SPKR     EQU  $C030
C050:     TXTCLR   EQU  $C050
C053:     MIXSET   EQU  $C053
C061:     SW0      EQU  $C061
C062:     SW1      EQU  $C062
F800:     PLOT     EQU  $F800
FB1E:     PREAD    EQU  $FB1E
FB39:     SETTXT   EQU  $FB39
FB4B:     SETWND   EQU  $FB4B
FBFD:     VIDOUT   EQU  $FBFD
FC22:     VTAB     EQU  $FC22
FC58:     HOME     EQU  $FC58
FCA8:     WAIT     EQU  $FCA8
0800:     *
0800:     * ZERO PAGE VARIABLES
0800:     *
0000:              DSECT
0000:              ORG  0
0000:     TIME     DS   2
0002:     TIME0    DS   2
0004:     SECS     DS   2
0006:     SCORE    DS   2
```

Listing 3 continued on page 352

WHEN WE ANNOUNCED THE COMMODORE 64 FOR $595, OUR COMPETITORS SAID WE COULDN'T DO IT.

THAT'S BECAUSE THEY COULDN'T DO IT.

The reason is that, unlike our competitors, we make our own IC chips. *Plus* all the parts of the computer they go into.

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For your $595,* the Commodore 64™ gives you a built-in user memory of 64K. This is hundreds of dollars less than computers of comparable power.

Lest you think that the Commodore 64 is some stripped-down loss leader, a look at its available peripherals and interfaces will quickly convince you otherwise.

SOFTWARE THAT WORKS HARD.

The supply of software for the Commodore 64 will be extensive. And with the optional plug-in Z80 microprocessor, the Commodore 64 can accommodate the enormous amount of software available in CP/M.®

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PERIPHERALS WITH VISION.

The Commodore 64 interfaces with all the peripherals you could want for total personal computing: disk drives, printers and a telephone modem that's about $100, including a free hour's access to some of the more popular computer information services. Including Commodore's own Information Network for users.

RUN YOUR BUSINESS BY DAY.
SAVE THE EARTH BY NIGHT.

At the end of a business day, the Commodore 64 can go into your briefcase and ride home with you for an evening's fun and games.

Because of its superior video quality (320x200 pixel resolution, 16 available colors and 3D Sprite graphics), the Commodore 64 surpasses the best of the video game machines on the market. Yet, because it's such a powerful computer, it allows you to invent game programs that a game machine will never be able to play; as well as enjoy Commodore's own video game cartridges.

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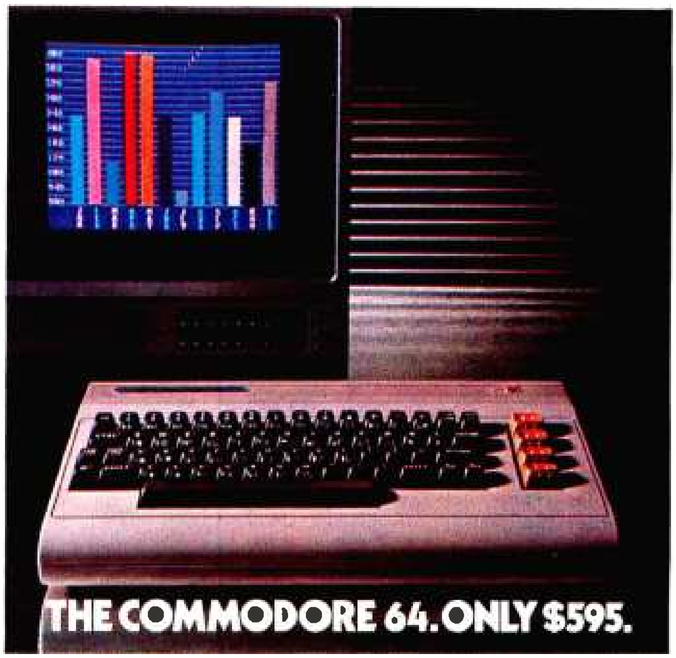

wish. It has sound quality you'll find only on separate, music-only synthesizers. And graphics and storage ability you won't find on any separate synthesizer.

DON'T WAIT.

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BT-11

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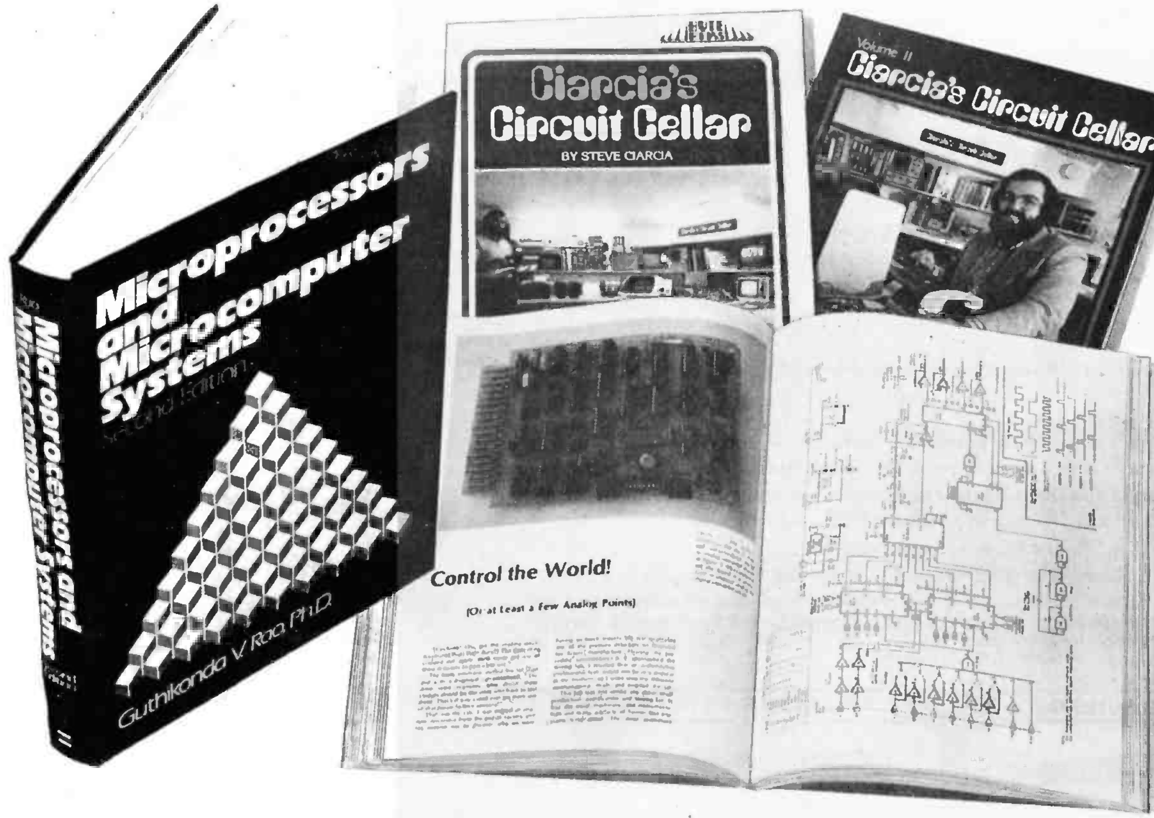
Circle 89 on inquiry card.

Listing 3 continued:

```
0008:             HISCO   DS    2
000A:             BGCLR   DS    1
000B:             RTX     DS    1
000C:             RTY     DS    1
000D:             RTCLR   DS    1
000E:             CHX     DS    1
000F:             CHY     DS    1
0010:             CHCLR   DS    1
0011:             CHCNT   DS    1
0012:             CHICNT  DS    2
0013:             POL     DS    2
0015:             TEMP1   DS    1
0016:             TEMP2   DS    1
0017:             TEMP3   DS    1
0018:             TEMP4   DS    1
0050:                     ORG   $50
0050:             DG1     DS    LDG*2+6
0060:             DG2     DS    LDG*2+6
0800:                     DEND
0800:             *
0800:             * DRAGON TEMPLATE
0800:             *
0000:                     DSECT
0000:                     ORG   0
0000:                     DS    LDG*2
000A:             DGH     DS    1
000B:             DGCLR   DS    2
000D:             DGCNT   DS    1
000E:             DGICNT  DS    1
000F:             DGRAD   DS    1
0800:                     DEND
0800:             *
0800:             * CONSTANTS
0800:             *
008D:             CR      EQU   $8D
009B:             ESC     EQU   $9B
00A0:             BLNK    EQU   $A0
0800:             *
                  ****************************************
0800:             *
0800:             * MAIN PROGRAM
0800:             *
                  ****************************************
0800:             *
0800:             * PRINT TITLE & INSTRUCTIONS
0800:             *
0800:20 39 FB             JSR   SETTXT     ;TITLE
0803:20 58 FC             JSR   HOME
0806:A9 FE                LDA   #>TITLE
0808:85 15                STA   TEMP1
080A:A9 0C                LDA   #<TITLE
080C:85 16                STA   TEMP2
080E:A9 05                LDA   #5
0810:85 25                STA   CV
0812:20 22 FC             JSR   VTAB
0815:20 90 0B             JSR   PRINT
0818:A9 60                LDA   #$60
081A:20 7E 0A             JSR   DELAY
081D:A9 0A                LDA   #10        ;AUTHOR
081F:85 20                STA   WNDLFT
0821:A9 1E                LDA   #30
0823:85 21                STA   WNDWDTH
0825:A9 0E                LDA   #14
0827:85 25                STA   CV
0829:20 22 FC             JSR   VTAB
082C:20 90 0B             JSR   PRINT
082F:A9 5A                LDA   #90
0831:20 7E 0A             JSR   DELAY
0834:A9 17                LDA   #23        ;INSTRUCTIONS
0836:85 25                STA   CV
0838:20 22 FC             JSR   VTAB
083B:20 A5 0B             JSR   SLOPRT
083E:             *
083E:             * INITIALIZE PROGRAM
083E:             *
083E:A2 00                LDX   #$0        ;HIGH SCORE
0840:86 08                STX   HISCO
0842:86 09                STX   HISCO+1
0844:             *
0844:             * INITIALIZE FOR NEW GAME
0844:             *
0844:AD 00 C0     NEWGAME LDA   KBD        ;WAIT FOR BUTTON PUSH
0847:C9 9B                CMP   #ESC
0849:D0 01                BNE   RANDOM
084B:60                   RTS
084C:E6 4E        RANDOM  INC   RND
084E:D0 02                BNE   CHKBTN
0850:E6 4F                INC   RND+1
0852:AD 61 C0     CHKBTN  LDA   SW0
0855:0D 62 C0             ORA   SW1
0858:10 EA                BPL   NEWGAME
085A:AD 50 C0             LDA   TXTCLR
085D:AD 53 C0             LDA   MIXSET
0860:20 49 FB             JSR   SETWND-2
```

Listing 3 continued on page 355



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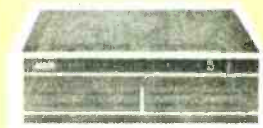

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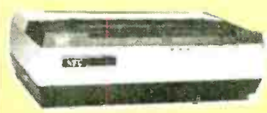

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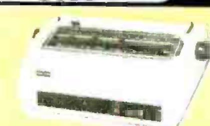

$1019

Listing 3 continued:

```
0863:               *
0863:               * SET COLORS
0863:               *
0863:A9 55                  LDA  #$55       ;SCREEN
0865:85 0A                  STA  BGCLR
0867:A9 88                  LDA  #$88       ;RAT
0869:85 0D                  STA  RTCLR
086B:A9 DD                  LDA  #$DD       ;CHEESE
086D:85 10                  STA  CHCLR
086F:A9 11                  LDA  #$11       ;DRAGON 1
0871:85 5B                  STA  DG1+DGCLR
0873:85 5C                  STA  DG1+DGCLR+1
0875:A9 44                  LDA  #$44       ;DRAGON 2
0877:85 6B                  STA  DG2+DGCLR
0879:85 6C                  STA  DG2+DGCLR+1
087B:               *
087B:               * SET POSITIONS
087B:               *
087B:A9 13                  LDA  #19
087D:85 0B                  STA  RTX        ;RAT
087F:85 0C                  STA  RTY
0881:A2 07                  LDX  #LDG*2-1   ;DRAGON
0883:95 50          SETDGXY STA  DG1,X
0885:95 60                  STA  DG2,X
0887:CA                     DEX
0888:10 F9                  BPL  SETDGXY
088A:A2 56                  LDX  #LDG*2-2+DG1
088C:86 5A                  STX  DG1+DGH
088E:A2 66                  LDX  #LDG*2-2+DG2
0890:86 6A                  STX  DG2+DGH
0892:A2 28                  LDX  #40
0894:86 5F                  STX  DG1+DGRAD
0896:86 6F                  STX  DG2+DGRAD
0898:20 89 0A               JSR  RND40      ;CHEESE
089B:86 0E                  STX  CHX
089D:20 89 0A               JSR  RND40
08A0:86 0F                  STX  CHY
08A2:               *
08A2:               * TIMING PARAMETERS
08A2:               *
08A2:A2 00                  LDX  #0
08A4:86 12                  STX  CHICNT
08A6:86 05                  STX  SECS+1
08A8:86 06                  STX  SCORE
08AA:86 07                  STX  SCORE+1
08AC:86 5E                  STX  DG1+DGICNT
08AE:86 6E                  STX  DG2+DGICNT
08B0:A2 01                  LDX  #1
08B2:86 11                  STX  CHCNT
08B4:86 5D                  STX  DG1+DGCNT
08B6:86 6D                  STX  DG2+DGCNT
08B8:A2 0A                  LDX  #10
08BA:86 00                  STX  TIME
08BC:86 02                  STX  TIME0
08BE:A2 27                  LDX  #39
08C0:86 01                  STX  TIME+1
08C2:86 03                  STX  TIME0+1
08C4:A2 3C                  LDX  #60
08C6:86 04                  STX  SECS
08C8:               *
08C8:               * PLOT SCREEN AND TITLES
08C8:               *
08C8:20 FF 08               JSR  PLTSCRN
08CB:20 58 FC               JSR  HOME
08CE:A2 16                  LDX  #22
08D0:86 25                  STX  CV
08D2:20 22 FC               JSR  VTAB
08D5:A2 2E                  LDX  #>TSCORE
08D7:86 15                  STX  TEMP1
08D9:A2 0F                  LDX  #<TSCORE
08DB:86 16                  STX  TEMP2
08DD:A2 05                  LDX  #5
08DF:86 24                  STX  CH
08E1:20 90 0B               JSR  PRINT
08E4:A2 17                  LDX  #23
08E6:86 24                  STX  CH
08E8:20 90 0B               JSR  PRINT
08EB:A2 0A                  LDX  #10
08ED:A0 06                  LDY  #SCORE
08EF:20 BB 0B               JSR  RGPRNT
08F2:A2 1D                  LDX  #29
08F4:A0 04                  LDY  #SECS
08F6:20 BB 0B               JSR  RGPRNT
08F9:               *
                    ******************************************
08F9:               *
08F9:               * MAIN LOOP
08F9:               *
                    ******************************************
08F9:               *
08F9:               * CHEESE
08F9:               *
08F9:A5 12          MAINLP  LDA  CHICNT
08FB:F0 32                  BEQ  RAT
08FD:C6 11                  DEC  CHCNT
08FF:D0 2E                  BNE  RAT
0901:85 11                  STA  CHCNT
0903:A2 00                  LDX  #0
0905:20 C2 09               JSR  MVECH
0908:A2 01                  LDX  #1
090A:20 C2 09               JSR  MVECH
090D:A4 0E                  LDY  CHX
090F:C4 15                  CPY  TEMP1
0911:D0 06                  BNE  CHEESE2
0913:A5 0F                  LDA  CHY
0915:C5 16                  CMP  TEMP2
0917:F0 16                  BEQ  RAT
0919:A6 0A          CHEESE2 LDX  BGCLR
091B:86 30                  STX  COLOR
091D:20 00 F8               JSR  PLOT
0920:A4 15                  LDY  TEMP1
0922:84 0E                  STY  CHX
0924:A5 16                  LDA  TEMP2
0926:85 0F                  STA  CHY
0928:A6 10                  LDX  CHCLR
092A:86 30                  STX  COLOR
092C:20 00 F8               JSR  PLOT
092F:               *
092F:               * RAT
092F:               *
092F:20 46 0C       RAT     JSR  PLTRAT
0932:A9 29                  LDA  #41
0934:20 A8 FC               JSR  WAIT
0937:               *
0937:               * DRAGON
0937:               *
0937:A2 50                  LDX  #DG1
0939:20 DA 09               JSR  MVEDG
093C:B0 2D                  BCS  DGBITE
093E:A2 60                  LDX  #DG2
0940:20 DA 09               JSR  MVEDG
0943:B0 26                  BCS  DGBITE
0945:               *
0945:               * CHECK KEYBOARD AND TIMER
0945:               *
0945:AD 00 C0               LDA  KBD
0948:C9 9B                  CMP  #ESC
094A:D0 01                  BNE  CHKTIM
094C:60                     RTS
094D:A9 64          CHKTIM  LDA  #100
094F:20 F0 0A               JSR  TIMER
0952:A5 05                  LDA  SECS+1
0954:D0 A3                  BNE  MAINLP
0956:A5 04                  LDA  SECS
0958:D0 9F                  BNE  MAINLP
095A:               *
                    ******************************************
095A:               *
095A:               * GAME OVER
095A:               *
                    ******************************************
095A:               *
095A:               * TIMEOUT
095A:               *
095A:20 58 FC               JSR  HOME
095D:A9 39                  LDA  #>TTMOUT
095F:85 15                  STA  TEMP1
0961:A9 0F                  LDA  #<TTMOUT
0963:85 16                  STA  TEMP2
0965:20 90 0B               JSR  PRINT
0968:4C 79 09               JMP  ENDGME
096B:               *
096B:               * DRAGON BITE
096B:               *
096B:20 58 FC       DGBITE  JSR  HOME
096E:A9 4C                  LDA  #>TDGGOT
0970:85 15                  STA  TEMP1
0972:A9 0F                  LDA  #<TDGGOT
0974:85 16                  STA  TEMP2
0976:20 90 0B               JSR  PRINT
0979:               *
0979:A9 63          ENDGME  LDA  #>TYSC
097B:85 15                  STA  TEMP1
097D:A9 0F                  LDA  #<TYSC
097F:85 16                  STA  TEMP2
0981:20 90 0B               JSR  PRINT
0984:A0 06                  LDY  #>SCORE
0986:20 BD 0B               JSR  RGPRNT1
0989:A9 6F                  LDA  #>THSC
098B:85 15                  STA  TEMP1
098D:A9 0F                  LDA  #<THSC
098F:85 16                  STA  TEMP2
0991:20 90 0B               JSR  PRINT
0994:A0 08                  LDY  #>HISCO
0996:20 BD 0B               JSR  RGPRNT1
0999:A5 07                  LDA  SCORE+1
099B:C5 09                  CMP  HISCO+1
099D:90 08                  BCC  ENDGME2
099F:D0 0E                  BNE  ENDGME3
09A1:A5 06                  LDA  SCORE
09A3:C5 08                  CMP  HISCO
```

Listing 3 continued on page 356

Listing 3 continued:

```
09A5:90 08                BCC  ENDGME3
09A7:A5 07        ENDGME2 LDA  SCORE+1
09A9:85 09                STA  HISCO+1
09AB:A5 06                LDA  SCORE
09AD:85 08                STA  HISCO
09AF:A9 8D        ENDGME3 LDA  #CR
09B1:20 FD FB             JSR  VIDOUT
09B4:A9 7D                LDA  #>TPUSH
09B6:85 15                STA  TEMP1
09B8:A9 0F                LDA  #<TPUSH
09BA:85 16                STA  TEMP2
09BC:20 90 0B             JSR  PRINT
09BF:4C 44 08             JMP  NEWGAME
09C2:             *
                  ***************************************
09C2:             *
09C2:             * SUBROUTINES
09C2:             *
                  ***************************************
09C2:             *
09C2:             * ANIMATION ROUTINES
09C2:             *
09C2:B5 0E        MVECH   LDA  CHX,X      ;MOVE CHEESE AWAY
09C4:D5 0B                CMP  RTX,X      ; DESTROYS A,Y
09C6:A8                   TAY             ; NEW CHX,Y IN TEMP1,2
09C7:90 09                BCC  MVECH2
09C9:C8                   INY
09CA:C0 28                CPY  #40
09CC:90 09                BCC  MVECH3
09CE:A0 27                LDY  #39
09D0:B0 05                BCS  MVECH3
09D2:88           MVECH2  DEY
09D3:10 02                BPL  MVECH3
09D5:A0 00                LDY  #0
09D7:94 15        MVECH3  STY  TEMP1,X
09D9:60                   RTS
09DA:             *
09DA:18           MVEDG   CLC             ;MOVE DRAGON
09DB:B5 0E                LDA  DGICNT,X   ; INPUT X POINTS TO DRAGON
09DD:F0 FA                BEQ  MVEDG-1    ; DESTROYS A,X,Y,TEMP1,2 & 3
09DF:D6 0D                DEC  DGCNT,X    ; UPDATES DGX,DGY,DGCNT,DGH
09E1:10 F6                BPL  MVEDG-1    ; SETS CARRY IF RAT IS CAUGHT
09E3:95 0D                STA  DGCNT,X
09E5:86 17                STX  TEMP3
09E7:A0 00                LDY  #0         ;  CALCULATE DRAGON'S TARGET
09E9:20 57 0A             JSR  TARGET
09EC:A0 01                LDY  #1
09EE:20 57 0A             JSR  TARGET
09F1:B4 0A                LDY  DGH,X      ;  CALCULATE NEW HEAD POSITION
09F3:B6 00                LDX  0,Y        ;  IN TEMP1 AND 2
09F5:A5 15                LDA  TEMP1      ;   X VALUE IN TEMP1
09F7:D9 00 00             CMP  0,Y
09FA:F0 06                BEQ  MVEDG3
09FC:B0 03                BCS  MVEDG2
09FE:CA                   DEX
09FF:90 01                BCC  MVEDG3
0A01:E8           MVEDG2  INX
0A02:86 15        MVEDG3  STX  TEMP1
0A04:B6 01                LDX  1,Y        ;   Y VALUE IN TEMP2
0A06:A5 16                LDA  TEMP2
0A08:D9 01 00             CMP  1,Y
0A0B:F0 06                BEQ  MVEDG5
0A0D:B0 03                BCS  MVEDG4
0A0F:CA                   DEX
0A10:90 01                BCC  MVEDG5
0A12:E8           MVEDG4  INX
0A13:86 16        MVEDG5  STX  TEMP2
0A15:A6 17                LDX  TEMP3      ;  ADJUST DGH TO NEW HEAD
0A17:B5 0A                LDA  DGH,X
0A19:38                   SEC
0A1A:E9 02                SBC  #2
0A1C:C5 17                CMP  TEMP3
0A1E:B0 02                BCS  MVEDG6
0A20:69 0A                ADC  #LDG*2
0A22:95 0A        MVEDG6  STA  DGH,X
0A24:AA                   TAX             ;  ERASE TAIL
0A25:A4 0A                LDY  BGCLR
0A27:A5 0E                LDA  CHX
0A29:D5 00                CMP  0,X
0A2B:D0 08                BNE  MVEDG7
0A2D:A5 0F                LDA  CHY
0A2F:D5 01                CMP  1,X
0A31:D0 02                BNE  MVEDG7
0A33:A4 10                LDY  CHCLR
0A35:84 30        MVEDG7  STY  COLOR
0A37:B4 00                LDY  0,X
0A39:B5 01                LDA  1,X
0A3B:20 00 F8             JSR  PLOT
0A3E:A5 15                LDA  TEMP1      ;  CHECK FOR RAT
0A40:A4 16                LDY  TEMP2
0A42:C5 0B                CMP  RTX
0A44:D0 06                BNE  MVEDG8
0A46:C4 0C                CPY  RTY
0A48:D0 02                BNE  MVEDG8
0A4A:38                   SEC             ;  WE HAVE RAT
```

Listing 3 continued on page 358

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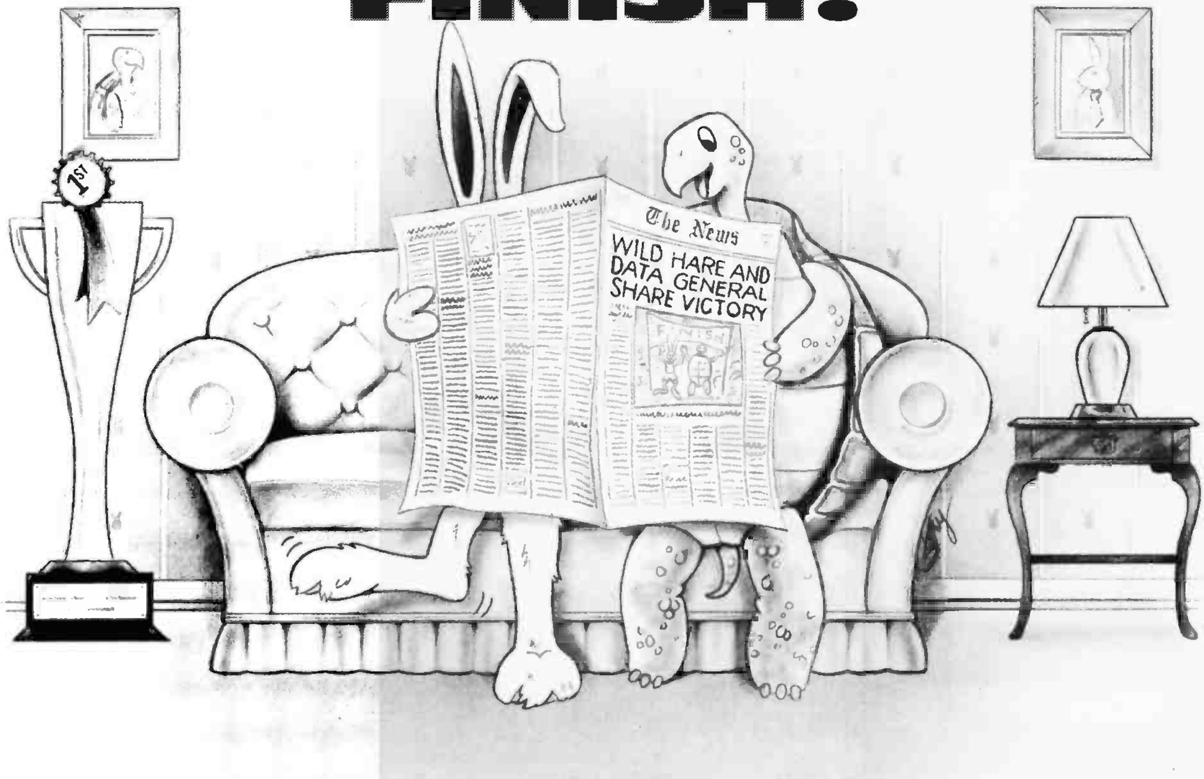

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Listing 3 continued:

```
0A4B:60              RTS
0A4C:95 00    MVEDG8 STA  0,X        ;  WE DON'T HAVE RAT
0A4E:94 01           STY  1,X
0A50:A4 17           LDY  TEMP3
0A52:20 A8 0C        JSR  PLTDG
0A55:18              CLC
0A56:60              RTS
0A57:         *
0A57:38       TARGET SEC             ;CALCULATE DRAGON'S TARGET
0A58:B9 0E 00        LDA  CHX,Y      ; INPUT Y SPECIFIES X(0) OR Y(1) COORD
0A5B:F5 0F           SBC  DGRAD,X    ;       X POINTS TO DRAGON
0A5D:B0 02           BCS  TARGET2    ; DESTROYS A
0A5F:A9 00           LDA  #0
0A61:99 15 00 TARGET2 STA TEMP1,Y    ; OUTPUT TEMP 1 OR 2 (X OR Y)
0A64:B9 0B 00        LDA  RTX,Y      ;          =MIN(CH+DGRAD,MAX(
0A67:D9 15 00        CMP  TEMP1,Y    ;             CH-DGRAD,RT))
0A6A:90 03           BCC  TARGET3
0A6C:99 15 00        STA  TEMP1,Y
0A6F:18       TARGET3 CLC
0A70:B9 0E 00        LDA  CHX,Y
0A73:75 0F           ADC  DGRAD,X
0A75:D9 15 00        CMP  TEMP1,Y
0A78:B0 03           BCS  TARGET9
0A7A:99 15 00        STA  TEMP1,Y
0A7D:60       TARGET9 RTS
0A7E:         *
0A7E:         * MISCELLANEOUS ROUTINES
0A7E:         *
0A7E:38       DELAY  SEC             ;DELAY
0A7F:48       DELAY1 PHA             ; INPUT A-REG AMOUNT OF DELAY
0A80:20 A8 FC        JSR  WAIT       ; DESTROYS A
0A83:68              PLA
0A84:E9 01           SBC  #$1
0A86:D0 F7           BNE  DELAY1
0A88:60              RTS
0A89:         *
0A89:20 93 0A RND40  JSR  RNDNG
0A8C:A5 4F           LDA  RND+1
0A8E:20 D7 0A        JSR  MPY125
0A91:AA              TAX
0A92:60              RTS
0A93:         *
0A93:A9 02    RNDNG  LDA  #$2        ;RANDOM NUMBER GENERATOR
0A95:85 16           STA  TEMP2      ; INPUT RND
0A97:A9 94           LDA  #$94       ; DESTROYS A,X,TEMP1-4
0A99:85 15           STA  TEMP1      ; OUPUT RND=661*RND+13849 MOD 2^16
0A9B:A5 4F           LDA  RND+1
0A9D:85 18           STA  TEMP4
0A9F:A5 4E           LDA  RND
0AA1:85 17           STA  TEMP3
0AA3:A2 10           LDX  #16
0AA5:46 16    RNDNG1 LSR  TEMP2
0AA7:66 15           ROR  TEMP1
0AA9:90 0D           BCC  RNDNG2
0AAB:18              CLC
0AAC:A5 4E           LDA  RND
0AAE:65 17           ADC  TEMP3
0AB0:85 4E           STA  RND
0AB2:A5 4F           LDA  RND+1
0AB4:65 18           ADC  TEMP4
0AB6:85 4F           STA  RND+1
0AB8:06 17    RNDNG2 ASL  TEMP3
0ABA:26 18           ROL  TEMP4
0ABC:CA              DEX
0ABD:D0 E6           BNE  RNDNG1
0ABF:18              CLC
0AC0:A5 4E           LDA  RND
0AC2:69 19           ADC  #$19
0AC4:85 4E           STA  RND
0AC6:A5 4F           LDA  RND+1
0AC8:69 36           ADC  #$36
0ACA:85 4F           STA  RND+1
0ACC:60              RTS
0ACD:         *
0ACD:20 1E FB PDLX   JSR  PREAD      ;READ PADDLE X
0AD0:98              TYA             ; INPUT X PADDLE #
0AD1:18              CLC             ;       PDL LAST PADDLE VALUE
0AD2:75 13           ADC  PDL,X      ; DESTROYS A,Y,TEMP1
0AD4:6A              ROR  A          ; RESULT A=0 TO 39
0AD5:95 13           STA  PDL,X      ;        PDL=0 TO 255
0AD7:         *
0AD7:85 15    MPY125 STA  TEMP1      ;A=A*1.25/8
0AD9:46 15           LSR  TEMP1      ; DESTROYS TEMP1
0ADB:46 15           LSR  TEMP1      ; OUTPUT A=0 TO 39
0ADD:18              CLC
0ADE:65 15           ADC  TEMP1
0AE0:6A              ROR  A
0AE1:4A              LSR  A
0AE2:4A              LSR  A
0AE3:60              RTS
              ****************************************
0AE4:         *
0AE4:AD 30 C0 CLICK  LDA  SPKR       ;CLICK SPEAKER
```

Listing 3 continued on page 360

Listing 3 continued:

```
0AE7:A9 10                LDA  #16       ; DESTROYS A
0AE9:20 A8 FC             JSR  WAIT
0AEC:AD 30 C0             LDA  SPKR
0AEF:60                   RTS
0AF0:              *
0AF0:              * BOOKEEPING ROUTINES
0AF0:              *
0AF0:A2 00         TIMER  LDX  #TIME     ;TIMEKEEPER
0AF2:20 78 0B             JSR  SUBATOR   ; INPUT A ELAPSED TIME * 10000
0AF5:B0 F8                BCS  TIMER-1   ; DESTROYS A,X,Y
0AF7:20 E4 0A             JSR  CLICK     ; UPDATES SEC
0AFA:A5 02                LDA  TIME0     ; CLEARS SCREEN AT SET TIMES
0AFC:85 00                STA  TIME
0AFE:A5 03                LDA  TIME0+1
0B00:85 01                STA  TIME+1
0B02:A2 04                LDX  #SECS
0B04:A9 01                LDA  #1
0B06:20 78 0B             JSR  SUBATOR
0B09:A2 1D                LDX  #29
0B0B:A0 04                LDY  #SECS
0B0D:20 BB 0B             JSR  RGPRNT
0B10:A5 05                LDA  SECS+1
0B12:D0 16                BNE  TIMER9
0B14:A5 04                LDA  SECS
0B16:A2 03                LDX  #3
0B18:DD D8 0C      TIMER1 CMP  TIMTAB,X
0B1B:90 0A                BCC  TIMER2
0B1D:D0 0B                BNE  TIMER9
0B1F:BD DC 0C             LDA  CLRTAB,X
0B22:85 0A                STA  BGCLR
0B24:4C FF 0B             JMP  PLTSCRN
0B27:CA            TIMER2 DEX
0B28:10 EE                BPL  TIMER1
0B2A:60            TIMER9 RTS
0B2B:              *
0B2B:A9 01         SCORER LDA  #1        ;SCOREKEEPER
0B2D:A2 06                LDX  #>SCORE   ; DESTROYS A,X,Y
0B2F:20 6C 0B             JSR  ADDATOR   ; UPDATES SCORE,CHX,CHY
0B32:A2 0A                LDX  #10       ; COMPLICATES GAME
0B34:A0 06                LDY  #>SCORE
0B36:20 BB 0B             JSR  RGPRNT
0B39:20 89 0A             JSR  RND40
0B3C:86 0E                STX  CHX
0B3E:20 89 0A             JSR  RND40
0B41:86 0F                STX  CHY
0B43:20 9D 0C             JSR  PLTCH
0B46:20 E4 0A             JSR  CLICK
0B49:20 E4 0A             JSR  CLICK
0B4C:A9 3E                LDA  #62
0B4E:20 F0 0A             JSR  TIMER
0B51:A5 07                LDA  SCORE+1   ;  CREATE COMPLICATIONS
0B53:D0 16                BNE  SCORER9
0B55:A5 06                LDA  SCORE
0B57:C9 29                CMP  #41
0B59:B0 10                BCS  SCORER9
0B5B:4A                   LSR  A
0B5C:B0 0D                BCS  SCORER9
0B5E:4A                   LSR  A
0B5F:B0 0A                BCS  SCORER9
0B61:0A                   ASL  A
0B62:A8                   TAY
0B63:BE E8 0C             LDX  SCOTAB-2,Y
0B66:B9 E9 0C             LDA  SCOTAB-1,Y
0B69:95 00                STA  $0,X
0B6B:60           SCORER9 RTS
0B6C:              *
0B6C:              * ARITHMETIC ROUTINES
0B6C:              *
0B6C:18           ADDATOR CLC            ;ADD A TO 16 BIT #
0B6D:75 00                ADC  0,X       ; INPUT A AMOUNT TO ADD
0B6F:95 00                STA  0,X       ;          X POINTS TO LOW BYTE OF #
0B71:B5 01                LDA  1,X       ; DESTROYS A
0B73:69 00                ADC  #0
0B75:95 01                STA  1,X
0B77:60                   RTS
0B78:              *
0B78:38           SUBATOR SEC            ;SUBTRACT A FROM 16 BIT REG
0B79:85 15                STA  TEMP1     ; INPUT A AMOUNT TO SUBTRACT
0B7B:B5 00                LDA  0,X       ;          X POINTS TO LOW BYTE OF REG
0B7D:E5 15                SBC  TEMP1     ; DESTROYS A,TEMP1
0B7F:95 00                STA  0,X
0B81:B5 01                LDA  1,X
0B83:E9 00                SBC  #0
0B85:95 01                STA  1,X
0B87:60                   RTS
0B88:              *
0B88:              * PRINTING ROUTINES
0B88:              *
0B88:20 FD FB      PRINT0 JSR  VIDOUT    ;FAST PRINT
0B8B:A9 01                LDA  #1        ; INPUT TEMP1&2 POINTER TO MESSAGE
0B8D:20 6C 0B             JSR  ADDATOR   ; DESTROYS A,X,Y
0B90:A2 15         PRINT  LDX  #>TEMP1   ; UPDATES TEMP1&2
0B92:A0 00                LDY  #$0
```

Listing 3 continued on page 363

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The UNIX operating system is versatile, simple and productive. Its built-in file system of highly uniformed sets and subsets of directories are arranged in a hierarchical tree-like structure. The Berkeley c-shell has been added to enhance communication between you and the operating system. A unique record lock-out system has been implemented to prevent more than one user from accessing the same record in a multi-user/multi-tasking environment. Now, with the 68000's 32-bit internal architecture, Unix becomes state of the art on the DUAL System 83/.

THE HARDWARE

An On-Board Memory Management Unit and a scatter-loading technique are used to allow efficient processing for multiple users performing multiple tasks. An interrupt-driven DMA disk controller speeds the system's throughput with up to 80 MB's of Winchester storage. An intelligent interrupt-driven I/O controller (with a 256 Byte FIFO buffer on input, and a DMA channel on output) takes the strain off the CPU for I/O, and eliminates any danger of lost characters. The 20-slot bus allows for expansion; • up to 3.3 MB's of directly addressable RAM • Multiple SIO4-DMA boards add four users per slot • Other S-100 peripheral cards may be added for system flexibility.

DUAL DELIVERS

The Dual System 83/ hardware has been designed from the ground up with the Bell UNIX operating system in mind. The System 83/ is no engineering pipe-dream; we've been shipping the power package since February 1982. So, if you've been looking for the missing link between UNIX and the 68000, search no further. For technical information, or a quotation, please call or write to:

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* UNIX is a trademark of Bell Laboratories and is supported on the DUAL System 83 by UniSoft Systems of Berkeley, Ca.

Listing 3 continued:

```
0B94:B1 15           LDA  (TEMP1),Y
0B96:D0 F0           BNE  PRINT0
0B98:A9 01           LDA  #1
0B9A:4C 6C 0B        JMP  ADDATOR
0B9D:              *
0B9D:20 FD FB SLOPRT0 JSR VIDOUT    ;SLOW PRINT
0BA0:A9 01           LDA  #1        ; INPUT TEMP1&2 POINTER TO MESSAGE
0BA2:20 6C 0B        JSR  ADDATOR   ; DESTROYS A,X,Y,TEMP1&2
0BA5:A2 15    SLOPRT LDX  #>TEMP1
0BA7:A0 00           LDY  #$0
0BA9:AD 61 C0        LDA  SW0
0BAC:0D 62 C0        ORA  SW1
0BAF:30 09           BMI  RTSSLP
0BB1:A9 B4           LDA  #180
0BB3:20 A8 FC        JSR  WAIT
0BB6:B1 15           LDA  (TEMP1),Y
0BB8:D0 E3           BNE  SLOPRT0
0BBA:60       RTSSLP RTS
0BBB:              *
0BBB:86 24    RGPRNT STX  CH        ;PRINTS TWO BYTE NUMBER
0BBD:B6 00   RGPRNT1 LDX  0,Y       ; INPUT X TAB
0BBF:86 15           STX  TEMP1     ;        Y POINTS TO NUMBER
0BC1:B6 01           LDX  1,Y       ; DESTROYS A,X,TEMP1,2, &3
0BC3:86 16           STX  TEMP2
0BC5:A2 04           LDX  #4
0BC7:86 17           STX  TEMP3
0BC9:A9 B0   RGPRNT2 LDA  #$B0
0BCB:85 18           STA  TEMP4
0BCD:A5 15   RGPRNT3 LDA  TEMP1
0BCF:DD E0 0C        CMP  NOTAB1,X
0BD2:A5 16           LDA  TEMP2
0BD4:FD E5 0C        SBC  NOTAB2,X
0BD7:90 0D           BCC  RGPRNT4
0BD9:85 16           STA  TEMP2
0BDB:A5 15           LDA  TEMP1
0BDD:FD E0 0C        SBC  NOTAB1,X
0BE0:85 15           STA  TEMP1
0BE2:E6 18           INC  TEMP4
0BE4:D0 E7           BNE  RGPRNT3
0BE6:A5 18   RGPRNT4 LDA  TEMP4
0BE8:E8              INX
0BE9:CA              DEX
0BEA:F0 0C           BEQ  RGPRNT6
0BEC:C9 B0           CMP  #$B0
0BEE:F0 02           BEQ  RGPRNT5
0BF0:85 17           STA  TEMP3
0BF2:24 17   RGPRNT5 BIT  TEMP3
0BF4:30 02           BMI  RGPRNT6
0BF6:A9 A0           LDA  #BLNK
0BF8:20 FD FB RGPRNT6 JSR VIDOUT
0BFB:CA              DEX
0BFC:10 CB           BPL  RGPRNT2
0BFE:60              RTS
0BFF:              *
0BFF:              * PLOTTING ROUTINES
0BFF:              *
0BFF:20 13 0C PLTSCRN JSR CLRSCRN   ;PLOT SCREEN
0C02:20 46 0C        JSR  PLTRAT    ; DESTROYS A,X,Y
0C05:20 9D 0C        JSR  PLTCH
0C08:A0 50           LDY  #DG1
0C0A:20 A8 0C        JSR  PLTDG
0C0D:A0 60           LDY  #DG2
0C0F:20 A8 0C        JSR  PLTDG
0C12:60              RTS
0C13:              *
0C13:A2 00   CLRSCRN LDX  #$0       ;SCREEN CLEAR
0C15:86 15           STX  TEMP1     ; INPUT BGCLR COLOR TO SET SCREEN
0C17:A2 04           LDX  #$4       ; DESTROYS A,X,Y,TEMP1 & 2
0C19:86 16           STX  TEMP2
0C1B:A2 15           LDX  #>TEMP1
0C1D:A0 77    CLRTO6 LDY  #119
0C1F:A5 0A           LDA  BGCLR
0C21:91 15    CLRLNG STA  (TEMP1),Y
0C23:88              DEY
0C24:10 FB           BPL  CLRLNG
0C26:A9 80           LDA  #$80
0C28:20 6C 0B        JSR  ADDATOR
0C2B:A0 06           LDY  #$6
0C2D:C4 16           CPY  TEMP2
0C2F:D0 EC           BNE  CLRTO6
0C31:A0 4F    CLRTO8 LDY  #79
0C33:A5 0A           LDA  BGCLR
0C35:91 15    CLRSHT STA  (TEMP1),Y
0C37:88              DEY
0C38:10 FB           BPL  CLRSHT
0C3A:A9 80           LDA  #$80
0C3C:20 6C 0B        JSR  ADDATOR
0C3F:A0 08           LDY  #$8
0C41:C4 16           CPY  TEMP2
0C43:D0 EC           BNE  CLRTO8
0C45:60              RTS
0C46:              *
0C46:A2 00    PLTRAT LDX  #0        ;READ PADDLES & PLOT RAT
0C48:20 CD 0A        JSR  PDLX      ; INPUT RTCLR COLOR OF RAT
```

Listing 3 continued on page 364

Listing 3 continued:

```
0C4B:85 17           STA   TEMP3
0C4D:A9 29           LDA   #41
0C4F:20 A8 FC        JSR   WAIT
0C52:A2 01           LDX   #1
0C54:20 CD 0A        JSR   PDLX
0C57:85 18           STA   TEMP4
0C59:A6 0D           LDX   RTCLR       ;  PLOT NEW LOCATION
0C5B:86 30           STX   COLOR
0C5D:A4 17           LDY   TEMP3
0C5F:20 00 F8        JSR   PLOT
0C62:A5 18           LDA   TEMP4       ;  COMPARE OLD LOCATION -
0C64:C5 0C           CMP   RTY         ;  IF SAME DON'T ERASE
0C66:D0 04           BNE   PLTRT2      ;  OLD LOCATION
0C68:C4 0B           CPY   RTX
0C6A:F0 13           BEQ   PLTRT3
0C6C:A5 0C     PLTRT2 LDA  RTY         ;  NOT SAME - ERASE
0C6E:A4 0B           LDY   RTX         ;  OLD POSITION
0C70:A6 0A           LDX   BGCLR
0C72:86 30           STX   COLOR
0C74:20 00 F8        JSR   PLOT
0C77:A5 17           LDA   TEMP3
0C79:85 0B           STA   RTX
0C7B:A5 18           LDA   TEMP4
0C7D:85 0C           STA   RTY
0C7F:18        PLTRT3 CLC              ;  ADJUST FOR PADDLE TIME
0C80:A5 0B           LDA   RTX         ;  APPROX 1.5*(P0+P1)
0C82:65 0C           ADC   RTY
0C84:4A              LSR   A
0C85:85 15           STA   TEMP1
0C87:4A              LSR   A
0C88:65 15           ADC   TEMP1
0C8A:20 F0 0A        JSR   TIMER
0C8D:A5 0B           LDA   RTX         ;  HAVE WE GOT CHEESE?
0C8F:C5 0E           CMP   CHX
0C91:D0 09           BNE   PLTRT9
0C93:A5 0C           LDA   RTY
0C95:C5 0F           CMP   CHY
0C97:D0 03           BNE   PLTRT9
0C99:20 2B 0B        JSR   SCORER
0C9C:60        PLTRT9 RTS
0C9D:          *
0C9D:A5 10     PLTCH  LDA  CHCLR       ;PLOT CHEESE
0C9F:85 30           STA   COLOR       ; INPUT CHX,CHY,CHCLR
0CA1:A4 0E           LDY   CHX         ; DESTROYS A,Y
0CA3:A5 0F           LDA   CHY
0CA5:4C 00 F8        JMP   PLOT
0CA8:          *
0CA8:B9 0E 00  PLTDG  LDA  DGICNT,Y    ;PLOT DRAGON
0CAB:F0 2A           BEQ   PLTDG9      ; INPUT Y POINTS TO DRAGON
0CAD:84 17           STY   TEMP3       ; DESTROYS A,X,TEMP1,2&3
0CAF:A2 00           LDX   #0          ; SWITCHES COLORS
0CB1:86 16           STX   TEMP2
0CB3:B6 0B           LDX   DGCLR,Y
0CB5:86 30           STX   COLOR
0CB7:A2 09           LDX   #LDG*2-1
0CB9:86 15           STX   TEMP1
0CBB:B1 15     PLTDG2 LDA  (TEMP1),Y
0CBD:AA              TAX
0CBE:C6 15           DEC   TEMP1
0CC0:B1 15           LDA   (TEMP1),Y
0CC2:A8              TAY
0CC3:8A              TXA
0CC4:20 00 F8        JSR   PLOT
0CC7:A4 17           LDY   TEMP3
0CC9:C6 15           DEC   TEMP1
0CCB:10 EE           BPL   PLTDG2
0CCD:B9 0B 00        LDA   DGCLR,Y
0CD0:B6 0C           LDX   DGCLR+1,Y
0CD2:96 0B           STX   DGCLR,Y
0CD4:99 0C 00        STA   DGCLR+1,Y
0CD7:60        PLTDG9 RTS
0CD8:          *
               ****************************************
0CD8:          *
0CD8:          * DATA
0CD8:          *
               ****************************************
0CD8:          *
0CD8:          *
0CD8:          * SCREEN CLEAR TABLE
0CD8:          *
0CD8:05 0A 14  TIMTAB  DFB  5,10,20,30
0CDB:1E
0CDC:00 22 66  CLRTAB  DFB  $00,$22,$66,$77
0CDF:77
0CE0:          *
0CE0:          * NUMBER CONVERSION TABLES
0CE0:          *
0CE0:01 0A 64  NOTAB1  DFB  $1,$A,$64,$E8,$10
0CE3:E8 10
0CE5:00 00 00  NOTAB2  DFB  $0,$0,$0,$3,$27
0CE8:03 27
0CEA:          *
0CEA:          * COMPLICATIONS TABLE
```

Listing 3 continued on page 366

Listing 3 continued:

```
0CEA:                 *
0CEA:5E 14        SCOTAB DFB  DG1+DGICNT,20 ;DRAGON 1
0CEC:5E 0A               DFB  DG1+DGICNT,10 ;SPEED IT UP
0CEE:5B 99               DFB  DG1+DGCLR,$99 ;FLASH IT
0CF0:6E 14               DFB  DG2+DGICNT,20 ;DRAGON 2
0CF2:12 80               DFB  CHICNT,128 ;CHEESE MOVES
0CF4:5F 0A               DFB  DG1+DGRAD,10 ;DG1 STAYS CLOSE
0CF6:6E 0A               DFB  DG2+DGICNT,10 ;DG2 MOVES FASTER
0CF8:6B CC               DFB  DG2+DGCLR,$CC ;DG2 FLASHES
0CFA:5E 05               DFB  DG1+DGICNT,5 ;DG1 MOVES FASTER
0CFC:12 0A               DFB  CHICNT,10 ;CHEESE MOVES FASTER
0CFE:D4 C8 C5     TITLE  ASC  "THE"
0D01:8D                  DFB  CR
0D02:C7 C1 CD            ASC  "GAME"
0D05:C5
0D06:8D                  DFB  CR
0D07:CF C6               ASC  "OF"
0D09:8D                  DFB  CR
0D0A:D2 C1 D4            ASC  "RAT"
0D0D:8D                  DFB  CR
0D0E:A6                  ASC  "&"
0D0F:8D                  DFB  CR
0D10:C4 D2 C1            ASC  "DRAGON"
0D13:C7 CF CE
0D16:8D 00               DFB  CR,$0
0D18:D4 D2 D5            ASC  "TRUCK    SMITH"
0D1B:C3 CB A0
0D1E:D3 CD C9
0D21:D4 C8
0D23:8D                  DFB  CR
0D24:B2 AF B1     DATIM  ASC  "2/13/82  1342"
0D27:B3 AF B8
0D2A:B2 A0 B1
0D2D:B3 B4 B2
0D30:8D 00               DFB  CR,$0
0D32:D4 C8 C9            ASC  "THIS     IS A CHASE GAME"
0D35:D3 A0 C9
0D38:D3 A0 C1
0D3B:A0 C3 C8
0D3E:C1 D3 C5
0D41:A0 C7 C1
0D44:CD C5
0D46:8D                  DFB  CR
0D47:C9 CE D6            ASC  "INVOLVING A RAT, A DRAGON,"
0D4A:CF CC D6
0D4D:C9 CE C7
0D50:A0 C1 A0
0D53:D2 C1 D4
0D56:AC A0 C1
0D59:A0 C4 D2
0D5C:C1 C7 CF
0D5F:CE AC
0D61:8D                  DFB  CR
0D62:C1 CE C4            ASC  "AND      AN UNLIMITED SUPPLY OF"
0D65:A0 C1 CE
0D68:A0 D5 CE
0D6B:CC C9 CD
0D6E:C9 D4 C5
0D71:C4 A0 D3
0D74:D5 D0 D0
0D77:CC D9 A0
0D7A:CF C6
0D7C:8D                  DFB  CR
0D7D:C3 C8 C5            ASC  "CHEESE."
0D80:C5 D3 C5
0D83:AE
0D84:8D 8D               DFB  CR,CR
0D86:D9 CF D5            ASC  "YOU      CONTROL THE RAT (THE"
0D89:A0 C3 CF
0D8C:CE D4 D2
0D8F:CF CC A0
0D92:D4 C8 C5
0D95:A0 D2 C1
0D98:D4 A0 A8
0D9B:D4 C8 C5
0D9E:8D                  DFB  CR
0D9F:C2 D2 CF            ASC  "BROWN    SQUARE) WITH THE"
0DA2:D7 CE A0
0DA5:D3 D1 D5
0DA8:C1 D2 C5
0DAB:A9 A0 D7
0DAE:C9 D4 C8
0DB1:A0 D4 C8
0DB4:C5
0DB5:8D                  DFB  CR
0DB6:C7 C1 CD            ASC  "GAME     PADDLES."
0DB9:C5 A0 D0
0DBC:C1 C4 C4
0DBF:CC C5 D3
0DC2:AE
0DC3:8D 8D               DFB  CR,CR
0DC5:D4 C8 C5            ASC  "THE      DRAGON (WHICH IS RED)"
0DC8:A0 C4 D2
0DCB:C1 C7 CF
```

Listing 3 continued on page 371

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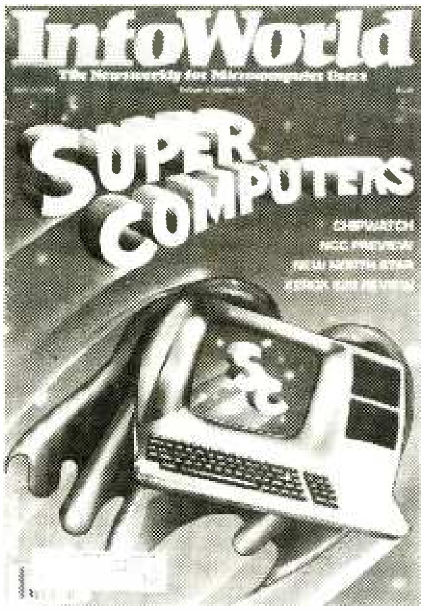

All quotes are from InfoWorld's Perfect Writer software review, by John Ford, June 14, 1982.

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Listing 3 continued:

```
0DCE:CE A0 A8
0DD1:D7 C8 C9
0DD4:C3 C8 A0
0DD7:C9 D3 A0
0DDA:D2 C5 C4
0DDD:A9
0DDE:8D              DFB   CR
0DDF:C9 D3 A0        ASC   "IS        CHASING YOU."
0DE2:C3 C8 C1
0DE5:D3 C9 CE
0DE8:C7 A0 D9
0DEB:CF D5 AE
0DEE:8D 8D           DFB   CR,CR
0DF0:D9 CF D5        ASC   "YOUR      OBJECTIVE IS TO EAT"
0DF3:D2 A0 CF
0DF6:C2 CA C5
0DF9:C3 D4 C9
0DFC:D6 C5 A0
0DFF:C9 D3 A0
0E02:D4 CF A0
0E05:C5 C1 D4
0E08:8D              DFB   CR
0E09:C1 D3 A0        ASC   "AS        MUCH CHEESE (YELLOW"
0E0C:CD D5 C3
0E0F:C8 A0 C3
0E12:C8 C5 C5
0E15:D3 C5 A0
0E18:A8 D9 C5
0E1B:CC CC CF
0E1E:D7
0E1F:8D              DFB   CR
0E20:D3 D1 D5        ASC   "SQUARES) AS YOU CAN WHILE"
0E23:C1 D2 C5
0E26:D3 A9 A0
0E29:C1 D3 A0
0E2C:D9 CF D5
0E2F:A0 C3 C1
0E32:CE A0 D7
0E35:C8 C9 CC
0E38:C5
0E39:8D              DFB   CR
0E3A:C1 D6 CF        ASC   "AVOIDING THE DRAGON."
0E3D:C9 C4 C9
0E40:CE C7 A0
0E43:D4 C8 C5
0E46:A0 C4 D2
0E49:C1 C7 CF
0E4C:CE AE
0E4E:8D 8D           DFB   CR,CR
0E50:D9 CF D5        ASC   "YOUR      TIME LIMIT: 60 SECONDS."
0E53:D2 A0 D4
0E56:C9 CD C5
0E59:A0 CC C9
0E5C:CD C9 D4
0E5F:BA A0 B6
0E62:B0 A0 D3
0E65:C5 C3 CF
0E68:CE C4 D3
0E6B:AE
0E6C:8D 8D           DFB   CR,CR
0E6E:C1 A0 D7        ASC   "A         WARNING - IF YOU GET TOO"
0E71:C1 D2 CE
0E74:C9 CE C7
0E77:A0 AD A0
0E7A:C9 C6 A0
0E7D:D9 CF D5
0E80:A0 C7 C5
0E83:D4 A0 D4
0E86:CF CF
0E88:8D              DFB   CR
0E89:C7 CF CF        ASC   "GOOD,     THE DRAGON MAY SEND"
0E8C:C4 AC A0
0E8F:D4 C8 C5
0E92:A0 C4 D2
0E95:C1 C7 CF
0E98:CE A0 CD
0E9B:C1 D9 A0
0E9E:D3 C5 CE
0EA1:C4
0EA2:8D              DFB   CR
0EA3:C6 CF D2        ASC   "FOR       REINFORCEMENTS."
0EA6:A0 D2 C5
0EA9:C9 CE C6
0EAC:CF D2 C3
0EAF:C5 CD C5
0EB2:CE D4 D3
0EB5:AE
0EB6:8D 8D           DFB   CR,CR
0EB8:C1 D4 A0        ASC   "AT        ANY TIME, IF YOU WISH TO"
0EBB:C1 CE D9
0EBE:A0 D4 C9
0EC1:CD C5 AC
0EC4:A0 C9 C6
0EC7:A0 D9 CF
0ECA:D5 A0 D7
```

Listing 3 continued on page 372

Listing 3 continued:

```
0ECD:C9 D3 C8
0ED0:A0 D4 CF
0ED3:8D          858           DFB  CR
0ED4:D1 D5 C9    859           ASC  "QUIT,    HIT THE ESC KEY."
0ED7:D4 AC A0
0EDA:C8 C9 D4
0EDD:A0 D4 C8
0EE0:C5 A0 C5
0EE3:D3 C3 A0
0EE6:CB C5 D9
0EE9:AE
0EEA:8D 8D       860           DFB  CR,CR
0EEC:C9 C6 A0    861           ASC  "IF       YOU FEEL YOU ARE READY,"
0EEF:D9 CF D5
0EF2:A0 C6 C5
0EF5:C5 CC A0
0EF8:D9 CF D5
0EFB:A0 C1 D2
0EFE:C5 A0 D2
0F01:C5 C1 C4
0F04:D9 AC
0F06:8D          862           DFB  CR
0F07:D0 D5 D3    863           ASC  "PUSH     EITHER ONE OF THE"
0F0A:C8 A0 C5
0F0D:C9 D4 C8
0F10:C5 D2 A0
0F13:CF CE C5
0F16:A0 CF C6
0F19:A0 D4 C8
0F1C:C5
0F1D:8D          864           DFB  CR
0F1E:D0 C1 C4    865           ASC  "PADDLE   BUTTONS."
0F21:C4 CC C5
0F24:A0 C2 D5
0F27:D4 D4 CF
0F2A:CE D3 AE
0F2D:00          866           DFB  $0
0F2E:D3 C3 CF    867 TSCORE    ASC  "SCORE"
0F31:D2 C5
0F33:00          868           DFB  $0
0F34:D4 C9 CD    869           ASC  "TIME"
0F37:C5
0F38:00          870           DFB  $0
0F39:D9 CF D5    871 TTMOUT    ASC  "YOUR     TIME RAN OUT"
0F3C:D2 A0 D4
0F3F:C9 CD C5
0F42:A0 D2 C1
0F45:CE A0 CF
0F48:D5 D4
0F4A:8D 00       872           DFB  CR,$0
0F4C:D4 C8 C5    873 TDGGOT    ASC  "THE      DRAGON CAUGHT YOU"
0F4F:A0 C4 D2
0F52:C1 C7 CF
0F55:CE A0 C3
0F58:C1 D5 C7
0F5B:C8 D4 A0
0F5E:D9 CF D5
0F61:8D 00       874           DFB  CR,$0
0F63:D9 CF D5    875 TYSC      ASC  "YOUR     SCORE "
0F66:D2 A0 D3
0F69:C3 CF D2
0F6C:C5 A0
0F6E:00          876           DFB  $0
0F6F:AC A0 C8    877 THSC      ASC  ",        HIGH SCORE "
0F72:C9 C7 C8
0F75:A0 D3 C3
0F78:CF D2 C5
0F7B:A0
0F7C:00          878           DFB  $0
0F7D:D0 D5 D3    879 TPUSH     ASC  "PUSH     EITHER BUTTON TO PLAY AGAIN"
0F80:C8 A0 C5
0F83:C9 D4 C8
0F86:C5 D2 A0
0F89:C2 D5 D4
0F8C:D4 CF CE
0F8F:A0 D4 CF
0F92:A0 D0 CC
0F95:C1 D9 A0
0F98:C1 C7 C1
0F9B:C9 CE
0F9D:00          880           DFB  $0

 0B6C ADDATOR      0A BGCLR        A0 BLNK         10 CHCLR
   11 CHCNT      0919 CHEESE2      12 CHICNT     0852 CHKBTN
 094D CHKTIM       0F CHY          24 CH           0E CHX
 0AE4 CLICK      0C21 CLRLNG     0C13 CLRSCRN    0C35 CLRSHT
 0CDC CLRTAB     0C1D CLRTO6     0C31 CLRTO8       30 COLOR
   8D CR           25 CV        ?0D24 DATIM      0A7F DELAY1
 0A7E DELAY        50 DG1          60 DG2        096B DGBITE
   0B DGCLR        0D DGCNT        0A DGH          0E DGICNT
   0F DGRAD      09A7 ENDGME2    09AF ENDGME3    0979 ENDGME
   9B ESC          08 HISCO      FC58 HOME       C000 KBD
?C010 KBDSTRB      05 LDG        08F9 MAINLP     C053 MIXSET
 0AD7 MPY125     09D2 MVECH2     09D7 MVECH3     09C2 MVECH
 0A01 MVEDG2     0A02 MVEDG3     0A12 MVEDG4     0A13 MVEDG5
```

Listing 3 continued:

```
0A22 MVEDG6     0A35 MVEDG7     09DA MVEDG      0A4C MVEDG8
0844 NEWGAME    0CE0 NOTAB1     0CE5 NOTAB2       13 PDL
0ACD PDLX       F800 PLOT       0C9D PLTCH      0CBB PLTDG2
0CA8 PLTDG      0CD7 PLTDG9     0C46 PLTRAT     0C6C PLTRT2
0C7F PLTRT3     0C9C PLTRT9     0BFF PLTSCRN    FB1E PREAD
0B88 PRINT0     0B90 PRINT      084C RANDOM     092F RAT
0BC9 RGPRNT2    0BE6 RGPRNT4    0BBB RGPRNT     0BBD RGPRNT1
0BCD RGPRNT3    0BF2 RGPRNT5    0BF8 RGPRNT6    0A89 RND40
  4E RND        0A93 RNDNG      0AA5 RNDNG1     0AB8 RNDNG2
  0D RTCLR      0BBA RTSSLP       0B RTX          0C RTY
  06 SCORE      0B6B SCORER9    0B2B SCORER     0CEA SCOTAB
  04 SECS       0883 SETDGXY    FB39 SETTXT     FB4B SETWND
0B9D SLOPRT0    0BA5 SLOPRT     C030 SPKR       0B78 SUBATOR
C061 SW0        C062 SW1        0A61 TARGET2    0A6F TARGET3
0A7D TARGET9    0A57 TARGET     0F4C TDGGOT       15 TEMP1
  16 TEMP2        17 TEMP3        18 TEMP4      0F6F THSC
  00 TIME         02 TIME0      0B18 TIMER1     0B27 TIMER2
0B2A TIMER9     0AF0 TIMER      0CD8 TIMTAB     0CFE TITLE
0F7D TPUSH      0F2E TSCORE     0F39 TTMOUT     C050 TXTCLR
0F63 TYSC       FBFD VIDOUT     FC22 VTAB       FCA8 WAIT
  20 WNDLFT       21 WNDWDTH

  00 TIME         02 TIME0        04 SECS         05 LDG
  06 SCORE        08 HISCO        0A BGCLR        0A DGH
  0B DGCLR        0B RTX          0C RTY          0D DGCNT
  0D RTCLR        0E DGICNT       0E CHX          0F CHY
  0F DGRAD        10 CHCLR        11 CHCNT        12 CHICNT
  13 PDL          15 TEMP1        16 TEMP2        17 TEMP3
  18 TEMP4        20 WNDLFT       21 WNDWDTH      24 CH
  25 CV           30 COLOR        4E RND          50 DG1
  60 DG2          8D CR           9B ESC          A0 BLNK
0844 NEWGAME    084C RANDOM     0852 CHKBTN     0883 SETDGXY
08F9 MAINLP     0919 CHEESE2    092F RAT        094D CHKTIM
096B DGBITE     0979 ENDGME     09A7 ENDGME2    09AF ENDGME3
09C2 MVECH      09D2 MVECH2     09D7 MVECH3     09DA MVEDG
0A01 MVEDG2     0A02 MVEDG3     0A12 MVEDG4     0A13 MVEDG5
0A22 MVEDG6     0A35 MVEDG7     0A4C MVEDG8     0A57 TARGET
0A61 TARGET2    0A6F TARGET3    0A7D TARGET9    0A7E DELAY
0A7F DELAY1     0A89 RND40      0A93 RNDNG      0AA5 RNDNG1
0AB8 RNDNG2     0ACD PDLX       0AD7 MPY125     0AE4 CLICK
0AF0 TIMER      0B18 TIMER1     0B27 TIMER2     0B2A TIMER9
0B2B SCORER     0B6B SCORER9    0B6C ADDATOR    0B78 SUBATOR
0B88 PRINT0     0B90 PRINT      0B9D SLOPRT0    0BA5 SLOPRT
0BBA RTSSLP     0BBB RGPRNT     0BBD RGPRNT1    0BC9 RGPRNT2
0BCD RGPRNT3    0BE6 RGPRNT4    0BF2 RGPRNT5    0BF8 RGPRNT6
0BFF PLTSCRN    0C13 CLRSCRN    0C1D CLRT06     0C21 CLRLNG
0C31 CLRT08     0C35 CLRSHT     0C46 PLTRAT     0C6C PLTRT2
0C7F PLTRT3     0C9C PLTRT9     0C9D PLTCH      0CA8 PLTDG
0CBB PLTDG2     0CD7 PLTDG9     0CD8 TIMTAB     0CDC CLRTAB
0CE0 NOTAB1     0CE5 NOTAB2     0CEA SCOTAB     0CFE TITLE
?0D24 DATIM     0F2E TSCORE     0F39 TTMOUT     0F4C TDGGOT
0F63 TYSC       0F6F THSC       0F7D TPUSH      C000 KBD
?C010 KDBSTRB   C030 SPKR       C050 TXTCLR     C053 MIXSET
C061 SW0        C062 SW1        F800 PLOT       FB1E PREAD
FB39 SETTXT     FB4B SETWND     FBFD VIDOUT     FC22 VTAB
FC58 HOME       FCA8 WAIT
```

Text continued from page 347:

illusion. With everything from the instructions to the display of the characters, the little touches heighten the game's quality. For example, in the instructions for Space Invaders, a letter Y is printed upside-down and an invader rushes out, drags the offending Y off the screen, and returns with a right-side-up Y as a replacement. In Pac-Man, each monster is given a slightly humorous name. Each of these ploys helps the player to become more involved in the world of the game.

In developing Rat and Dragon, I spent considerable time on the instructions—not in programming them, which was easy, but in writing them, laying them out on the screen, and making sure of their clarity. The result of this work is a feeling of high quality from the very start of the program. I even wrote a special routine to print the instructions slowly, letter by letter. Experienced players can bypass the instructions by pushing the paddle button to start play.

Lots of colors and fantastic details in your characters are not always necessary. If you try for a realistic look but can't quite bring it off, your game may suffer. Most game players accept a simple representation of the game's idea as believable. Space Invaders sold worldwide in its original one-color version. Pac-Man, for all its bright colors, gets by with very simple monsters and an even simpler Pac-Man. In both games the basic idea, the complications, and other small touches, not the details of the animation, make the illusion believable.

The screen display serves a dual function. Like the timing, it should be subtle enough not to detract from the believability of the illusion and sufficiently exciting to make people looking over the shoulder of the player want to play.

In Rat and Dragon the display is very simple: a colored background (the color indicates how much time remains), colored squares for the rat and the cheese, and two flashing dragons, one red and one green. The program handles all the animation, except that of the dragons, by plotting the new location before erasing the old one to achieve continuity of movement. The program also avoids screen flicker by erasing and replotting the rat and cheese only if movement occurs. The dragons are replotted fully every time, alternating between shades of red or green, to get the flashing effect.

Perhaps nothing is more frustrating to game players than to have a program end because they hit a key accidentally. The Rat and Dragon program can be stopped only by hitting the Reset or Escape keys. Another nice feature of the program is that it ensures variation in the game by using a different series of random numbers (affecting the placement of the cheese) for each play.

Such distinctive features are often overlooked because all the designer's effort is directed to other aspects of the game. These details, however, seem to make the difference between a popular game and one that gathers dust on the shelf.

Summary

When you decide to take a trip, it helps to have a good idea of where you're going. This is also true when you design a computer game; there's room for experimentation and detour along the way, but you must have a destination in mind.

The basic game framework starts with your idea stated as a simple goal with simpler objectives. Add complications only as necessary to keep the game exciting, but remember that some complications are needed to keep the players' interest.

Smooth play is crucial to the success of your game. Timing both determines the smoothness of play and maintains the illusion of the game. Your programming effort is better spent in making the game play smoothly and adding well-planned complications than in prettying up the animation, for while it is the screen display that attracts new players, it is the overall quality of the game design and implementation that brings the players back. ■

The author has offered to make copies of his program available to BYTE readers for $8. Send a blank disk and a self-addressed stamped envelope to:

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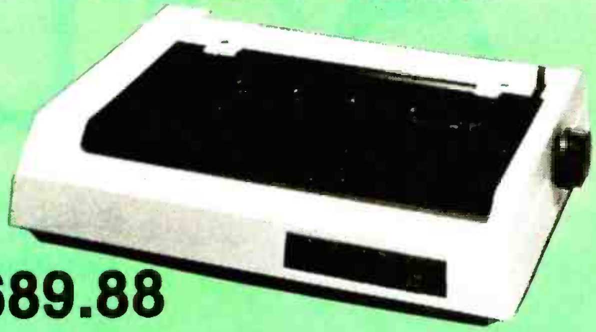

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An Introduction to the Human Applications Standard Computer Interface

Part 2: Implementing the HASCI Concept

The details of an easy-to-use, consumer-quality computer console are discussed.

Chris Rutkowski
Rising Star Industries
24050 Madison St., Suite 113
Torrance, CA 90505

Will personal computers ever be as common as typewriters or automobiles? We learned last month that for the computer to evolve into a consumer product it must be both *useful* and *usable*; that is, it must be capable of improving the general quality of life and be convenient and easy to use.

The Human Applications Standard Computer Interface (HASCI) was designed to meet these requirements. Part 1 of this two-part article explained the theory and principles behind the development of the HASCI interface. This month I'll describe specific details of the interface, starting with a common feature of easy-to-use computer systems—the menu.

All patents, copyrights, etc. are the property of the Rising Star Foundation, a nonprofit research corporation. For further information contact the Rising Star Foundation, 24050 Madison St., Suite 113, Torrance, CA 90505.

Menus present an exceptionally easy way of introducing the newcomer to the operation of a system. They tend to fail, however, on two points: first, some designers create unwieldy menus by trying to throw in everything but the kitchen sink; second, they provide no alternative for experienced users who eventually learn the menus cold and find it irritating to have to wait for each menu to appear.

In the HASCI scheme, the problem of cumbersome menus is eliminated by treating the entire computer system as a series of interconnected choices in an inverted tree of decisions. Each branch of the tree represents a possible function that the computer can perform for you. Also, in virtually all cases, the number of choices in a menu is kept below eight. This number of choices has proven to be a perceptual limit for understandability.

The problem of menus that make you wait is solved by allowing you to input menu selections as fast as you can make them; thus, the tedium of sitting through long, familiar menus is entirely eliminated.

The Choices

When dealing with HASCI, as with any computer system, your first choice is whether or not you want to use the computer. If you do, you must of course turn the machine on. When power is first applied, the system comes up automatically as a word processor—you needn't access the operating system.

Figure 2 illustrates the controls of the HASCI keyboard, which are divided into seven main groups of keys. Of these, the following three groups are typical of many contemporary keyboards in their configuration and layout:

- typing keys
- editing and cursor-movement keys
- the numeric keypad

The remaining four groups take the

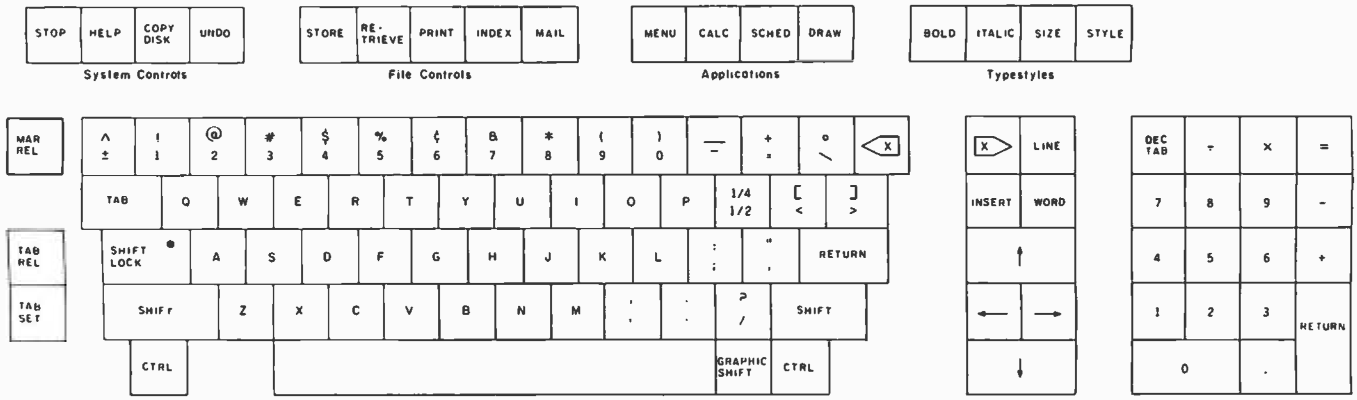

Figure 2: *The HASCI keyboard is a link between the user as intellect and the computer as tool. The interface of a computer is essentially the "handle" of the tool. All controls are clearly labeled so that the average person can correctly guess their intended functions.*

place of programmable-function keys (which have always had such clever names as F1, F2, F3, and so on). These groups give you access to the most essential functions of the system:

- system controls
- file controls
- application controls
- typestyle controls

Each of these four groups is clearly labeled on the keyboard itself. In contrast, the first three groups are self-explanatory and are not labeled.

This arrangement of the keyboard provides the first menu level of the system: you choose the *group* whose function title (or self-evident application) most closely matches your needs.

People should be able to guess which group, and which key within each group, performs any given function. The titles of the groups and the individual keys on the HASCI keyboard have been chosen to facilitate this capability. (The keyboard has been tested on a large number of people unfamiliar with computers; virtually everyone was able to correctly guess the intended function of each key the first time.) In addition, after selecting any given key, the effect on the system is immediately obvious. And, if all else fails, the HASCI system has a Help key. Thus the HASCI system is nearly manual-independent.

The second menu level involves choosing an individual key from among the seven groups on the keyboard. As mentioned before, the keys of the first three groups are already fairly familiar. Of greater interest are the individual keys of the four function control groups.

The System Controls

The four system controls affect the execution of a system program already in progress:

Stop takes the place of more usual Pause and Break keys. When pressed, it effectively halts system execution and asks if you wish to stop or continue.

Help provides you with specific information relating to the nature of the choices available at any point in the decision tree. Your options are explained in some detail. Additionally, you may access information about any specific function.

Copydisk lets you do just that: copy a disk. (We didn't use a Backup key because inexperienced computer users expected Backup to make the machine go backward.) Although Copydisk is a fundamentally necessary function in any floppy-disk-based system, this key might not be used in other implementations of HASCI.

Undo is an "undecide" key. At any point, virtually any decision can be undone with this key. It protects you from accidental deletions and also allows you to skip rapidly back up a menu tree.

The File Controls

File controls allow you to easily manipulate your files (i.e., the places where your documents are kept):

Store places a document you've created into the mass storage files.

Retrieve is the complement of Store. It allows you to procure a specific document for further symbol manipulation.

Print allows you to print the contents of any document on the system printer. Numerous print-time options are provided.

Index may be the most novel and useful key on the machine. It displays an index of all files in the system. All files are filed by date and time or sequence of creation. This information is automatically assigned by the system. The name of the file or index reference is requested by the computer in response to the Store command; you may specify a reference of up to eight words in length. When Index is pressed, you are offered three choices. You may view the index (1) sequentially by date and time of creation; (2) alphabetically by index reference; or (3) alphabetically cross-indexed, with every word in each reference cross-referenced to every other word. (This is exactly what most people wish they could do with their manual systems.)

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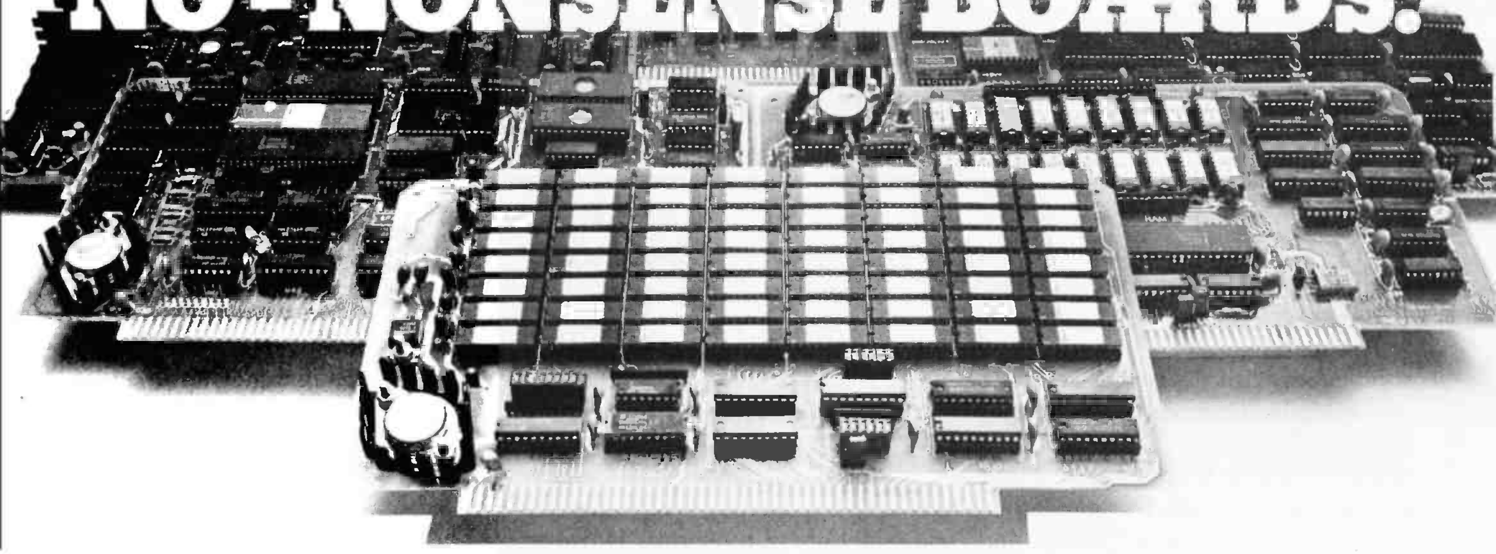

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The Applications Keys

The applications keys cover the entire family of symbol processors. If you recall from Part 1, a computer is basically a symbol manipulator, and there are four kinds of symbols that we need to manipulate: words and letters, numbers, graphic symbols, and the temporal relationships among these symbols (time).

The manipulation of words is accomplished with the typing keys and is essentially self-evident. Of the four keys in this group, three are dedicated to the remaining symbol types. These keys are labeled Calc (for calculator), Draw (for graphics utilities), and Sched (for schedule).

The nature of each of these programs is flexible: while a four-function calculator may be enough for me, you may require a sophisticated scientific processor, and a spreadsheet calculator may be ideal for someone else. Likewise, some people have simple appointment-scheduling needs while others require complicated systems such as the Performance Evaluation Review Technique (PERT) or the Critical-Path Method (CPM). The same is true for the Draw utility. Thus, no standard exists for these functions. However, HASCI standardizes the means by which one enters and departs from any symbol processor.

We didn't use a Backup key because inexperienced computer users expected it to make the machine go backward.

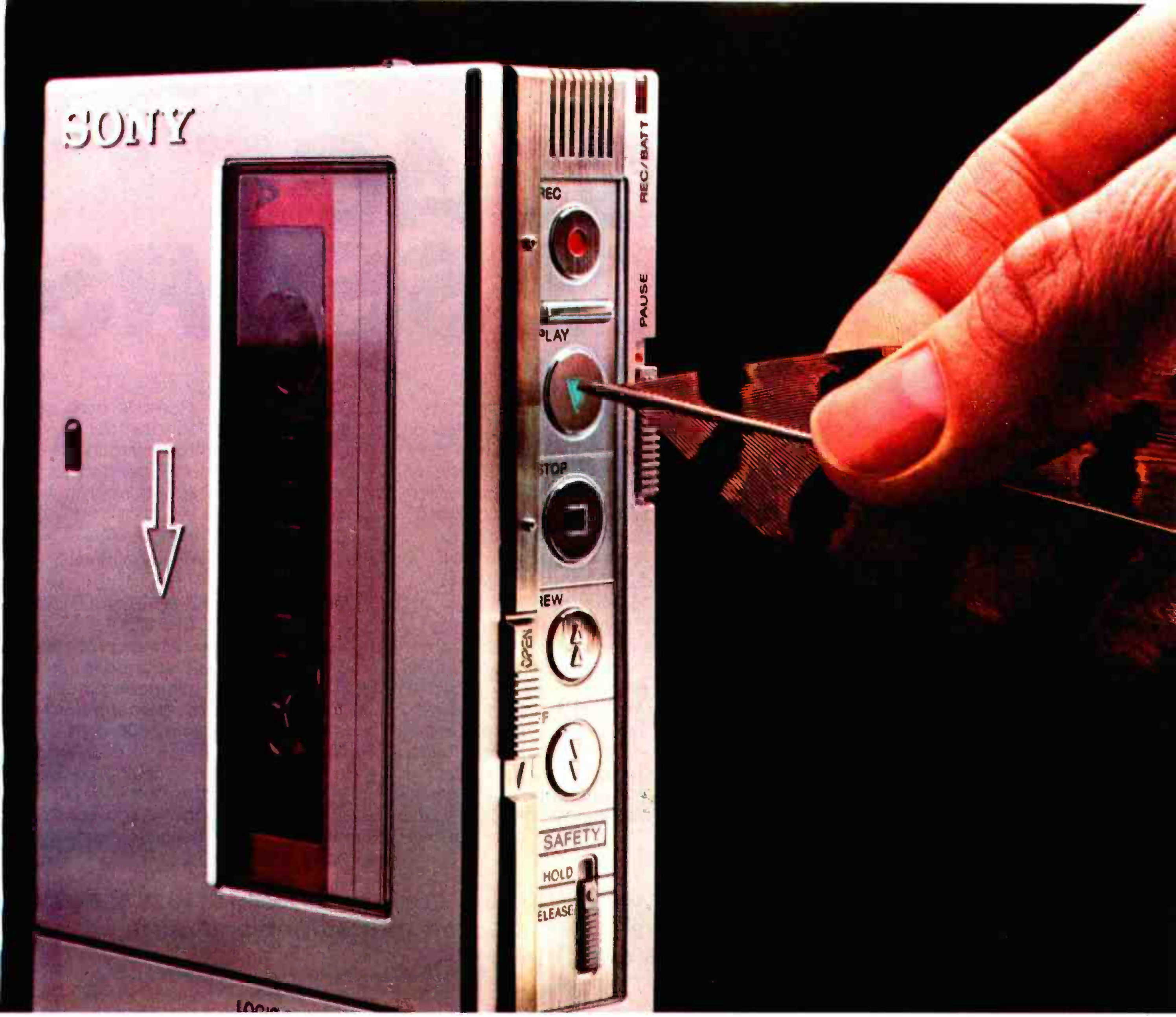
You switch from one application type to another by pressing the appropriate key. On larger systems these keys would have indicator lights to show when they were selected. The selection would also be clearly indicated on the screen.

The fourth key of this group is labeled Menu. As you might guess, it is the garbage can; everything else is found there: languages, utilities, *all* the stuff that normally clutters up a directory listing. Ideally, any programs resident on the particular operating system that had not been converted to use the functions and protocols of HASCI would appear under Menu. In other words, a HASCI system running over CP/M should be capable of running any standard CP/M software. The same would be true for a system running Unix or any other operating system.

The Typestyle Keys

You can alter the symbol type style displayed on the screen in alphanumerics by using one of the four typestyle control keys: Italic, Bold, Size, and Style.

The Italic and Bold keys operate immediately. If either key is pressed



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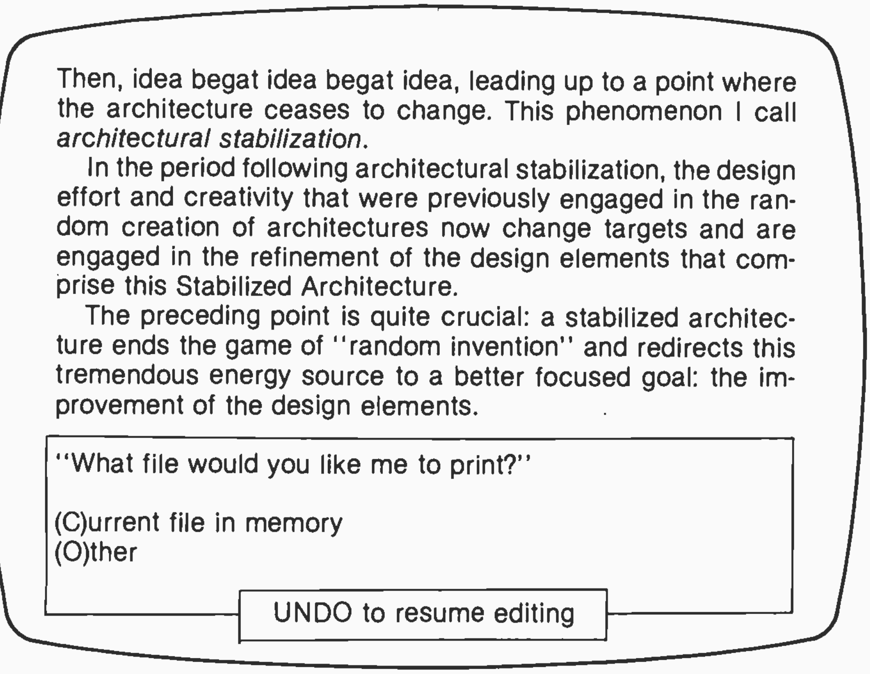

Figure 3: *The HASCI screen is divided into three parts: (1) the document window, which contains the document being observed or manipulated, (2) the interaction window, wherein the system and the user exchange information and requests (here the system is showing the first menu after the PRINT button is pressed), and (3) the prompt window, wherein the system can place reminders about basic functions.*

while typing, all subsequent text entered will assume that type style. Pressing the key again reverts to the previous type style. The Size and Style keys access menus that allow you to select from whatever choices are supported by the terminal and printer used. In regard to Style, a machine must have at least one font; however, two (one serif and one sans-serif font) would be desirable.

The Third Menu Level

The third menu level occurs after a function has been selected by pressing its key. In some cases, there is no third level: the functions act immediately. Examples include the cursor keys and the Italic and Undo keys. Other keys may have one or more levels of menu existing beyond the keyboard. These levels are indicated on the display screen.

Screen Standardization

The screen layout should be essentially identical from menu to menu and present all necessary information in an easy-to-understand manner. The HASCI screen (see figure 3) is divided into three *windows*, each of which contains a specific type of information.

The *document window* contains the main document, which holds the symbols under inspection or manipulation. When the machine is first powered up, the display resembles that of a word processor—the document window fills the screen.

The document window may contain visual devices to simplify the manipulation of the symbol type in question. In the case of a word processor, this window contains a *ruler line*, which marks column positions, shows current column position, shows tab settings, and so forth. The window also contains a status line showing the name of the document under inspection along with more mundane items such as date and time.

When you're browsing through a file, examining a directory, or performing some similar task where you may wish to select from among many choices, the document being examined for these choices (for example, an index) would appear in the document window. If you are to make a

A Short History of the Keyboard

by Phil Lemmons
West Coast Editor

Keyboards are meant to let our fingers do the talking, but more often they make us swear aloud. Every manufacturer seems to want its keyboard to be unmistakably different from any other. The only keys that seem to be sacred and immovable are badly placed: the familiar QWERTYUIOP and its companion rows of the alphabet. The Shift and Return keys occasionally stray, and the control keys and function keys wander from one end of the keyboard to the other. Perhaps most puzzling of all, the placement of the cursor keys is not yet standardized in the most logical configuration, with the "up" key above, the "down" key below, the "left" key at the left, and the "right" key at the right. Let's hope that Chris Rutkowski's efforts to organize the placement of the most common control functions in sensible groupings will be a major step toward standardization.

If you think it's hard to adjust to a new keyboard now, though, consider the situation 80 to 90 years ago. The Gay Nineties were nightmarish for office temps. They would never know what keyboard was waiting at their next assignment. Oh, the QWERTYUIOP keyboard was around, all right, but it was only one among a hundred. Almost every company that made a typewriter used a different keyboard. Typewriters of the time (and their top-row key arrangements) included the Crandall (ZPRCHMI), the American (CJPFUBL), the Hall (KBFGNIA), the Columbia (ZKPWMCR), the Morris (XVGWSLZ), and so on, ad nauseam.

Most of the early keyboards seemed to have totally random key arrangements, but a few designs represented attempts at some sort of order. Some keyboards put T, H, and E near one another, for example, on the theory that "the" has to be typed perhaps more often than any other word. Similarly, the World typewriter keyboard put A, N, and D together, and the Edison Mimeograph typewriter grouped not only A, N, and D, and T, H, and E, but also O and F and I, N, and G.

But there's more to a keyboard than how you label the keys. Keyboards in the 1890s differed greatly in how many keys they had, how many rows of keys, and how the rows were arranged. Part of the problem was that many keyboards still lacked a shift key. Today it's hard to conceive of a typewriter without a shift key, but the idea didn't occur to anyone until Byron A. Brooks thought of it in 1875.

"Too complicated!" many people complained.

"Too tiring for the operator!" others insisted.

Such reactions prolonged the survival of some interesting mutant keyboards. The Caligraph, for example, had a circular keyboard and no shift key; all the small letters were grouped in the center and surrounded by all the capital letters, with no apparent correspondence between the arrangements of the two sets of letters. The Imperial Model B had three semicircular rows of 10 keys each, arranged in an arc convex to the typist—the central keys were nearest and the outer keys farthest from the fingertips (apparently it was designed for a typist whose outer fingers were longer than the inner ones); the layout included a shift key and a space bar, and the top row of keys read ZHJAYSCPG. Compared to the Imperial, the Hartford keyboard almost seemed to make sense: it had six straight rows of keys, no shift key, and a separate key for each small and capital letter, with identical rows of keys for both cases. The Yost keyboard, like the Imperial, had all the small letters arranged on the lower rows and all the capital letters in the same pattern in the upper rows; but the Yost had eight rows of keys instead of six. The Saturn keyboard had only one straight, very long row of keys. The Hammond had two semicircular rows, the Salter had three such rows, and the Kanzler had four gently arced rows.

One keyboard of the 1890s, the Ideal, seemed to make more sense than the others. The idea behind the Ideal keyboard was that more than 70 percent of all English words are made up of the letters DHIATENSOR; therefore, placing all these keys in one row should make typing more efficient. Some major companies adopted the Ideal keyboard, including the maker of the best typing machine of the day, the renowned Blickensderfer. (Blickensderfer's engineering prowess was such that, in 1902, it was producing an electric typewriter that used a type wheel much like the modern IBM Selectric "golf ball" or the daisy wheel.) But the Ideal keyboard, despite being as sound as a Blickensderfer, lost out to an inferior competitor, our familiar QWERTYUIOP (also known as the Universal keyboard).

By 1943, when Dr. August Dvorak proposed a clearly superior keyboard, the QWERTYUIOP keyboard had become too deeply entrenched to be easily overthrown. Dvorak's idea was to place the five vowels under the fingers of the left hand and the five most common consonants under the fingers of the right. The row of keys that resulted was AOEUIDHTNS.

Dvorak's keyboard is not the only so-called reform keyboard. The idea behind most of the reforms is to put the most common letters in easiest reach of the strongest fingers and to put the most frequenctly combined letters under the control of opposite hands. To make typing "the" faster, for example, a keyboard might put T on the right side, H on the left side, and E on the right side of the keyboard. Note that the Dvorak keyboard doesn't arrange these three letters in that way, which only proves that Dvorak wasn't trying to optimize the keyboard for typing "the."

Michael H. Adler, author of The Writing Machine *(London: George Allen & Unwin, 1973), argues persuasively for a new standard keyboard that puts the 10 most common letters, ETAONIRSHD, on a single row curved in such a way that each of the 10 fingers (thumbs included) rests comfortably on one of the keys. Our thumbs now spend most of their time lolling on the space bar; Adler delegates the space bar, the shift key,* *and the carriage return to the feet, freeing the thumbs for a higher destiny. This somewhat piano-like arrangement should result in much faster typing. As Adler points out, "After all, . . . a pianist can comfortably handle over 1500 to 2000 keystrokes a minute (the equivalent of 300 to 400 words per minute) on a much less compact keyboard than the one described, and without trying to break world speed records, either."*

The Battle of the Numeric Pads

Many of today's keyboards have numeric keypads—groupings of keys separate from the main alphabetic grouping—to help typists enter numbers more quickly. The numerals on the main keyboard are, of course, laid out in a single horizontal row above the QWERTYUIOP row of letters. Using the main keyboard to enter most numbers requires the use of both hands. The numberic keypad makes all the numerals available to one hand. Besides a key for each of the numerals 0 through 9, numeric keypads have a decimal-point key, a "+" key, a "-" key, and an Enter key, but for now let's consider only the numerals.

In the numeric (calculator) keypad the numerals are usually laid out something like this:

```
7 8 9
4 5 6
1 2 3
0
```

The usual keypad arrangement contrasts with the telephone company's numeric pad for entering telephone numbers:

```
1 2 3
4 5 6
7 8 9
  0
```

The designers of the push-button telephone considered and tested several different arrangements of the 10 numeric keys, including two vertical rows of five buttons, two horizontal rows of five buttons, and a circle. After deciding on four rows of three keys, why didn't the designers use the traditional calculator arrangement for the numerals? Because tests established that people entered numbers more quickly and accurately with the top-to-bottom, left-to-right arrangement (perhaps because we read things in that order).

Designers of nonstandard keyboards are invited to take all these factors into account in their next designs. But a proliferation of keyboard designs would probably do more harm than good, even if most of the new designs represented an improvement on the QWERTYUIOP and calculator arrangements.

A Solution without a Standard

The programmable detached keyboard, such as those on the Victor and Epson QX-10 microcomputers, raises a new possibility: because every key on the keyboard can be programmed and the keyboard is detached, there's no reason not to have more than one keyboard for each computer. Just unplug one keyboard, plug in another, and load the operating system that loads the correct codes for the keys. This would mean that, on one computer, Harvey could type on the Dvorak keyboard with a telephone-style numeric keypad, and Eloise could use the QWERTY layout with a calculator keypad, so long as the two were content to use the system at different times. Each person could use or edit the data entered by the other; two keyboard units would be necessary only to save the trouble of relocating the key caps. This sort of flexibility would be possible on many new systems if the manufacturers would supply utility programs to enable nonprogrammers to program the keyboard. Instead of a single standard keyboard, we would have a standard of high adaptability. ■

choice from such a document, a cursor will appear to indicate that a selection is expected. But there is never more than one cursor at a time on the screen.

The *interaction window* appears only when the machine requires some discrete information or a specific response. It always appears below the document window. On an 80-column by 25-line screen, this window is 80 columns by 8 lines in size.

Two classes of interaction can occur. In the first, the computer may request a string of typed characters. For example, the system may ask, "What is your name?" The question is presented in the interaction window, along with a cursor indicating where your response will be entered. In the second class of interaction the computer requests a selection from a menu. All menus appear in the interaction window. Whenever you have to make a decision, the system prompts that explain the choices appear in the interaction window.

The *prompt window* is a small window at the bottom of the display that contains brief reminders (prompts) or flags of use for any given situation. They are optional with the software designer.

Rules for Menus

Menus must follow certain rules. First, menus should always appear in the same place on the screen. Second, menus should be designed so that you may indicate your choice by one of two standard methods: type the first letter of the first word and press the Return key, or move the cursor until it is over that letter and press Return. A third, optional method, which can be activated by a software switch, would be to type the letter without pressing Return to activate the choice immediately. The first two schemes allow the casual user simple and fail-safe means of choosing from a menu, and the third method allows experienced users to reduce the number of keystrokes and access menu choices more rapidly.

Finally, menus should be organized so that the most common choices occur first in position and potentially destructive choices occur last.

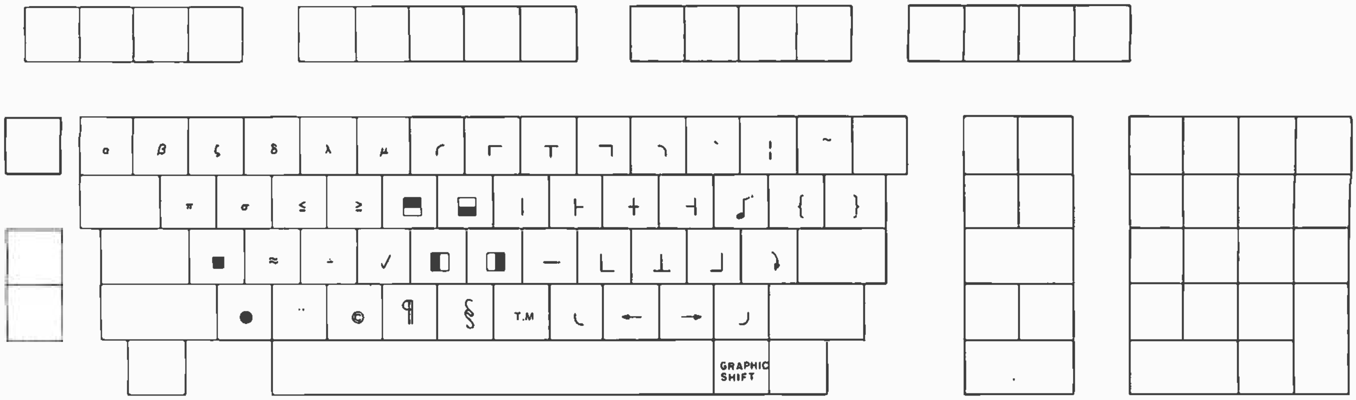

Figure 4: *The graphic symbols produced when the Graphic-Shift key is depressed. For easy reference, these symbols should be marked on the front side of the keys in an unobtrusive manner.*

The HASCI Keyboard

Like it or not, the keyboard is with us to stay. In designing a keyboard, we chose the format of the typical office typewriter. The key positions are identical and the feel is similar, so anyone familiar with a typewriter should be reasonably comfortable with the HASCI keyboard. However, by adding just a few additional keys, we were able to have the keyboard generate an entire 8-bit superset of the ASCII (American Standard Code for Information Interchange) character set. Thus the HASCI system is upward compatible with ASCII-based systems; a computer using HASCI can run any standard software.

Included in the extended ASCII is a set of standard graphic characters. These allow the creation of accented letters (by actually overtyping one character on top of another) and line drawings for boxes and forms. Also included are some Greek and special-purpose mathematical symbols. You gain access to these characters by pressing a Graphic-Shift key, which converts the normal typing keys to symbol generators. The first set of these symbols should be printed, etched, stamped, or otherwise marked on the front of the key caps in a color similar to that of the key cap. This should *not* be a high-contrast color; such treatment causes visual distraction and fatigue. Figure 4 illustrates the layout of the unshifted graphic symbols.

In addition to this primary set, one may simultaneously press Shift and Graphic Shift to access a second set of graphic characters. Most of these are logically related to their unshifted character. For example, all *line* symbols have a *double-line* counterpart. Thus, while the second set is not shown on the keycaps, it is easily learned. Figure 5 illustrates these shifted graphic symbols.

Types of Physical Controls

We have avoided using any controls other than keys and push buttons in the current HASCI standard (although voice recognition may certainly be incorporated when appropriate). Of two primary motivations the first was familiarity. Contrary to a current myth, keyboards are extremely familiar objects in our society, and a vast number of potential computer users are already familiar with their use; no other practical means of entering textual data into a computer exists today. Second, the HASCI keyboard must be available on portable computers as well as on fixed desktop units. If the interfaces

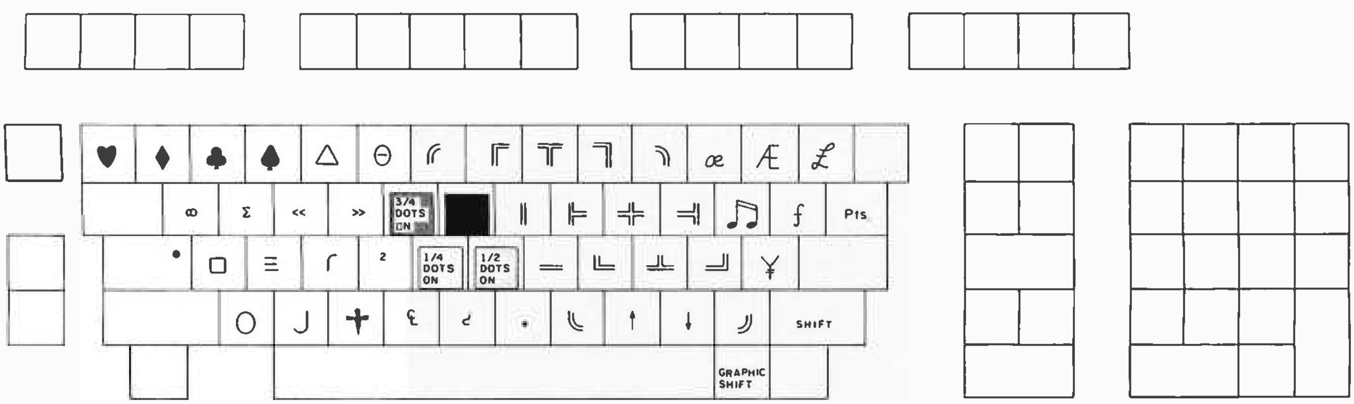

Figure 5: *The graphic symbols produced when both the Graphic-Shift and Shift keys are depressed. The symbols are not printed on the keys but are logically related to the unshifted set: single lines shift to double, fractions shift to eighth and sixteenth notes, etc. Thus the shifted set is easily remembered or learned. A certain optimal level of difficulty encourages user participation: the extremes of too easy and too difficult are both undesirable.*

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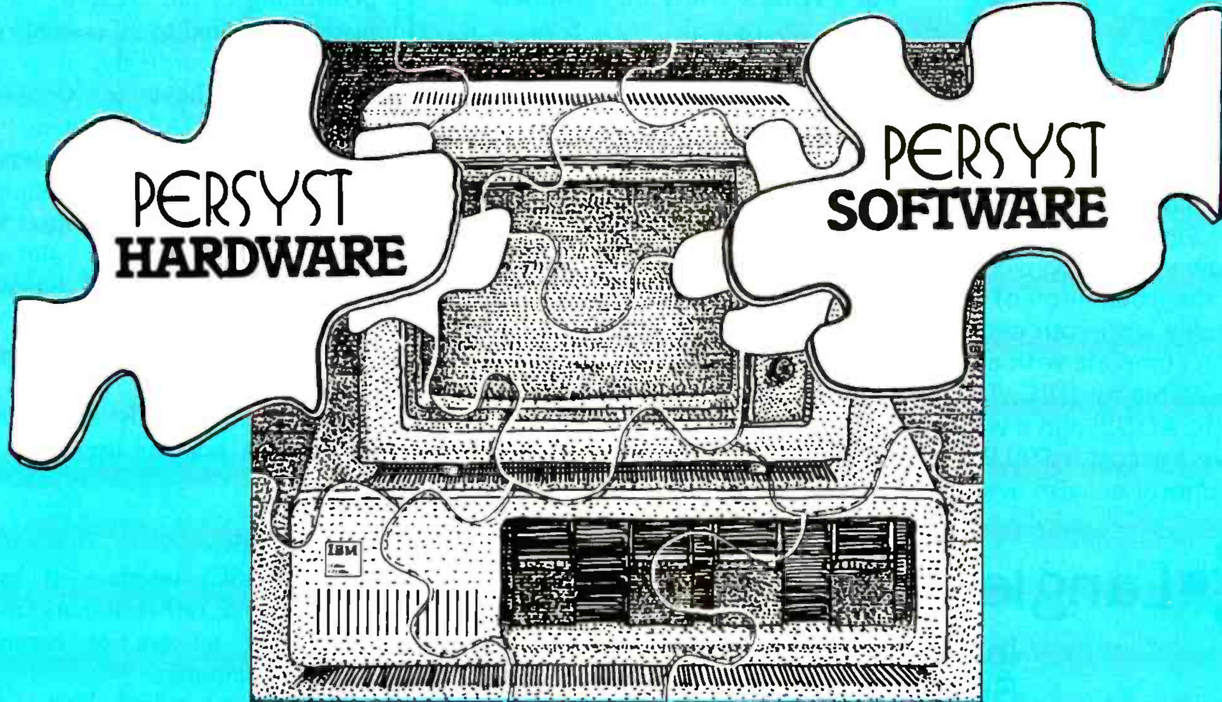

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on portable and fixed units are substantially different, the concept of transportable operator knowledge would be violated.

HASCI allows a number of ways of performing certain actions. No one method is suited to all possible environments. Accordingly, it is quite possible to have a Xerox-style "mouse" in a HASCI system (that's just one more way of moving a cursor around a screen and making choices). Similarly, cursor keys, control keys, joysticks, etc. are equally valid in the proper time and place. A typewriter keyboard represents merely one valid method of entering text. Others will evolve and become common, but typewriter keyboards are likely to continue in popular use for a long time.

Conclusions

The HASCI interface is by no means an end; rather, it marks the beginning of an era of consumer-oriented computers.

HASCI is not intended to be a fixed thing. We hope it will evolve and improve with time. Keys will come and go, menus will change, and groups of keys will grow and shrink. We expect that computers specifically designed from the ground up to support HASCI will help to reduce substantially the overall system cost and increase system performance.

Perhaps the best news for users is that the Epson QX-10, the first computer using HASCI, *will be available* from Epson America during the latter part of 1982 (see Gregg Williams's "The Epson QX-10/Valdocs System," September 1982 BYTE, page 54). And it will be very cost competitive with the current crop of personal microcomputers. ■

Acknowledgments

I would like to acknowledge the courage and support of Mr. Yasuhiro Tsubota, president of Epson America, and all the fine people of the Epson family. Without their support, the HASCI interface could not have been developed.

I would also like to acknowledge the technical assistance of Richard Mossip and Roger Amidon, whose contributions to the HASCI interface are many.

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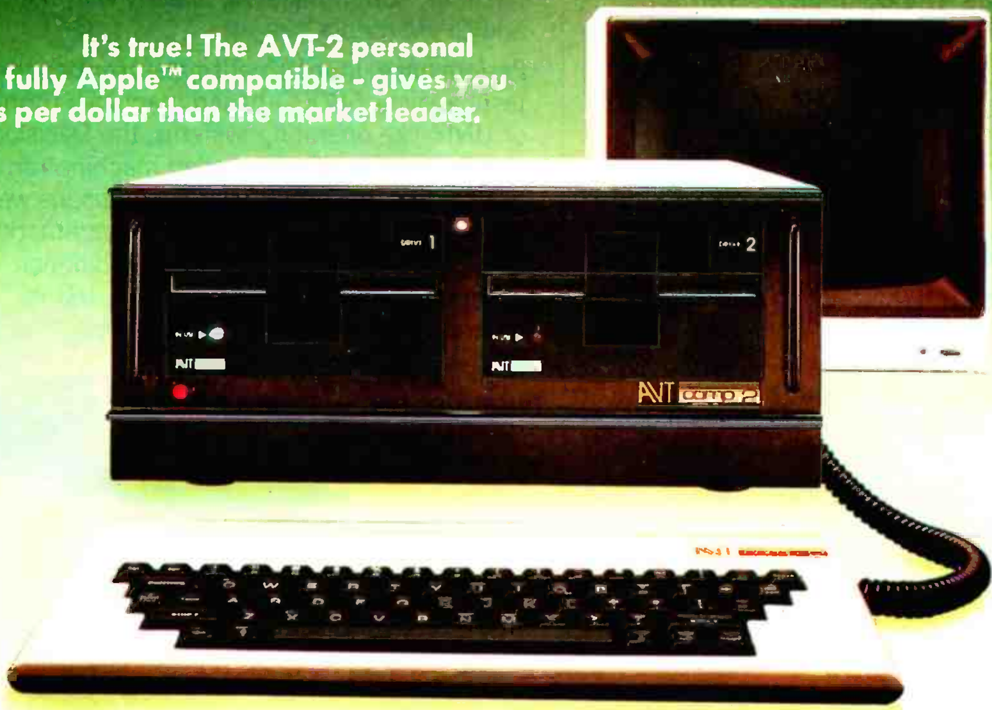

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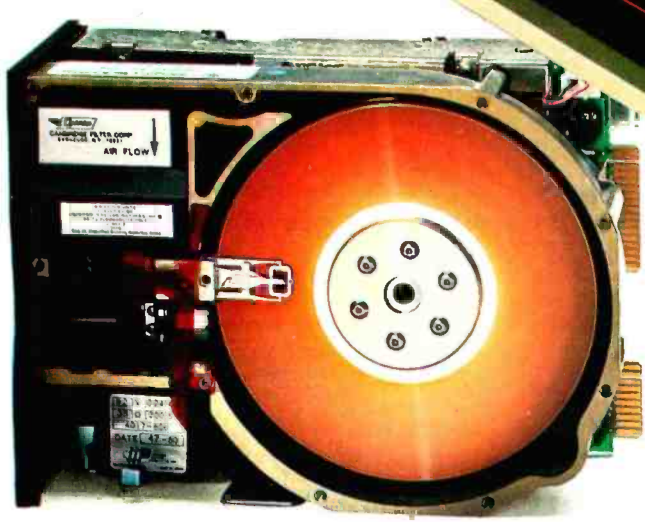

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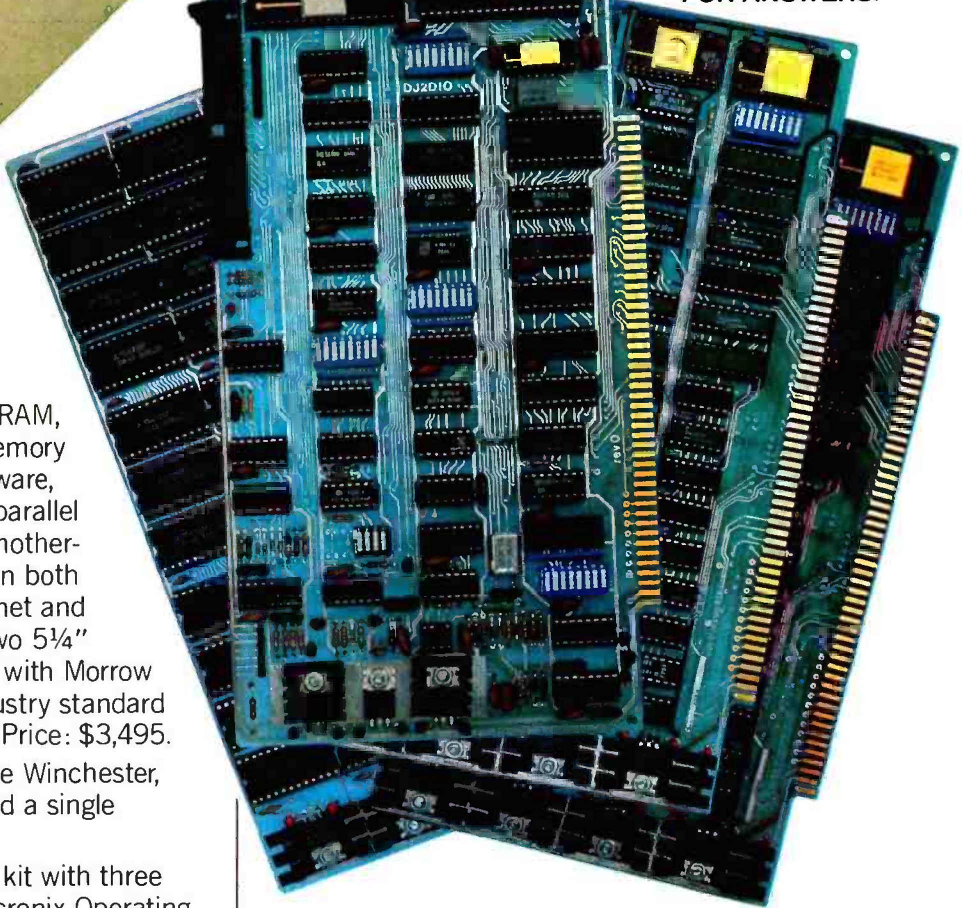

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Terminals, Keyboards, and How Software Piracy Will Bring Profits to Its Victims

Jerry Pournelle
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Most of this column is built around mail I've received. It takes considerable ingenuity to answer mail and still have a theme to what you write. I tried and gave up.

More Terminal Madness

After my remarkable experiences with the Televideo 950 (see "Terminal Madness, The Word, Grammatik, and Then Some," June 1982 BYTE, page 286), I got a ton of mail from people urging me to give the terminal another try. I confess the suggestion wasn't unwelcome; I liked a lot about the 950. Eventually I talked myself into getting another. Bill Grieb of Systems Interface Consultants volunteered to get it set up and checked out. Incidentally, Bill and his wife Sylvia are the people I recommend whenever anyone is looking for a Godbout system and wants help. They give excellent advice on choosing hardware and software, and they'll hold your hand while you're getting things running. They also give a class called "The Small Business Computer Today and Tomorrow." On that, more later.

Anyway, I've been using the Televideo 950 for about a month now. It works fine. Alas, I don't much care for it. Once again, the reasons are personal. I know a lot of programmers love the thing, and it certainly is handsome enough. The problem for me is in the features. There are too many keys.

I wouldn't have thought you could *have* too many keys on a terminal, but Televideo Systems has managed it. Understand, it's not the reprogrammable function keys across the top. Those are great; they're the best feature on the terminal. They're really reprogrammable; you can make them send whole messages, like "Hello there," as well as control characters and escape sequences.

Unfortunately, the cursor-arrow keys, which are down to the right of the space bar, are *not* reprogrammable; and while some of them send what you might expect, some don't. The Down Arrow key, for example, sends Control-V, for reasons that aren't clear to me. I sure wish it could be reprogrammed.

Then, a number of keys are packed around the regular keyboard. Not, I hasten to add, in as miserable a fashion as the IBM Personal Computer has done it. There is a very good Selectric-style key layout huddled in among all those extra keys. But outboard of the left-hand Shift key is Back Tab, which sends the two characters Escape and I. Down by the space bar are two more keys, Print and Funct. Up where the Delete key ought to be, there's the Clear Space key. All of these send escape sequences. Most are placed admirably for being hit when you didn't want to hit them. The result can be devastating.

Finally, there's the display. I rather like it. Like most modern terminals, it has 24 lines of 80 characters each, which is best for programming. (For

writing I stick to my old 16 lines of 64 characters on a 15-inch screen, but I have eye problems.) A twenty-fifth or status line comes on in reverse video when you turn on the terminal. Alas, it's nearly impossible to get rid of that line. It takes the darndest sequence of escape and control characters you ever saw because what you must do is fill a line with spaces and output all 80 of them. If there's a better way, neither Tony Pietsch nor I have been able to figure it out from the Televideo 950's rather poorly organized documents. (The operator's manual is quite good on how to connect the 950 and set the switches and such but plain lousy when it comes to explaining the many "smart" features.)

So, all in all, I'm not enormously pleased. Fortunately, we have a friend setting up a new system who does like it, so I'll be able to find it a good home.

(By the way, Tony continues to work on interrupt-driven software projects using the DEC [Digital Equipment Corporation] VT 100; but since I haven't got it yet, I can't say how much I'll like it.)

Hacksaw, Anyone?

Meanwhile, I have several letters from readers advising me that it's possible to detach the keyboard from a Heath/Zenith Z-19 terminal. The simplest instructions came from Sherril Cawn of Los Angeles, California, and Peter Kip Mercure of Blacksburg, Virginia. Mercure writes, "Remove the keyboard (six screws on bottom), and note that a fair length of ribbon cable connects the keyboard to the logic board; cut the keyboard base off with a saw. You then have a detached keyboard."

This will certainly work. If you try it, you'd want to cover the resulting raw edges. Cawn suggests a piece of varnished pine. I understand the whole system can be made quite attractive.

Mercure likes both Z-19 terminals and Z-89 computers, in part because the Z-89 comes with extensive documentation including the sources for the software. He says, "When we needed to write a new device driver for IBM Selectric and Olympia 25100, the code was available to be modified."

Incidentally, Robert A. Heinlein has two Z-89 computers and is quite pleased with them.

Jiggering Up the Displays

The following is *not* guaranteed to work. I got it from a reliable source, but it's a great deal more in Steve Ciarcia's line than mine, so I haven't tried it.

To make the Z-19 display "beautiful" (easier to read):

> Remove chip U477 (which is a 74LS08 quad AND gate logic chip) and bend up pins 4, 5, and 6 so that they do not go into the socket any more. (This is an unused portion of the chip.) Replace the chip. Remove U478 (a 74S74 chip) and bend up pin 6. Attach a wire to the hole in the socket where pin 6 of U478 would normally go, run that wire to pin 6 of U477, and solder. Insert the 74S74 back in its socket, being certain that pin 6 does not touch the socket or the wire coming out of it.
>
> Solder a wire from U478 pin 6 to U477 pin 5; solder a wire from U478 pin 3 to U477 pin 4.
>
> The dot clock now gates the video logic output, resulting in a very nice display. It gets rid of the solid lines that cause inconsistent brightness in vertical and horizontal lines.

Tony Pietsch's comment is that this ought to work, but of course it will *not* make solid blobs and other graphics characters when altered this way; and you should be very careful not to overheat chips when you solder directly to their pins. It's quite easy to ruin the chips if you don't know what you're doing.

I pass this along for what it's worth, but I disclaim any responsibility for disasters. If you don't really understand what's going on, don't try it.

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In his newest book, *From Bauhaus to Our House*, Tom Wolfe gives a screamingly funny account of how post-World War I European architecture came to dominate in the United States, resulting in all those dreadful boxes that clutter big city skylines. As he points out, European architects spoke of "functionalism" while building flat-roofed buildings in heavy snowfall areas.

It seems the Europeans are also wrecking our keyboards.

As I've mentioned in this column before, the IBM Personal Computer has that stupid key between the Z and the left-hand Shift key. It also has an egregiously small Return key placed too far away from the home keys.

I've just seen the keyboard layout for the DEC Personal Computer, and, by golly, DEC has done the same thing! Yet here are DEC and IBM, both of which have made good keyboards. Heck, I'm typing this on a DEC keyboard. When we were first searching for good keyboards, we took one out of an old DECWriter and set it up to stand alone. Larry Niven and I liked that so much that we have two each now. And of course the IBM Selectric has probably the best keyboard ever made for typists. So why are these companies doing this to themselves?

Because, I'm told, there's a "standard." It comes from Europe.

As far as I'm concerned, it can go back to Europe. There are probably more keyboards and typewriters in the United States than in the rest of the world combined. If someone has to relearn how to type, why should it be us?

And to make it worse, it's only a keyboard. Why the devil don't they make them in *many* layouts and styles? I once worked for Dr. Dvorak up at the University of Washington (see in this issue "A Short History of the Keyboard," page 386, and "Victor Victorious," page 216, both by Phil Lemmons). He'd invented an entirely new—and much more sensible—keyboard layout, which never caught on because it was just too hard to go from the Dvorak to the QWERTY. (It's easy enough to convert from the old QWERTY to Dvorak's layout; the problem comes when you have to go *back* again.) There was never a large enough market for the Dvorak layout. Now, though, when it's only a matter of reprogramming a PROM (programmable read-only memory) chip and moving the key tops around, you'd think *somebody* would come out with choices.

And I know that can be done: when Tony Pietsch first set up Ezekial, my ancient Cromemco Z-2 machine, we looked for keyboards. We didn't find the DEC boards until later. Meanwhile, my mad friend and I bought surplus Memorex keyboards from Dick Dickensen. Alas, although

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M-Drive	128K bytes	$1198
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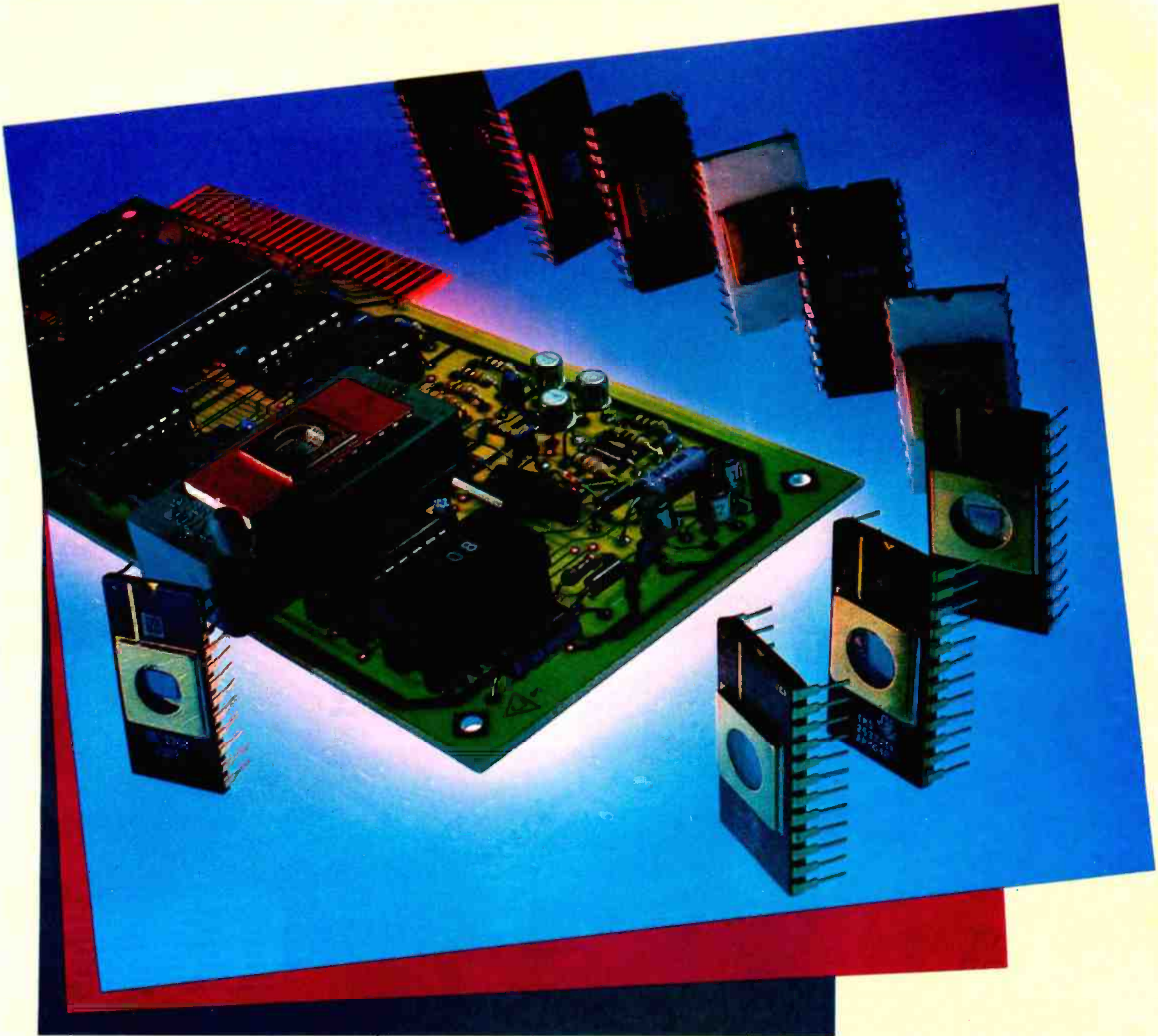
Semidisk	512K bytes	$1995
Semidisk Systems POB GG Beaverton, OR 97075 (503) 642-3100	1 megabyte	$2995
Disk Doctor Supersoft POB 1628 Champaign, IL 61820 (217) 359-2112		$100
SPAT (included in Utility Disk One) Workman and Associates 112 Marion St. Pasadena, CA 91106 (213) 796-4401	(postpaid)	$32.50
COLORTROL	demo ("locked")	$49.95
Soft-Link 3255-2 Scott Blvd. Santa Clara, CA 95051 (408) 988-8011	charge to unlock	$150

Books Reviewed

Compu Guide by Martha Eischen, Beaverton, OR: Dilithium Press, 1982.	$14.95
Osborne CP/M User Guide by Thom Hogan, Berkeley, CA: Osborne/McGraw-Hill, 1981.	$15.95
Interfacing to S-100/IEEE-696 Microcomputers by Sol Libes and Mark Garetz, Berkeley, CA: Osborne/McGraw-Hill, 1981.	$15
Microcomputer Operating Systems by Mark Dahmke, Peterborough, NH: BYTE/McGraw-Hill, 1982.	$15.95



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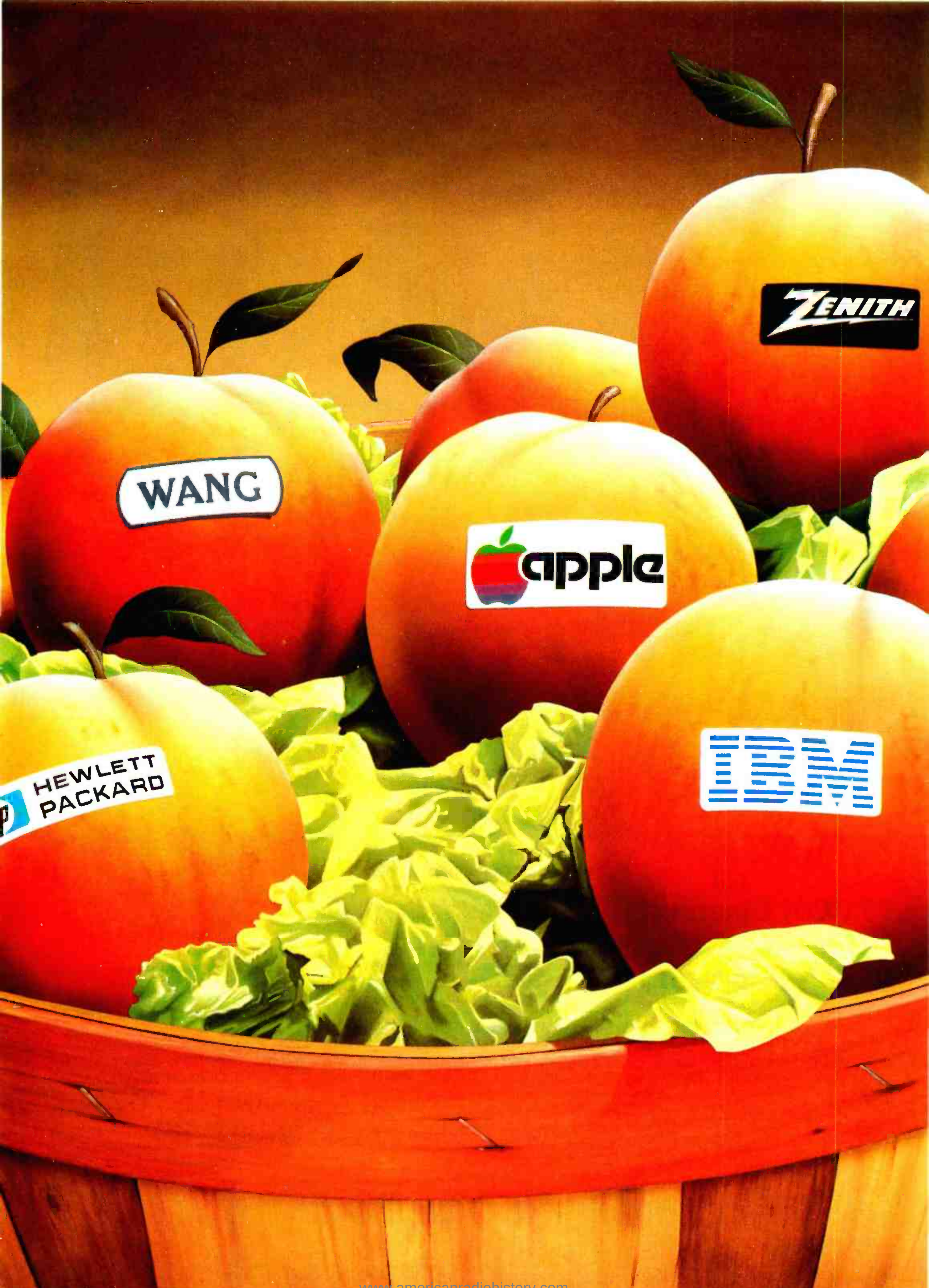
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the boards had a good feel to them, the keys were laid out Teletype (TTY) style, with the single and double quotes up as Shift numerals. Novelists use quote marks a lot.

"I need a Selectric layout," I said.

"You'll have it," said Mac Lean. "Tony will take care of it." My mad friend had a lot of confidence in Tony.

And indeed, Tony did. But that made for another problem: Mac Lean was used to the TTY key layout and couldn't use my machine. Back to Tony Pietsch, who installed a small switch up at the top of the keyboard. Click up, and the keys were in Selectric layout for me. Click down, and they were in TTY style for my mad friend.

This was in 1978. If Tony Pietsch could do that using surplus equipment back then, I know it can be done now. What man can do, man can aspire to.

Meanwhile, I continue to look for the perfect keyboard. I may—just may—have found it. (Sorry, I won't say what until I've had a chance to test it.) If I don't find it, my BYTE associate Mark Dahmke and I have just about decided to design our own terminal, using an S-100 bus, Z80 processor, and a memory-mapped video board.

What Is a Memory Map?

Which neatly brings me to several letters asking "what the devil is memory-mapped video?" Not long ago, that question was of historical interest only; now it's relevant again.

In the old days—say, prior to 1980—memory was very expensive, and there weren't very many terminals. Console input and output were real problems. When Larry and Marilyn Niven got their first microcomputer, an early Altair, they used a Teletype machine, and a number of others did it that way. Of course, the TTY was pretty inconvenient, and you couldn't do word processing with it (well, not very well, anyway); so a lot of people dreamed of having a "glass Teletype," which is to say a video screen.

One way to do that was to buy a terminal; but as I said, there weren't many terminals available, and most of those available had problems; so there arose an alternate way to get a video-screen console.

An 8-bit computer chip, such as the 8080 or Z80, uses 2 bytes or 16 bits for a memory address; thus it can directly address 2^{16} locations. That's the number 65,536, which is invariably called *64K bytes* for reasons that aren't important here. Random-access read/write memory (RAM) was so expensive back then that few microcomputers had more than 48K bytes, leaving a full 16K-byte block empty.

Some designers saw this as a great opportunity and constructed memory-mapped video boards, which could be addressed to any memory location. Suppose, for example, that the last addressable memory location in your system was at byte 49152, which is C000 in hexadecimal. Your machine was capable of addressing locations 49152, or C000 hexadecimal, to 65535, or FFFF hexadecimal. (Remember that we start with location 0, not 1, so that the top number is 65535, not 65536.) Although it was capable of addressing those locations, there was nothing there to address. Thus you could put a memory-mapped video board up there. Assume we addressed the first memory-map cell at 52224 (CC00 hexadecimal), and ignore the fact that there's a gap between the top of "real" memory and the beginning of our memory-mapped video board because the computer doesn't mind at all.

This board looked to the system just like more memory. You could read it and write to it. However, in addition to saving whatever information was stashed in memory locations there, the board showed them on a video display. Thus, if you put in the letter B at the first memory location (CC00), a Y at the second (CC01), a T at the third, and an E at the fourth and then connected a video monitor to the board, you would see the word BYTE in the upper left-hand corner of the screen.

And so forth. For technical reasons, memory-mapped video boards came in two sizes: 16 lines of 64 characters, and 24 lines of 80 characters. The 16 by 64 board took up 1024 memory locations, and not surprisingly, the 24 by 80 used up 1920, i.e., a 1K-byte and (almost) a 2K-byte block respectively.

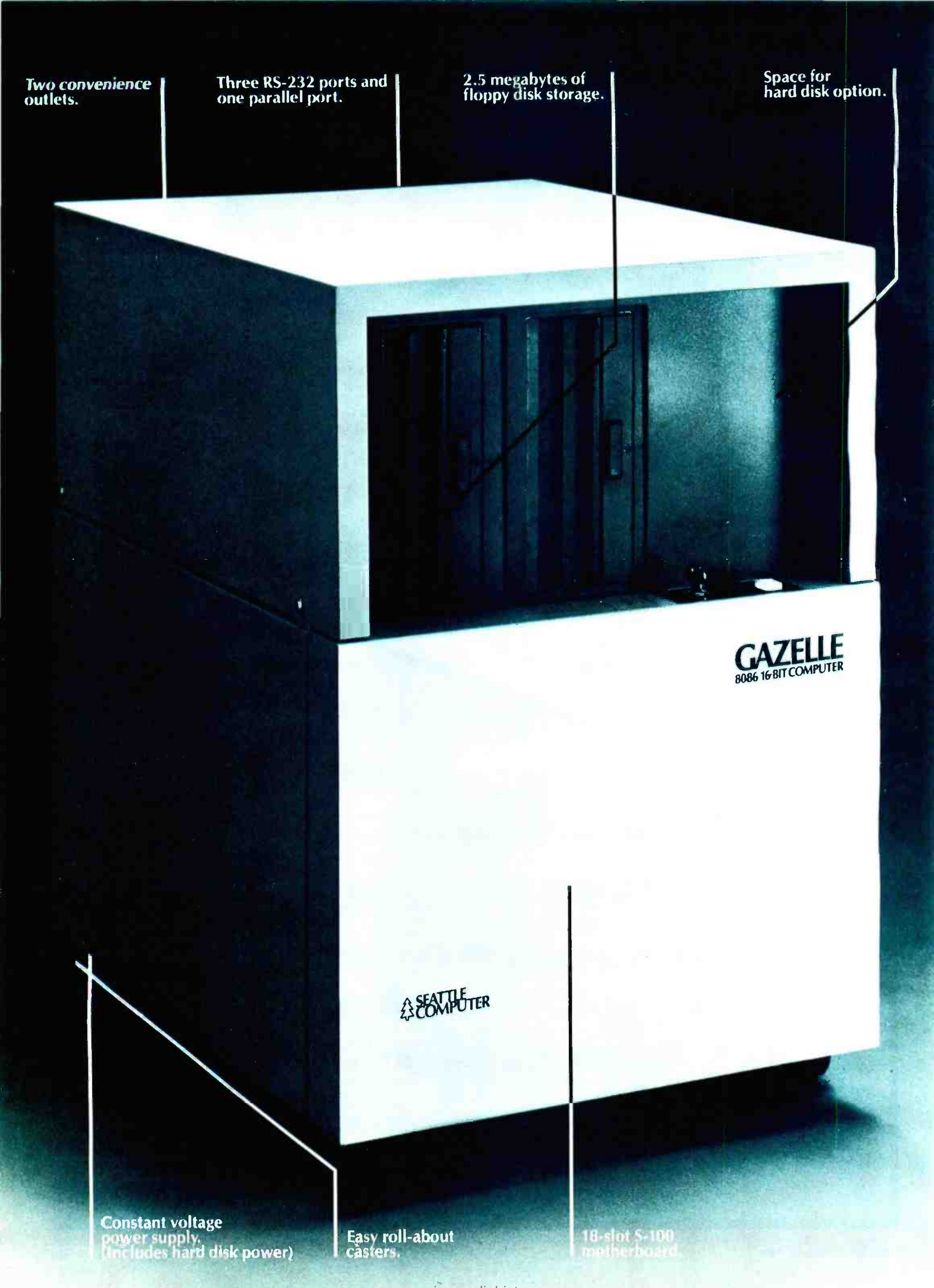
There were a lot of good things about memory-mapped video. For one thing, it was fast. I mean really fast, nearly instantaneous, and this was back in the days when terminals and Teletypes were so slow that it seemed to take forever to rewrite a full screen of information.

Then, too, you could change the character sets: that is, when the video screen displayed an *a* or a Z or whatever, if you didn't find that aesthetically pleasing, you could actually reprogram the letter's shape (although few actually did that). You could go out and choose a keyboard you liked, which is how I got first my Memorex and then my DEC keyboards. You could output the result onto any video monitor you liked. Finally, you could write your own "terminal software." That is, because all you were doing was moving data around in memory, you could write all kinds of routines for "insert character" and "insert line." You could make it scroll, and all this happened *fast*.

Moreover, what was then (in my judgment) the best text editor available for microcomputers, Michael Shrayer's Electric Pencil, worked *only* with memory-mapped video. Indeed, Shrayer cleverly took advantage of the fact that the video display was memory and used that memory location as the input buffer, rewriting from screen to "real memory" only at the ends of lines. Because this took time, the result was Electric Pencil's infamous habit of dropping characters if you typed too fast; but given the dreadful editors available then, Electric Pencil was so superior in every other respect that most of us didn't care.

The result was that in the early days of microcomputers about as many machines were developed with memory-mapped video as terminals, and a lot of people with terminals envied us memory-mapped types.

Of course, the problem was that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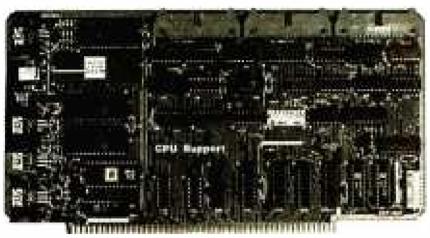

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the board *did* take up space in memory, whereas a terminal operated through an I/O (input/output) port and didn't take up memory at all; and when memory prices plummeted, computer owners had to make a choice. Did we really want to use up memory for our video display? Also, terminals got better—and cheaper—and new text editors were developed. Some computer systems continue to use memory-mapped video, but now many send their console output through terminals, and a lot of experienced computer users haven't a clue as to what memory-mapped video might be. [Editor's note: Jerry is referring to S-100 systems in this discussion. Other machines, both 8 and 16 bit, have used memory-mapped video for some time, including Apple, Radio Shack, IBM, and Victor.]

However (and here's why this has been worth the discussion), memory-mapped video may come back, now that the 16-bit machines are here. After all, a 16-bit machine can address a huge amount of memory, far more than you'll ever need. So, some of us ask, why not address a memory-mapped video board *way* up there in high memory? We could also write our own "smart terminal" software, burn that into PROMs, and have a terminal that does what we want it to do instead of what some terminal designer thought we'd want.

Which is what Mark Dahmke and I have been discussing for some time, and maybe one day we'll do it. Whether we do it or not, it's only a question of time before BYTE readers will once again be offered the choice between terminal or memory-mapped video for a console.

More Tricks with M-Drive

Craig Anderton of Redwood Valley, California, is a Wordstar user who has found some nifty ways to use Wordstar plus the Compupro M-Drive (or G & G Engineering Warp Drive). M-Drive, as most of you must know, is a way to fool your computer into thinking a lot of extra memory is a disk, so that read and write operations onto that "disk" will be nearly instantaneous. Incidentally, Anderton's tricks would work just as well with Semidisk, and probably with any other "pseudo-drive."

Anderton writes:

> One of the main advantages of M-Drive is that I can load Wordstar, Spellguard, and some CP/M utilities into M-Drive. This means that not only do the Wordstar commands react instantaneously, but Spellguard takes just a few seconds to proof several thousand words, with none of the "whirr-clunk" that occurs when the disk drive loads the dictionary into RAM.
>
> Another trick involves find-and-replace substitutions for complex words. For example, I recently wrote a manual for a device called the Hyperflange and Chorus. As you can imagine, typing that out gets pretty tedious. So, I just typed an asterisk (*) wherever the phrase was to appear and did a find-and-replace procedure throughout the entire file. With a normal disk drive, that process can take quite some time; with M-Drive, it takes very little time. Another word I don't like is *oscillator*, so I just type "osc." and do a find-and-replace.

I don't use Wordstar, but of course it's obvious that M-Drive (or Semidisk) will speed up its operations.

I use M-Drive for spelling checking too; but, alas, I have to use Spellguard rather than The Word if I want to do that. The Word expects the dictionary to be on the A drive, and because Tony has set things so that our M-Drive is literally M: (and Semidisk is N:), The Word just can't work on text out there. It's a pity because otherwise The Word is an awfully good spelling checker, and some of its built-in utilities, such as the capability of making an alphabetized disk file of the unique words in a text file, are simply invaluable. [Wayne Holder of Oasis Systems is working to adapt The Word for use with M-Drive under Tony Pietsch's BIOS. Under Compupro's current BIOS, M-Drive *is* A:, and there should be no problem using The Word. . . . **P.L.**]

So Just What Do I Buy?

Daily we receive letters asking for advice. Some are pathetic. I can't possibly answer them.

For example, Max from upstate New York writes a horror story about trying to integrate Shugart 851R disks and the CCS (California Computer Systems) 2210A computer—no BIOS, documentation problems, and round robins of difficulties, probably exacerbated by the inexperience of the local computer repair people.

As of the time he wrote, he didn't really have a working system. I've since put him in touch with Dr. Colin Mick, who built the system my colleague Stefan Possony uses, and I expect that by now his problems are solved. Colin didn't think there'd be any difficulty.

Max went on:

> New news. Datastar needs to be patched to get it to run with the Televideo 950 terminal. I don't have any idea what a patch is or how to do it. But, the instructions are supposed to be on the way? Wordstar needs to be patched to get it running with the Epson printer in parallel interface. More fun!!!
>
> People keep telling me that my computer will be a great one when it finally, if ever, starts working.
>
> My impression of the computer industry so far is that it is not ready to sell anything yet. It seems to me that no one knows what is going on and that all that one can do as a consumer is to make discoveries for the manufacturers so that future products may work well and together. I don't like being the experimental subject, and I can't afford it.

Alas, this is not an extreme letter, either. I recall my late mad friend fulminating about companies that use their customers as a quality-control department. That's not really the case here; CCS equipment works fine if you know what you're doing. Unfor-

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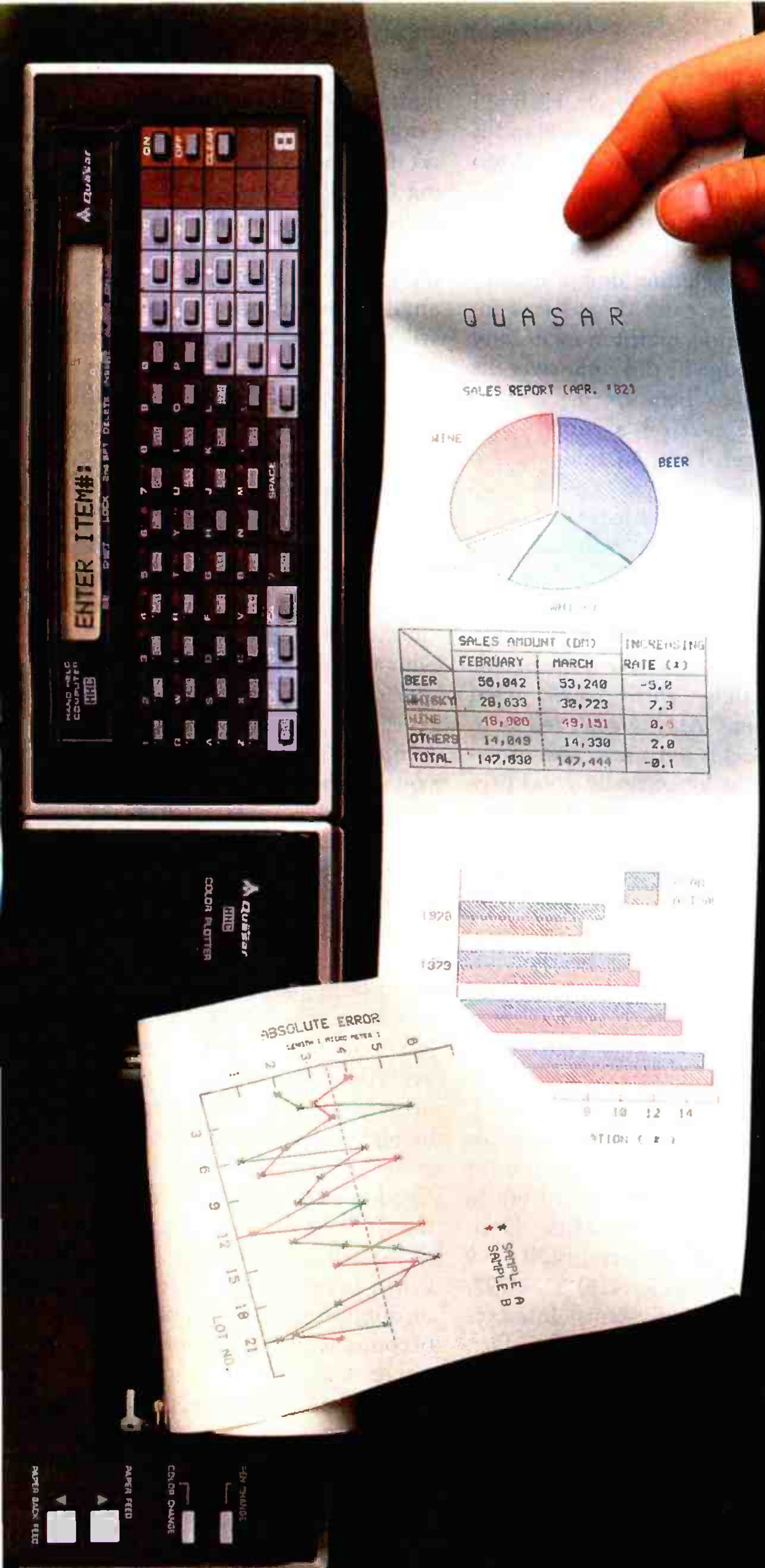

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QUASAR COMPANY, Division of Matsushita Electric Corporation of America, 9401 West Grand Avenue, Franklin Park, IL 60131 (312) 451-1200 tunately, Max didn't, but he needed a machine immediately for a particular project. What should he have done?

I'm going to try to answer that question, but with a caveat: this is *my opinion*. It is an opinion based on considerable experience, both personal and secondhand, but it is still an opinion. There are no definitive answers in this business.

Given that, let me review how I got into the microcomputer world.

My mad friend Mac Lean got an old Imsai, which he cobbled up with this and that, and, lo!, it did wonderful things. He had it running Electric Pencil, and when he showed it to me, I fell in love. I just had to have one.

Fortunately, though, Mac Lean knew better than to aim me at a computer store with a shopping list. Instead, he took me to lunch with a graduate student named Tony Pietsch. Tony was just starting a systems consulting house (literally house; it operated in his living room) called Proteus Engineering. I told them what I wanted. Tony told me what he could do. Actually, nearly every word he said was incomprehensible at the time, but at least I understood the price—which was somewhat higher than all the component costs.

"Why?" I asked.

"Systems integration," chorused Tony and my mad friend.

I thought it over and shelled out the money. It was the smartest decision I ever made; if I hadn't, I might still be struggling with a system that *almost* works.

Instead, Ezekial (the Z80 Tony bought for me) worked from the first day. I could and did concentrate on learning how to use the system rather than trying to put it together. If something went wrong (those were the early days, remember; something *always* went wrong at first), I called Tony. More than once he showed up in the middle of the night to get old Zeke working again. The result was that I rapidly began writing with computers, turned out several books much faster than I had expected, and so forth. Within a year, I'd made the cost back several times over.

Later, when friends wanted a machine, I knew precisely what to tell them: "Go to Tony Pietsch. He'll tell you how much to give him. Hand it to him and stand well back." That too worked, and splendidly, and no one I know of has ever regretted it.

Now, though, Tony has too much other work (including doing updates to WRITE); he can't do systems integration and maintenance any longer, although he did come over the other night to help fix Zeke after someone stepped on a cable. Thus you can't get Tony to build you a system.

So where does that leave us?

First, the absolute ironclad rule, never to be violated, is *unless you know what you're doing, deal with people who do*.

But how do you know if the people you're dealing with know what they're doing? Alas, I can't tell you. This business is very new and growing rapidly; a lot of really good people are just getting started, so you can't judge by how long an outfit has been in business.

However, I'm getting so much mail asking my advice that I must do *something*. After a lot of thought, I've decided to say in print what I tell my friends who want a system.

I know two systems consultants well enough and have known them long enough to recommend them. Both have put together systems for people I know well (although *not* for me). I've already mentioned both in this column: Dr. Colin Mick, Decision Information Services, POB 5849 Stanford, CA 94305, (415) 327-5797; and Bill Grieb, Systems Interface Consultants, 17440 Revello Dr., Pacific Palisades, CA 90272, (213) 454-2100. Both are well qualified to listen to your problems, recommend a system including both hardware and software, and get it working for you. They do expect to get paid for their services. I hasten to add that I have no financial stake in their companies. I have introduced them to each other, and they are contemplating offering some joint seminars on computer systems.

Now do understand, I know there are a lot of good people operating small-systems houses. Some may well offer more services for less money than either Colin or Bill. The point is I don't know anyone else as well as I do them; and I get too many despairing letters to allow me to ignore the problem, because Max is partially right. It isn't that the computer industry isn't ready to sell anything to anyone; but it may not be ready to sell everything to everyone. Neither the systems nor the documents are complete enough just to turn things over to users without help; the exceptions to this tend to be expensive.

Dr. Mick on Piracy

Mentioning Dr. Mick reminds me of his solution to the software piracy problem: publishers ought to sell "authorized-user" licenses to anyone who applies. Without the authorized-user code, you can't get updates and revisions; with it, you can, and the company ought not to inquire how you got the software.

At first this sounds like encouragement of piracy, and it's unlikely to appeal to companies who hope to get several hundred dollars for their programs. However, software prices are coming down rapidly. (I am in the midst of preparing a BYTE feature on low-cost software already available.) It will not be many years hence before everything will be under $100. (The price in the first year of release may be higher, but after that it will plummet. This, incidentally, is the price trend of new computer chips: high in the first year or two, falling to dirt—well, sand—cheap thereafter.) When prices get really low, the cost of duplicating and shipping software becomes a critical part of the package price.

Thus I can see a time in the not too distant future when the major profits will come from selling documents and updates. The actual machine-readable program will be sort of incidental, and the publisher, while never admitting it, will be pleased as anything if the software is stolen by someone who subsequently buys the documents and an authorized-user number.

Creating the program will then be thought of in the same way as doing the research for a book: it's impossi-

ble to sell the book without doing research, but no one expects to sell his research notes. The money comes from the book itself.

So How Do I Learn More?

The next most common request I get is bibliographic: isn't there a book that will teach all?

Alas, no. I can't even think of a whole series of books that will do the job. There are, however, some that are very useful for present and potential microcomputer users.

For example, take Martha Eischen's *Compu Guide*, subtitled "A consumer's guide to small business computers." That subtitle is a complete misnomer; the book doesn't talk about computers at all. Instead, it's a discussion of the kinds of questions a small businessman ought to ask before buying a computer—indeed, before hiring a systems consultant. Moreover, the book is pitched toward those about to buy a pretty expensive minicomputer; the prepurchase studies Eischen recommends would cost more than most microprocessor systems.

The book is thus useful as a sort of preliminary orientation tool, to be read before you really get started; but I sure wouldn't take it any more seriously than that. Eischen moves toward a number of subjects, but just as she gets interesting, she veers off and heads toward another.

A much more useful book is the *Osborne CP/M User Guide* by Thom Hogan. The Osborne in the title is, of course, Dr. Adam Osborne, who first made his reputation publishing computer books before he developed the Osborne 1 computer.

The *Osborne CP/M User Guide*, as I'm sure comes as no great surprise, is useful only to those contemplating systems using the CP/M operating system; but since in my judgment the only professional systems you ought to buy run CP/M, that's not a bug, it's a feature.

This is the book that CP/M's producer, Digital Research, ought to have put out as part of the documentation. It is an introduction to CP/M; it is not the last word or anything like it. However, I have not seen a better introduction to the CP/M operating system and recommend the book highly.

CP/M is a computer *operating system*. What that means is defined in the glossary of Mark Dahmke's *Microcomputer Operating Systems* as: "Any program or group of related programs whose purpose is to act as intermediary between the hardware and the user. The operating system's main job is to manage resources such as disk drives, printers, and other peripherals, freeing the programmer from having to rewrite commonly used functions for each application. In this way, the operating system provides a uniform, consistent means for all user-written software to access the same machine resources."

Dense, isn't it? Fortunately, Mark doesn't always write like that; and if you want to learn more about operating systems—and you should—then this is the book to read.

Unfortunately, the book tells you both too much and not enough. Sometimes it assumes you know a lot; other times it gets down to user levels. For all its problems, the book is unique; there's literally nothing else in its class. Those who want to understand what operating systems do are well advised to get this book.

Alas, though, the book I'd want would fit in between Hogan's and Dahmke's: a user-level book on the CP/M system that would tell you something of CP/M's file structure and how the data is stored. This would give you insights into how to use programs like Disk Doctor and SPAT (which let you read and write disk files 1 byte at a time) and thus be able to correct your disks after a calamity.

In my case the worst calamity was a power failure that happened while I was transferring the only copy of a new chapter onto the safety copy of the disk. The directories to *both* disks were damaged, and in those days I kept only one safety copy. (Now I know better: I have "safety copy" and "working safety copy" for all important projects.) Fortunately my mad friend was able to reconstruct the disk directory using a program called SPAT.

I don't recall who wrote SPAT, which is available from the CP/M User's Group. Probably Ward Christensen; he did a very great many of the useful public-domain utilities available from the CP/M User's Group. SPAT (with a number of other useful programs) is also available from Workman and Associates on Utility Disk One.

An alternative to SPAT is Supersoft's Disk Doctor. I understand that this program has made its writer, John Holland, a wealthy man. (He also wrote Analiza; see "Ada, MINCE, CP/M Utilities, Overpriced Documentation, and Analiza II," July 1982 BYTE, page 290.) Disk Doctor's documentation is a bit better than what comes with SPAT, but it's not really good enough to let you start operating on disks without some further study of Digital Research's notoriously dense CP/M manuals. So it goes. Tony Pietsch's evaluation of Disk Doctor was that "anyone who knows enough about CP/M file structure to use this will be turned off by the cutesy stuff: it's called 'Disk Doctor,' which must be why they talk about various 'wards' of the 'clinic.' Bah." My own view is not quite so harsh as all that; still, Tony does have a point.

In any case, I've wandered far from my point, which was that the definitive book about CP/M has yet to be written. Pity.

A Standard at Last!

The Institute of Electrical and Electronics Engineers (IEEE) has finally acted: there's now a standard S-100 bus, which means that if you buy equipment that conforms to the standard, all of it ought to work together. This is a real breakthrough.

The standard is described in *Interfacing to S-100/IEEE-696 Microcomputers*, a book by Sol Libes and Mark Garetz. (Many other documents and books that describe the standard bus are available.)

Sol Libes is, of course, the elder statesman of the microcomputer world, while Mark is president of Compupro. Mark not only coauthored this book but also chairs the

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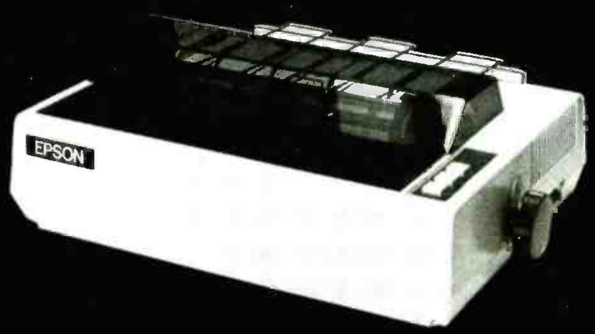

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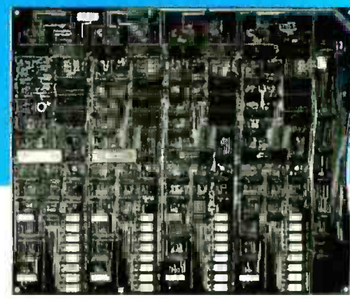

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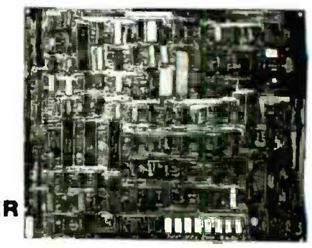

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IEEE committee that adopted the IEEE-696 Standard—that's the official designation for the S-100 bus standard.

The book tells an awful lot about the S-100 bus; more than I will ever want to know. It's not light reading, but then it wasn't intended to be. Ciarcia's readers will find it far more interesting than mine will. Still, it needs to be mentioned because everyone ought to be aware that the standard exists.

And now that there *is* a standard, I hope everyone will design to it and refuse to buy equipment that doesn't conform; that way we can eliminate *some* of the systems-integration horror stories.

Updated BIOS Information

An announcement: Tony has definitely sent his BIOS (basic input/output system) to Compupro, and Compupro likes it and is evaluating it further.

Not long ago there was a big parking-lot sale at a well-known electronics supply house here in Los Angeles, and Mark Garetz of the Compupro organization was down with many of his staff. After the sale was over I invited the team here to Chaos Manor for a drink. That was when the cable got stepped on. (I had an ulterior purpose: maybe I could get them to talk about things not yet announced. But they brought along Vicky Andresen of the rival Morrow Designs company, so, alas, I learned little about either Bill Godbout's or George Morrow's plans.)

Anyway, while they were here I demonstrated Tony's BIOS on The Golem, which is my Compupro 8085/8088 dual processor. Among other things, I removed the disk from the drive and then tried to access it. In the old BIOS, that results in "BDOS ERROR ON B: SELECT," but with Tony's it merely says "Please close the drive door." Everyone was impressed, and somewhat eager to get Tony's BIOS for his own evaluation. What impressed *me* was learning just how thoroughly Tony Pietsch's software insulates me from some of the more common irritants of the microcomputer world.

The Book of Leviticus, Revisited

My mad friend used to rail against what he called "Levitical documentation, full of Thou Shalt Nots." I've got a doozy here.

During the West Coast Computer Faire this year, I saw COLORTROL, which made file-folder labels that vere color-coded in some peculiar way. It looked rather pretty and quite possibly useful, but I saw it on the afternoon of the last day, and I didn't have time for a full demonstration; so I asked them to send me a copy.

My mad friend used to rail against what he called "Levitical documentation." I've got a doozy here.

Not long ago an enormous box arrived. It was mostly full of plastic worms, but down in the bottom was a loose-leaf notebook, a couple dozen colored file-folder labels in a pin-feed fanfold, a disk, and some documents. A cover letter was included announcing that this was an evaluation copy of COLORTROL—and that the program was currently in a "locked" state. There was a telephone number to call so I could learn how to "unlock" the program.

Curious. Because this is a CP/M program disk, it can certainly be copied; indeed, one of the first instructions given was to make a backup copy. So why the "lock," and what the devil did it mean?

I fear I haven't yet found out, because the second thing I saw was the licensing agreement. It's positively frightening.

First, of course, Soft-Link warrants nothing, in block capitals. To be precise, "SOFT-LINK MAKES NO WARRANTIES, EXPRESS OR IMPLIED, WITH RESPECT TO THE SOFTWARE OR ITS QUALITY, PERFORMANCE, MERCHANTABILITY, OR FITNESS FOR ANY PARTICULAR PURPOSE. THE SOFTWARE IS LICENSED AND DELIVERED 'AS IS.' "

Then comes paragraph after paragraph of *tiny* print in lowercase letters, according to which I'm to guarantee that I will keep records on all copies made and their locations; that I won't make more than five copies; that I won't use this on more than one "computer system"; and that "the customer agrees to take all reasonable precautions to secure the licensed programs including, without limitation, the same precautions he takes with his own proprietary materials. In particular, the Customer agrees not to provide or otherwise make available or disclose any Licensed Program to any person other than his authorized employees and/or agents without prior written consent of Soft-Link."

Whatever all that means—and there's more—it says I agree to it if I open this sealed package the company sent.

Now back in San Francisco at the Faire I thought I wanted that program; but now that I look at my obligations (many) and Soft-Link's (none), I begin to wonder. And sure, I know, everyone is doing this and no one pays attention to it; but darn it, isn't there a limit somewhere? Do we all have to become scofflaws in order to use the programs we buy?

Look, here in Chaos Manor we have Ezekial and The Golem. They're linked together. Does this make them one system or two? If I remove the cable connecting them, have they become two when they were one before? And of course there's Helen, my son Alex's CCS, which is in another room. Suppose I want to generate some file-folder labels, and the printer in here is occupied; am I really breaking the law if I have Alex run them off?

And—horrors!—the NEC (Nippon Electric Company) Spinwriter we'll use to generate the labels has a microprocessor in it! Is this a separate system? Do I need the firm's written consent? For a program to generate *file-folder labels*? Ye immortal gods!

In any event, I've been too intimidated to open COLORTROL, and I've yet to learn how to "unlock" it. Perhaps next month.■

Inexpensive Transducers for the TRS-80

Part 2: Another Look at Monitoring Real-World Quantities

A practical look at the devices that put real-world interfaces to work.

William Barden Jr.
28122 Orsola
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Last month I looked at some simple switch-sensing techniques for the TRS-80 Model I/III and Color Computer. This month I'm going to discuss the subject of inexpensive transducers more generally. These devices enable us to monitor real-world physical quantities such as wind speed, temperature, and air pressure. I believe this subject will serve as a logical and useful ending to the 12-part series on TRS-80 interfacing techniques.

The devices in this article are more than switches. They are actually transducers, devices that transform one form of energy into another. An example of this is the National Semiconductor LX0503A pressure transducer, which transforms energy in the form of pressure to a voltage via a piezoelectric "bridge."

The two most common electrical "analogs" (quantities that correspond to real-world phenomena) that I'll be working with here are changing voltage, produced by devices such as the LX0503A, and changing resistance, produced by devices such as a thermistor, which has a resistance that varies with temperature. Furthermore, when the electrical analog is resistance, it's convenient to convert it to voltage, which can be more easily manipulated in computer-interfacing schemes. Therefore, I'm really measuring only voltage, by means of the Color Computer's joystick analog-to-digital (A-to-D) converter or an equivalent Model I/III circuit. I'll use the Color Computer for sample programs here, but all the concepts apply to the Model I and III as well.

The Color Computer A-to-D channels operate with voltage inputs in the range of 0 V (volts) to +5 V direct current (DC). The various A-to-D converters described for the Model I/III in earlier articles in this series also operate in this approximate voltage range. However, the devices that I'll be talking about here operate at much lower voltages, typically in the hundred millivolt (mV) range. For that reason, the first thing I'll do is look at a general way to amplify the transducer outputs.

Using Op Amps to Amplify A-to-D Converter Signals

I'll use three basic amplifier circuits in the following discussions. All of them use operational amplifiers.

Operational amplifiers are linear integrated circuits (ICs) that are commonly used for low-frequency amplifiers. They are characterized by high input impedance, low output impedance, and input voltages that track each other. There are always two inputs with op amps, a minus and a plus input. The minus input is called the *inverting* input because a voltage increase on this input will result in a decrease in the output voltage. The plus input is *noninverting* input because a voltage increase here will result in an increase in the output voltage.

Earlier op amps used dual power supplies; however, some newer versions draw on a single supply. I'll use the single-supply type in the circuits in this article.

A typical configuration for an op amp is the inverting system shown in figure 1. The input resistor (R1) and

the feedback resistor (R2), which is connected from the output to the minus input, determine the voltage gain of this amplifier. The voltage gain is:

$$V_{out} = -V_{in} \times (R2/R1)$$

Typical values for R2 and R1 are 1 megohm and 100,000 ohms. These values will produce a ×10 op amp, one that multiplies the input voltage by 10. Note that in this case the input voltage must be negative. Inputting −0.1 V will produce a +1 V output, inputting −0.2 V will produce a +2 V output, and so forth. Inputting a positive voltage such as +0.2 V will produce a 0 V output. The output voltage will increase linearly to about +3.5 V, as shown in figure 2, giving this particular op amp circuit an input range of 0 V to −0.35 V, for an output range of 0 V to +3.5 V.

A ×5.6 op amp can be made by substituting a 560k-ohm resistor for the feedback resistor (R2). Similar substitutions can be made for other voltage gains. I'll be using the ×10 and ×5.6 inverting op amps in the applications discussed later.

The parts layout for a ×10 or ×5.6 op amp is shown in figure 3. It is built on a Radio Shack prototype board (part number 276-175), which allows easy connection of ICs and components.

Figure 4 shows a noninverting op amp. It amplifies a positive voltage applied to the plus terminal, producing a positive output. The voltage gain is again dependent upon the values of the two resistors, R2 and R1, according to this formula:

$$V_{out} = V_{in} \times ((R2/R1) + 1)$$

The op amp configuration shown in the figure gives a gain of about 11; I'll use it with most of the transducers discussed in the remainder of the article.

Figure 5 depicts the parts layout for the noninverting op amp, again on a prototype board.

A third type of op amp amplifier (shown in figure 6) multiplies the difference between two input signals applied to the plus and minus inputs. This is handy for amplifying bridge-type inputs, in which one value increases and the other decreases, as is the case with the National Semiconductor LX0503A pressure transducer.

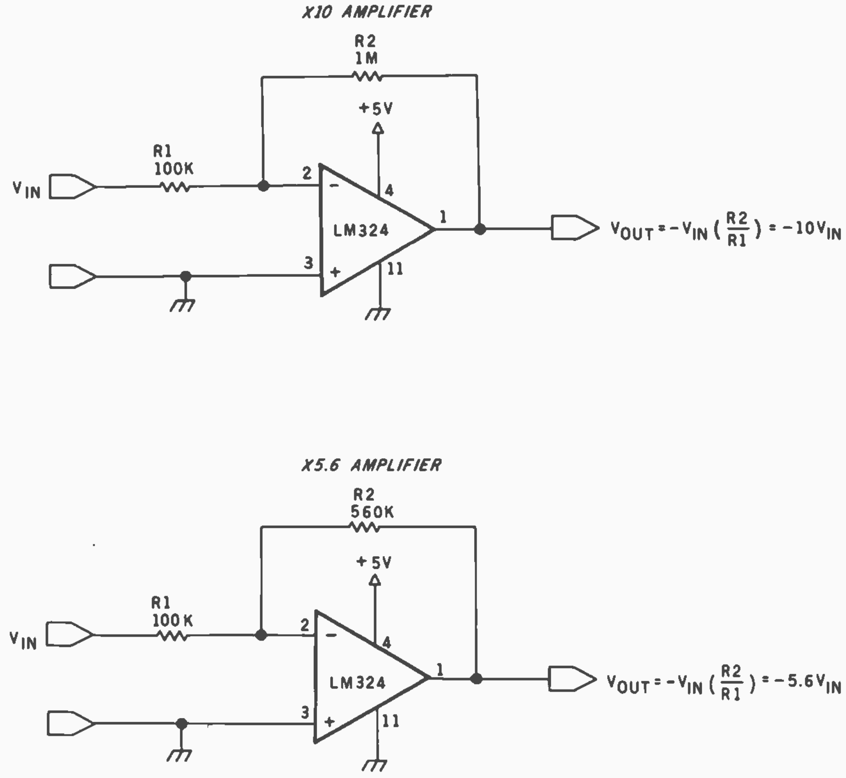


Figure 1: *Using three components you can construct an inverting operational amplifier with a ×10 or a ×5.6 gain. It will increase typical transducer outputs to a range compatible with A-to-D converter inputs.*

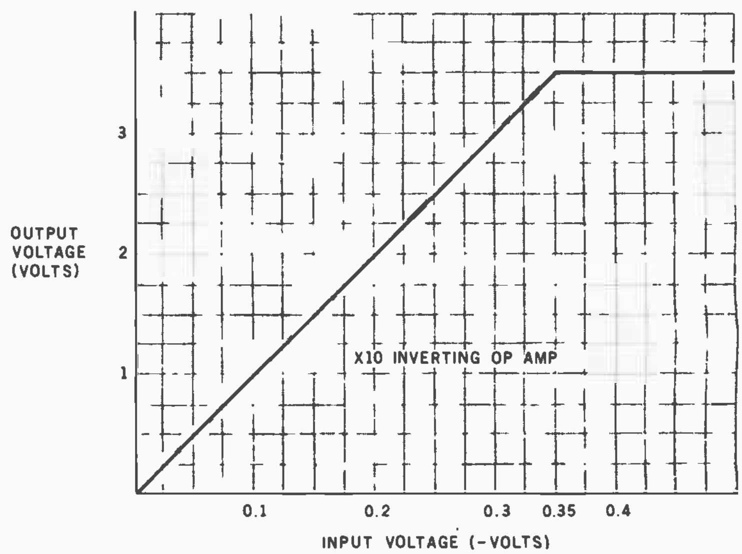
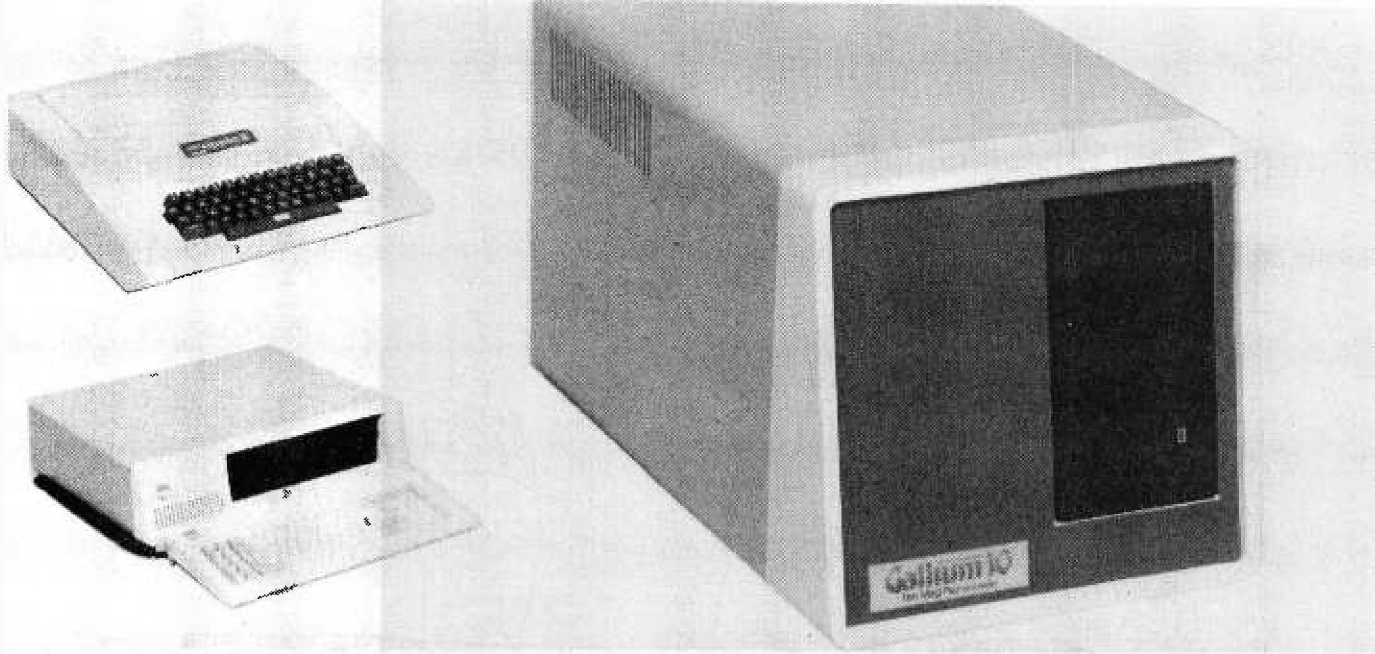


Figure 2: *The op amp operates in linear fashion up to about 3.5 V for a supply voltage of 5 V.*



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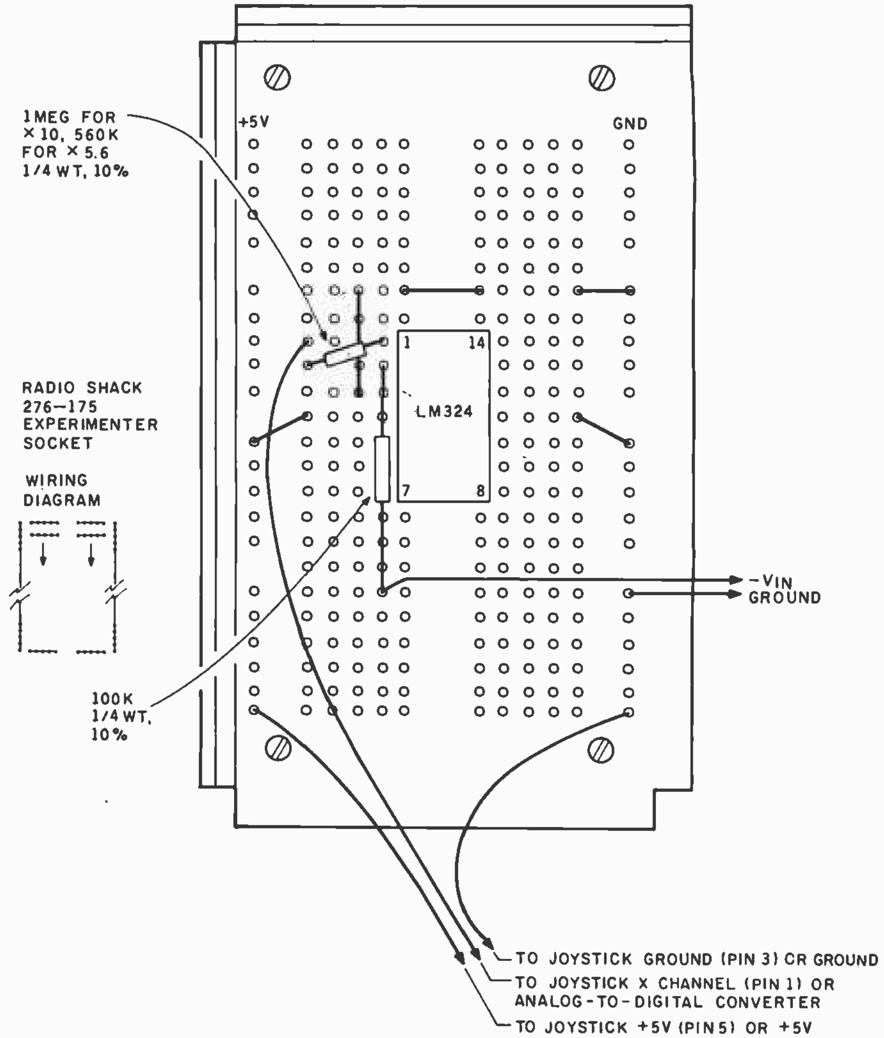

Figure 3: *Component layout for the ×10 or ×5.6 inverting op amp. Parts are mounted on a prototype board.*

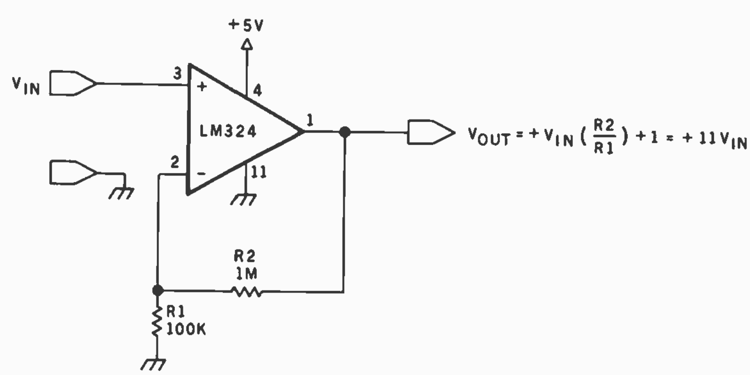

Figure 4: *A noninverting operational amplifier.*

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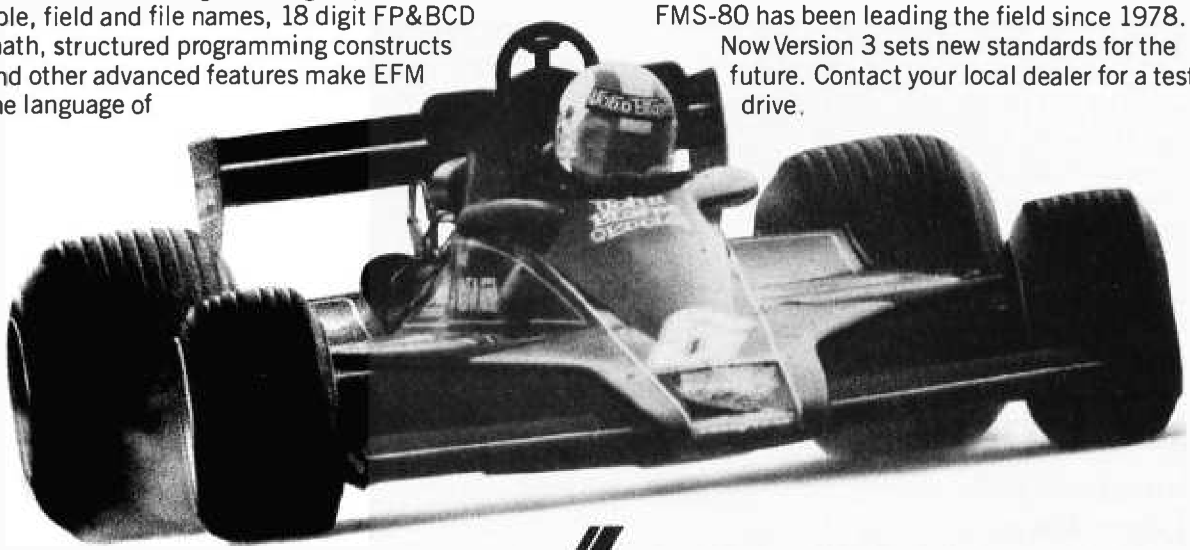

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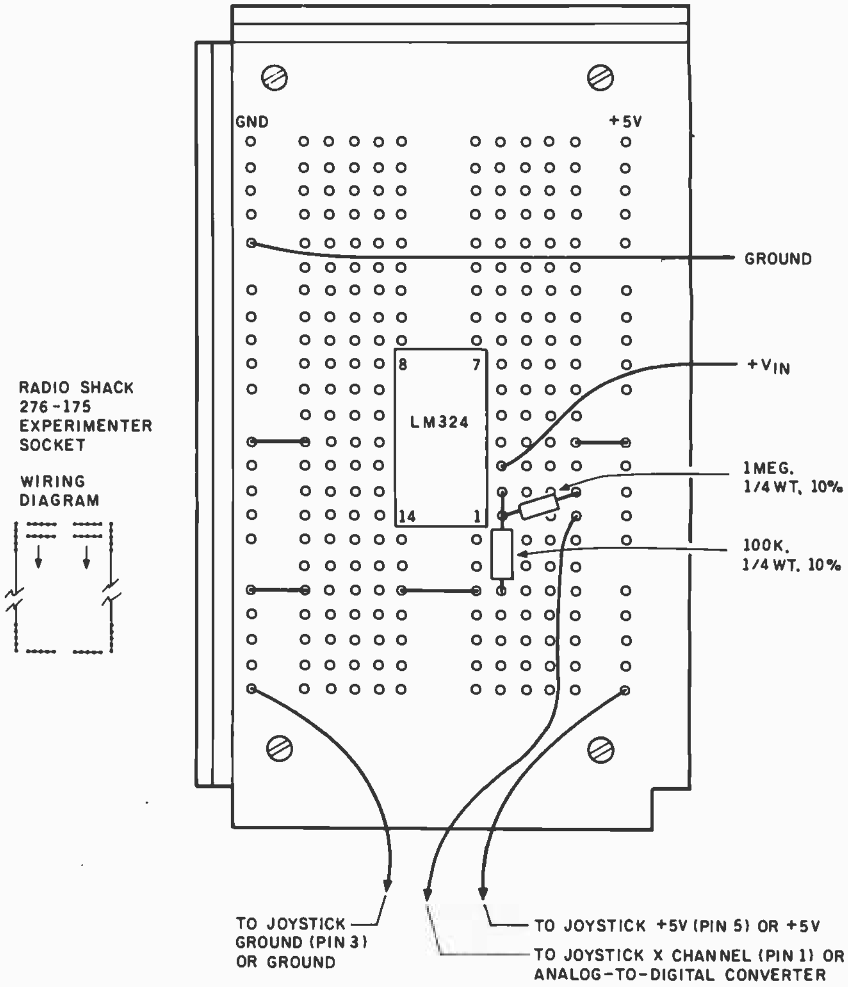

Figure 5: *Component layout for a noninverting op amp on a prototype board. Again, three components suffice.*

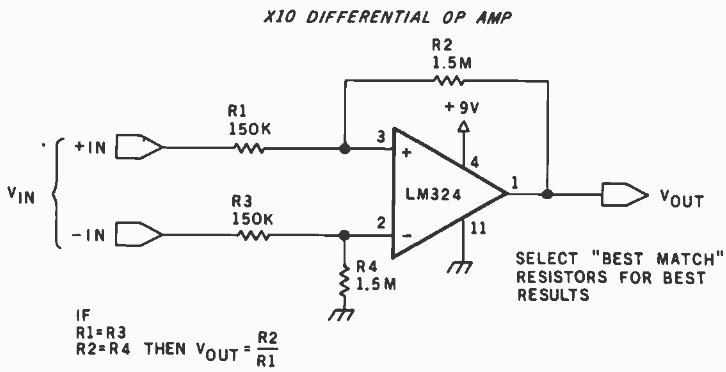

Figure 6: *A differential op amp amplifies the differential voltage across two inputs. These inputs come from many transducers. Gain is similar to the inverting type of op amp.*

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Condition	Output (in volts)
Direct sunlight at 0900	0.535
Turned 90 degrees from sun	0.490
Facing sun, overcast	0.482
Turned 180 degrees from sun	0.478
Outdoors, shade gradations	0.39 to 0.445
Inside house, day, facing window	0.225
Inside house, day, facing inside	0.065
Inside house, dark hallway	0.003
Inches from 75-watt lamp	
6	0.426
12	0.359
18	0.228
24	0.163
30	0.116
36	0.085

Table 1: *Measured performance of the solar cell used as a light detector.*

Voltage with No Load	Load Added (ohms)	Resulting Voltage with Load Added	Resulting Current with Load Added (in milliamperes)
0.482	8.6	0.30	37.00
0.4	46.8	0.35	6.29
0.4	36.5	0.33	7.52
0.4	23.4	0.27	9.45
0.4	8.6	0.13	13.88

Table 2: *Effects of an electrical load on the solar cell.*

Listing 1: *A simple BASIC light-detector program for use with the solar cell. A warning tone sounds when a light activates the solar cell.*

```
100 'X10 FOR LIGHT DETECTOR
110 A=JOYSTK(0)
120 IF A>0 THEN SOUND 100,1
130 GOTO 110
```

Listing 2: *A BASIC program for reading and displaying solar-cell output. The solar cell is connected to the right joystick by the x channel.*

```
100 'X5.6 OP AMP FOR SOLAR CELL
110 CLS
120 A=JOYSTK(0)
130 PRINT @ 256+5,"JOYSTICK VALUE=";A
140 PRINT @ 288+5,"A/D V=";INT((A/64)*4.9*100)/100
150 PRINT @ 320+5,"CELL V=";INT((A/64)*4.9/5.6*100)/100
160 GOTO 120
```

The configuration shown uses a ×10 amplifier.

A Solar-Cell Light Detector

Solar cells are designed to convert sun or incandescent light into electricity. In recent years, solar cells have improved both in cost and efficiency.

The unit I tested was a Radio Shack cell (part number 276-124); similar products are available from Edmund Scientific (101 E. Gloucester Pike, Barrington, NJ 08007). Normally you think of solar cells as energy converters, but of course they work quite well as light detectors too.

On a clear day at 25° Celsius (C) at noon in direct sunlight, the cell produced about 0.535 V and 0.18 ampere, or about 0.1 watt. When the cell is taken out of direct sunlight, its output falls rapidly. Table 1 lists voltages developed under different lighting conditions and light sources.

Some other results might prove interesting. The solar cell was not responsive to any degree to infared light. Voltage dropped considerably when the load on the cell output was increased as shown in table 2.

You can activate the solar cell with a flashlight. Because it has a large surface area compared with that of a photocell or other photosensitive device, your aim doesn't have to be precise. Using the ×5.6 op amp and the Color Computer program in listing 1, the flashlight could be detected from 8 feet away. With the ×10 op amp, the input exceeds the linear range of the circuit, but the flashlight beam is detected from 16 or 20 feet.

Listing 2 is a general BASIC program for use with the ×5.6 op amp and solar cell.

Readers may want to compare the solar-cell circuit with another photosensitive circuit that uses the Radio Shack cadmium-sulfide photocell (see "Color Computer from A to D," December 1981 BYTE, page 134). This device puts out a decreasing resistance as light intensity increases; resistance varies from about 20 ohms in sunlight to 5 megohms in the dark. The cadmium-sulfide photocell can be used in a voltage-

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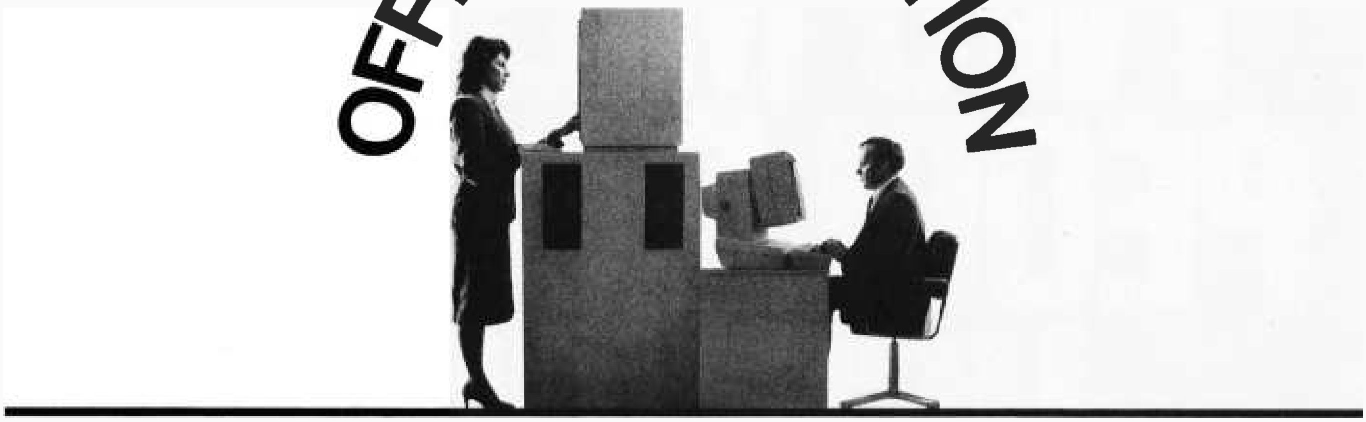

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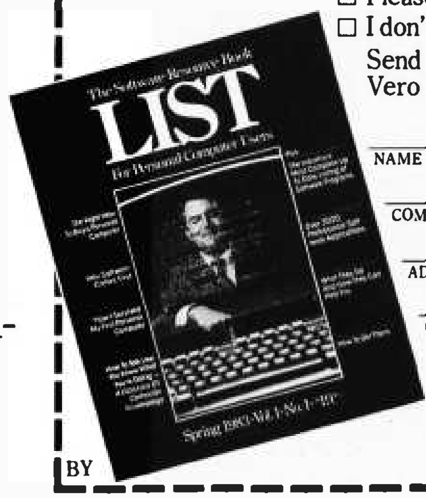

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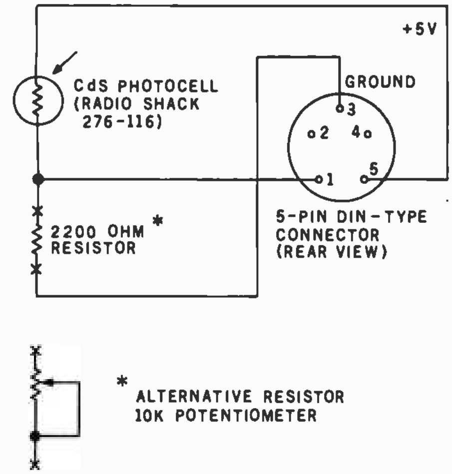

Figure 7: *The cadmium-sulfide photocell changes resistance with light. You can use a simple voltage divider to convert the resistance change to voltage input for an A-to-D converter.*

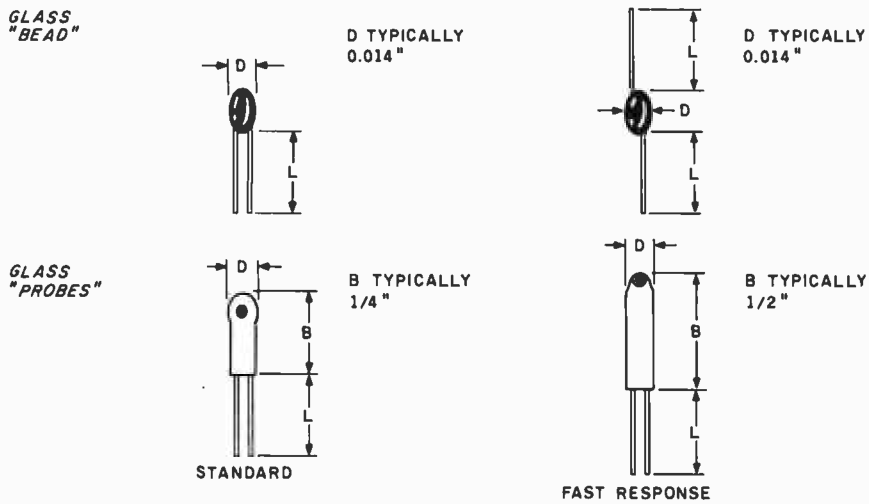

Figure 8: *Thermistors come in a variety of shapes and sizes. Response time is generally better for smaller thermistors.*

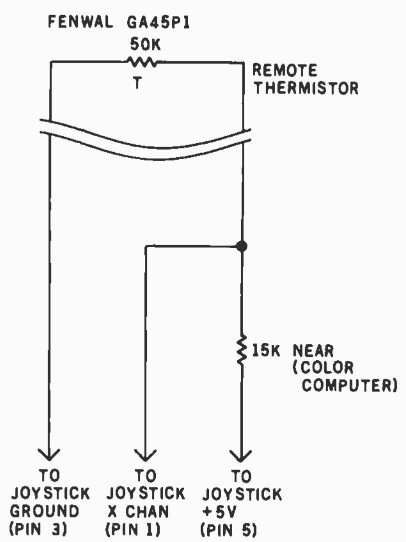

Figure 9: *You can convert thermistor-resistance change into a corresponding voltage for input to an A-to-D converter with a voltage divider.*

divider circuit as shown in figure 7.

A Thermistor Temperature-Sensing Circuit

In the December 1981 article, I discussed a thermistor, another device that puts out a varying resistance, in this case, according to ambient temperature. The device chosen for that article was ill-suited for a computer system input; it was a large thermistor, like those found in television sets, used to detect overcurrent conditions.

Plenty of available smaller thermistors are very sensitive to small changes in temperature and respond within a second or less. One of the chief suppliers of such devices is Fenwal Electronics (63 Fountain St., Framingham, MA 01701). They carry a complete line of every available thermistor and have local distributors.

The Fenwal (and other) thermistors come in many different sizes and packages, some of which are shown in figure 8. Generally, the smaller the package, the more sensitive the thermistor. The "probe" package is intended for immersion in liquid.

The nominal resistance (e.g., the resistance at 25°C) of Fenwal thermistors ranges from about 1000 ohms to 10 megohms. Prices are on the order of a few dollars, depending upon the package type.

In my test setup I used a Fenwal GA45P1 thermistor. This is a 50k-ohm thermistor in a standard glass probe configuration that responds (changes resistance) within a few seconds. The input to the A-to-D converter is shown in figure 9.

The resistance of the GA45P1 for various temperatures is shown in table 3, along with the expected voltage at the junction of the voltage divider. The R_{coeff} is the coefficient to be multiplied times the 25°C resistance to find the resistance at various temperatures. You can see that the resistance/temperature curve is far from linear. You've got to deal with wide extremes in resistance.

I used a Color Computer BASIC program to read in the voltage-divider values and came up with the readings in table 4. These values

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−10	14	6.12	306,000	4.71
0	32	3.51	175,500	4.55
10	50	2.08	104,000	4.32
20	68	1.27	63,500	4.04
25	77	1.00	50,500	3.81
30	86	0.794	39,700	3.59
40	104	0.510	25,500	3.11
50	122	0.336	16,800	2.61
60	140	0.226	11,300	2.12
70	158	0.155	7,750	1.68

$$V = 4.95 \left(\frac{R_T}{15{,}000 + R_T} \right)$$

Table 3: *Resistance of the thermistor changes drastically over a short temperature range.*

Temp. °F	VOM Reading	Color Computer JOYSTK (0)
116	2.83	36
110	2.92	37
104	3.07	39
100	3.23	41
96	3.41	44
90	3.49	45
85	3.64	48
80	3.73	49
57	3.94	52
41	4.33	57

Table 4: *Sample data compares actual voltage readings at junction of voltage divider and Color Computer JOYSTK(0) values.*

Listing 3: *A BASIC program to compute temperature based on inputs from GA45P1 thermistor; the program utilizes table lookup and interpolation.*

```
80 'GA45P1 THERMISTOR I/O
90 CLS
101 DATA 14,4.71,4.55,32,4.55,4.32,50,4.32,4.04,68,4.04,3.59
102 DATA 86,3.59,3.11,104,3.11,2.61,122,2.61,2.12
103 DATA 140,2.12,1.68,-1,-1,-1
109 CLS
110 A=JOYSTK(0)
120 V=(A/63)*(4.95)
130 RESTORE
140 READ T,V1,V2
150 IF (T=-1 OR V>4.71) THEN PRINT "OUT OF RANGE":STOP
170 IF ((V>=V2) AND (V<=V1)) THEN GOTO 180 ELSE GOTO 140
180 V=((V1-V)/(V1-V2))*18+T
190 PRINT @ 256+10,INT(V*10)/10,"     "
200 GOTO 110
```

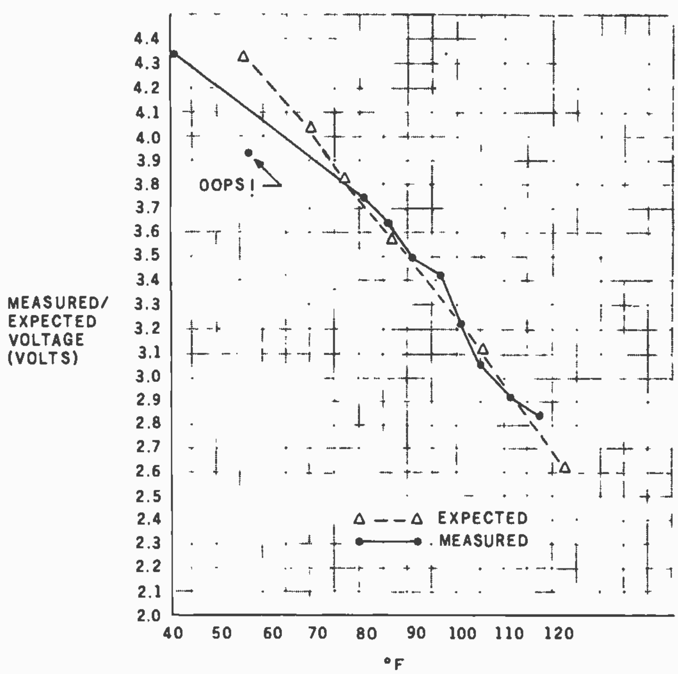

Figure 10: *Test results for the thermistor. Data compares favorably with expected results except for one anomaly.*

represent the voltage normalized to JOYSTK values of 0 through 63; each count represents about 78 mV (5 V/64).

You will see in listing 3 a more elaborate BASIC program that interpolates values based upon resistance values from table 3.

Plotting the expected voltages at various temperatures versus measured values produced the plot shown in figure 10. Rather than fake the readings, as we used to do in the university physics lab, I left in the anomaly. I varied the temperature by immersing the probe in a container filled with ice or hot water.

Although the thermistor loses sensitivity (in this setup) at temperature extremes, it is still a very useful device because it is small, uncomplicated, and inexpensive. Large thermistor values will be unaffected by long runs of wire, so the device can be located quite a distance away from the computer. Resolution from 0°C to 51°C is fine, allowing you to detect changes in temperature as small as 2.2°C (e.g., you can tell the difference betwen 0°C and 2.2°C).

Another important aspect of thermistors is the *self-heating mode*. If current through a thermistor increases without limit, the thermistor resistance drops, increasing the current, and so forth, until thermal runaway occurs, burning up the thermistor. However, this self-heating mode can be initiated and held in check by a suitable series resistance. The thermistor will then heat up to 100°C or so. Any change in ambient

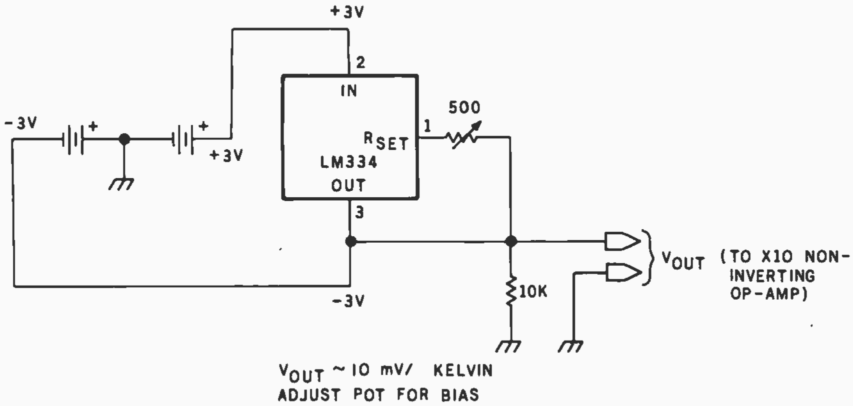

Figure 11: *An LM334 temperature sensor can be biased so that output is midrange. Voltage output changes about 10 mV per degree C.*

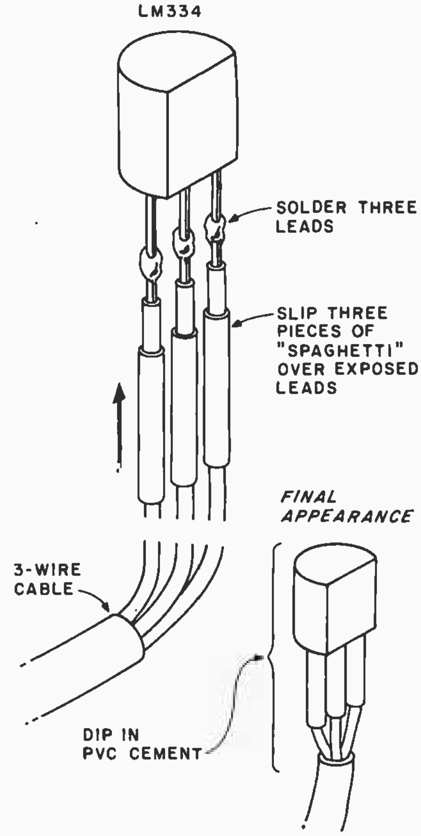

Figure 12: *The LM334 comes in a small package, which can be waterproofed. The sensor can be located long distances away from the A-to-D converter and computer.*

conditions now affects the thermistor temperature and also the current flow through the thermistor. Blowing on the thermistor, for example, will take heat away from the thermistor by convection, as will fluids flowing by. You can create excellent flowmeters (including anemometers), vacuum pressure gauges, and similar types of instruments with thermistors operating in the self-heated mode. See Fenwal specifications if you'd care to experiment.

An LM334 Temperature-Sensing Circuit

An alternative approach to computer temperature sensing is the use of an LM334 (Radio Shack part number 276-1734) temperature sensor and adjustable current source. In addition to its customary use as a current limiter, the LM334 also offers temperature-sensing capability. Its output voltage will change approximately 10 mV per Kelvin, according to published specs. Kelvin? Since you rarely deal with absolute zero in the three computer systems (except when interfacing to some assistant electronics store managers) let's think in terms of degrees Celsius or Fahrenheit. For every °C (1.8°F), the output will change by 10 mV. An 18°F change will result in a change of 0.1 V, and a 72° F change will result in a change of 0.4 V. These changes are too small by a factor of 10 for your A-to-D converter, but you have the ×10 amplifier.

Note that the temperature changes are linear, unlike the thermistor. A 1-degree change in temperature always results in a 10-mV change in output!

Figure 11 shows the circuit I used in this application. This circuit "floats" the LM334 between +3 V and −3 V. The 500-ohm potentiometer is adjusted until the output is about midscale (2.5 V) for the center temperature in the range. The output of the LM334 goes to a noninverting ×10 op amp, which then connects to the A-to-D-converter channel.

For this test setup, I used an LM334 on a long wire, as shown in figures 12 and 13. An advantage of this circuit, by the way, is that it is current-driven, allowing long runs to the sensor. The assembly was dipped in PVC (polyvinyl chloride) cement for waterproofing.

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Circle 131 on Inquiry card.

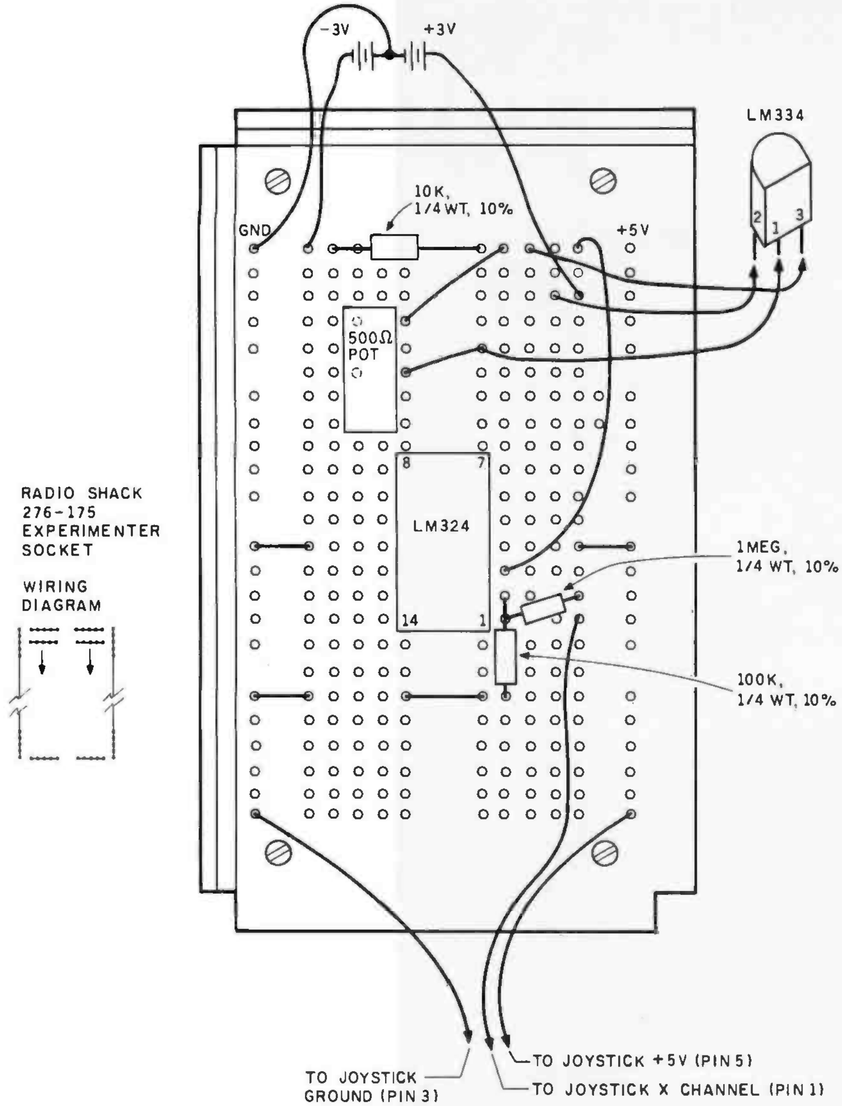


Figure 13: *You can build the complete LM334 temperature-sensing circuit on a prototype board by using five components plus the sensor.*

The graph in figure 14 represents the test results. The slope of the line shows about 10 mV per 0.972°C, which compares favorably with the expected results. Here, the range of input temperatures was about 37°F through 91°F. Adjust the potentiometer for the range you require or use less amplification in the op amp.

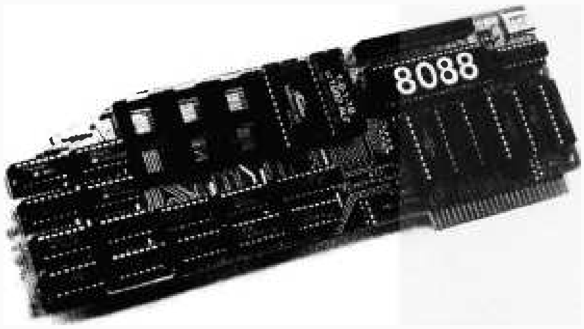
The LM334 makes an excellent temperature sensor, and I would tend to prefer it to the thermistor method for precise temperature readings. Changes in temperature of about 1.2°F can be detected with the circuit described in this section.

DC Motors Used as Generators

Radio Shack and many other suppliers sell small DC motors that will operate from 1.5 V through 6 V DC and rotate as fast as 8,000 or 10,000 rpm (revolutions per minute). You can also use a small permanent magnet DC motor as a generator if an external force turns the shaft and you have motor leads as power sources. Is it feasible to use a DC motor's generating capacity to measure rotational speed? Here's what I found out.

The motors I used were Radio Shack part number 273-208. They are specified for 1.5 V to 6 V DC and 3550 rpm with no load. Figure 15 shows the test setup. A variable power supply drove the motor on the left. The motor on the right was driven by the first motor, via a piece

The speed and power of an IBM PC on a $345 Apple® card.



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ALF's AD8088 Processor Card adds a fast 16-bit 8088, the processor used in the IBM PC, to your Apple II. It runs programs from its on-board memory at a full 5 MHz—12% faster than the IBM PC—while the Apple also runs at full speed. And two or more AD8088's can be used in one Apple, to tackle problems that are beyond many mainframe systems.

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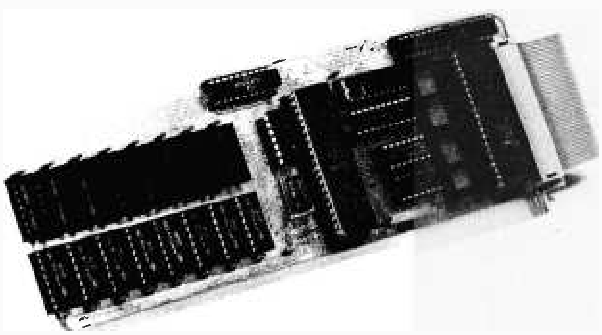

THE 8087 NUMERIC DATA PROCESSOR

The AD128K Memory Card features a socket for the Intel 8087 Numeric Data Processor. The 8087's 80-bit internal format gives 18 digits of accuracy (Applesoft has only 9). Its speed is equally impressive: it multiplies two 80-bit floating-point numbers faster than the Apple runs 10 machine codes!

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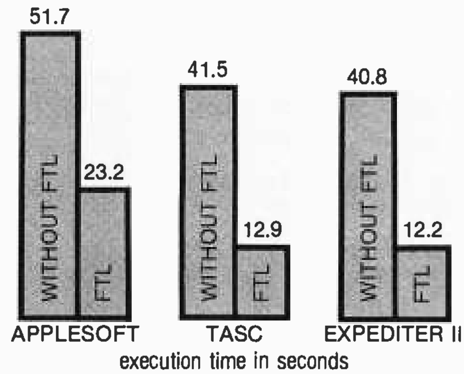
```
10 PRINT "2 3 ";
20 FOR B = 5 TO
   1000 STEP 2
30 FOR C = 3 TO
   SQR (B) STEP 2
40 IF B/C = INT
   (B/C) THEN 70
50 NEXT
60 PRINT B;" ";
70 NEXT B
```

Program to compute prime numbers from 2 to 1000.



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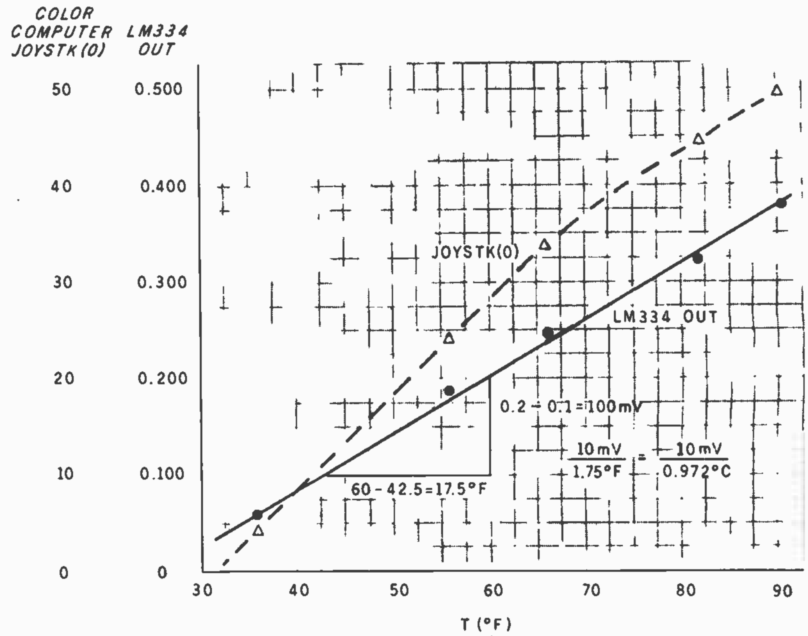

T	LM344 OUT(V)	LM324 OUT VIA COLOR COMPUTER JOYSTK(0)
37°	0.064	4
57	0.186	24
67	0.245	33
82	0.323	44
91	0.376	48 (LIMIT)

Figure 14: *Test results for LM334 show that the manufacturer didn't exaggerate. The LM334 is indeed an excellent device for sensing even small variations in temperature.*

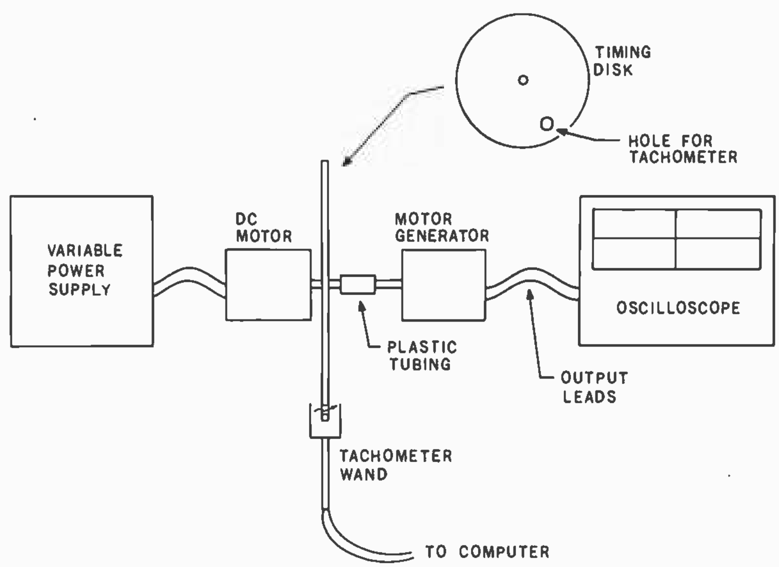

Figure 15: *The test setup for measuring DC voltage output from a DC motor used as a generator. The right-hand motor is driven physically by the left-hand motor through a coupling made of plastic tubing. I used a tachometer wand to measure speed of rotation.*

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	OLIVETTI M20 Personal Computer	IBM Personal Computer	Apple III Personal Computer	Xerox 820 Personal Computer
True 16-bit microprocessor*	**YES**	No	No	No
Standard memory	**128K**	64K	128K	64K
Maximum memory	**512K**	512K	256K	64K
Expandability	**5 extra expansion slots in sample configuration****	No extra expansion slots in sample configuration**	4 extra expansion slots in sample configuration**	No expansion slots
Diskette storage (per drive)	**320K**	160K	140K	92K
Mass storage (per drive)	**11MB hard disk**	None	5MB hard disk	None
Display capability	**High-resolution B/W or high-resolution color**	High-resolution green or color	High-resolution green or color	High-resolution B/W
Built-in screen graphics	**YES**	No	Yes	No

*Defined as 16-bit microprocessor with 16-bit bus

**Sample configuration means system includes display, dual-disk drives, printer and RS 232C communicator.
NOTE: Chart based on manufacturers' information and configuration available as of August, 1982

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M20 Personal Computer

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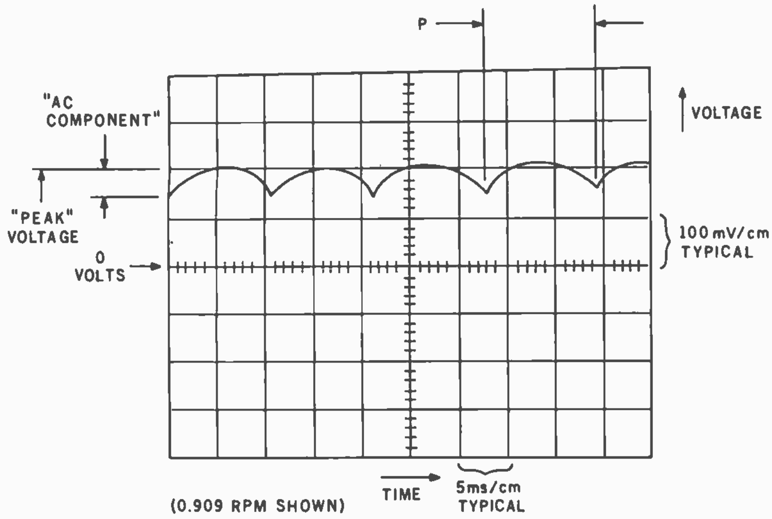
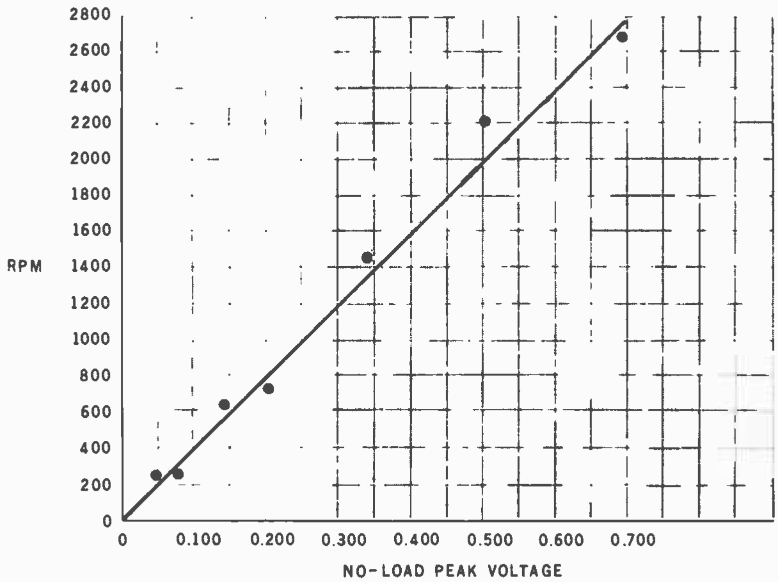


Figure 16: *Typical output from a motor generator shows the AC component on top of the DC level. You can find the speed of rotation by timing the peaks of the AC component.*



RPS	*RPM*	*PEAK V*	*AC*
4	240	0.05	0.016
5	300	0.075	0.025
11.1	666	0.140	0.040
13	778	0.20	0.070
24.4	1464	0.33	0.090
37	2220	0.50	0.16
46.5	2790	0.68	0.24

Figure 17: *A plot of the DC voltage for various rotational speeds shows that output is more or less linear. Output is about 0.68 V for 2790 rpm.*

of plastic tubing. I monitored the output of the motor generator with an oscilloscope. The motor on the left had a disk with small circular cutout so that I could include the tachometer wand described in the next project to measure rotational speed of the shaft.

The motor on the left produced about 2200 rpm with a supply voltage of about 1.2 V. I got up to 4000 rpm, but at this speed the motor had the characteristic ozone smell that anyone who has ever pushed a model electric train to its limit will recognize.

A typical output from the motor generator appears in figure 16. There is an AC component on top of a DC level. This AC component handles about the same proportion of the output regardless of speed. The period between "breaks" (low points) on the AC component is one sixth of the actual period for the speed of the motor. In other words, the motor *commutates* (reverses current direction) six times per revolution, and the true rotational speed is given by:

revolutions per second = 1/(P × 6)
or rpm = 10/P

This suggests that an A-to-D-converter circuit that was fast enough could derive the rotational speed of the motor generator directly from the output waveform by measuring the period between breaks. The A-to-D-converter software would have to be in assembly language, of course.

The voltages produced for various rotational speeds are shown in figure 17. The output is linear, and ranges from 0 V through 0.68 V for speeds from 0 through 2790 rpm.

I did not measure the output of the motor/generator with an A-to-D converter. Before you do, you should filter the output to smooth "ripple" and get rid of noise spikes generated by motor mechanical actions. If you want to retain the AC component, bypass noise spikes by putting a 0.1-microfarad capacitor to ground from the motor output. It might also be a good idea to use a zener diode to limit the input and prevent excessive voltage. These schemes are shown in figure 18.

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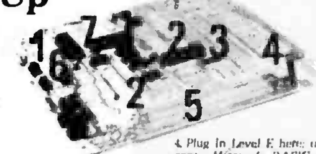

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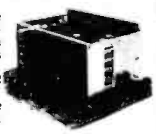

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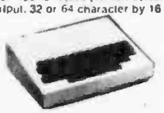

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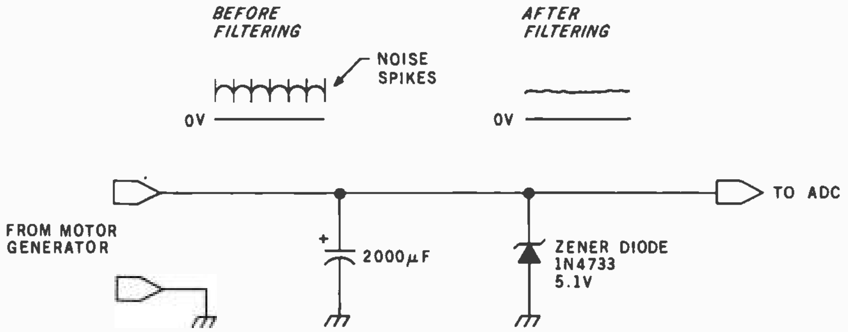


Figure 18: *You can filter the motor generator output to smooth "ripple" and eliminate noise spikes. A zener diode provides overvoltage protection.*

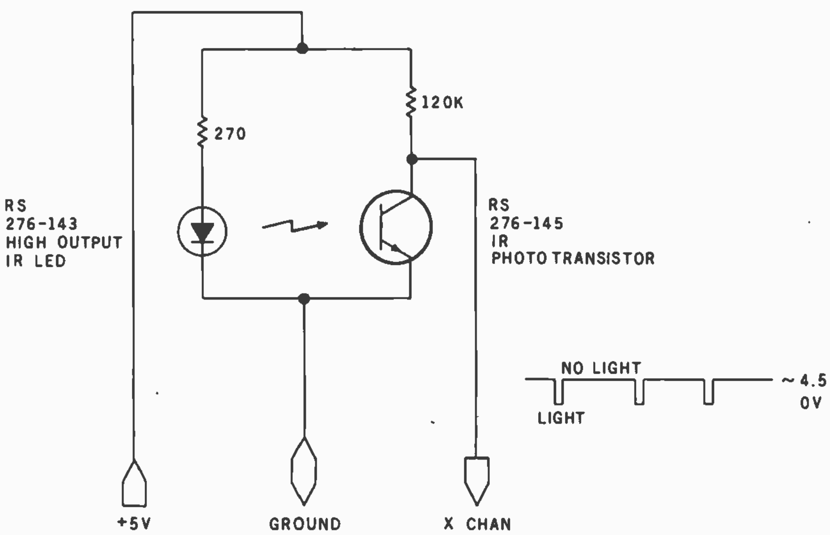


Figure 19: *The tachometer-wand circuit uses an infared LED and receiving phototransistor. The period of the pulse output can be easily measured by the Model I/III or Color Computer.*

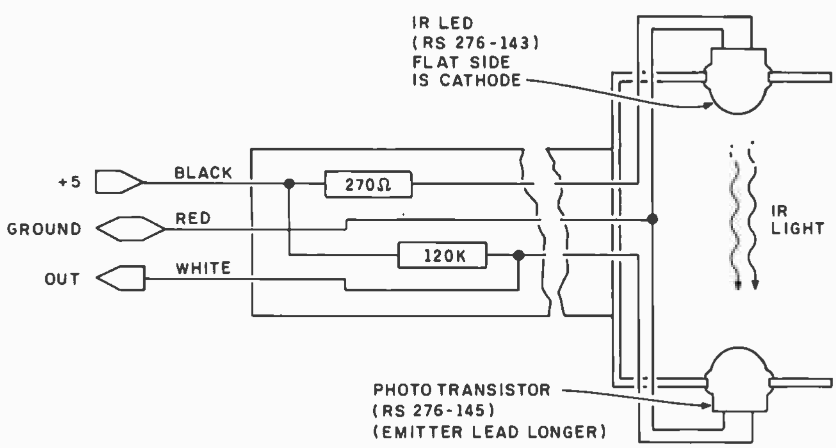


Figure 20: *Components for a tachometer wand fit inside a Vector Slit 'N Wrap tool. An LED and phototransistor fit existing holes in the U-shaped portion of the tool.*

A Tachometer Wand

I used a tachometer wand to measure rotational speed. I described the circuit for this in "Ports of Entry and Soft Breezes for the Color Computer and Model III" (May 1982 BYTE, page 162) and summarized it in figure 19. The circuit uses a high output infared LED (light-emitting diode; Radio Shack part number 276-143) and an infared (IR) phototransistor (Radio Shack part number 276-145). When the IR light is blocked, the phototransistor output goes to about 4.5 V. One word of warning: Use the wand away from a strong incandescent light source; there is enough IR component in such light to trigger the phototransistor.

I mounted the wand in a Vector Slit 'N Wrap wiring device (a somewhat expensive way to fabricate it!). The Slit 'N Wrap tool (Vector Electronic Company, 12460 Gladstone Ave., Sylmar, CA 91342) needs no modification except to cut off the wrapping end with a hacksaw. The two resistors are mounted within the barrel of the tool, and the two IR devices fit perfectly into the holes of the U-shaped section of the tool (see figure 20).

Refer to my May 1982 article to get some ideas on assembly-language programs to read rotational speed directly.

A Pressure Transducer

The last device I'll consider here is a National Semiconductor LX0503A pressure transducer. This device is the most expensive of all I considered but is still less than $20. The LX0503A converts pressure into voltage and operates in the range of 0 to 30 pounds per square inch (psi). Normal atmospheric pressure is about 14.7 psi.

The device is pictured in figure 21. It is similar to a TO-5 package (a typical metal-can transistor), with an inlet port on the top of the can. Eight leads come out of the device, five of which are used in this project.

Figure 22 shows the circuit for the LX0503A. A piezoelectric crystal element forms one leg of the bridge. Voltage output is measured between V2 and V1. This is a differential-type

output, in which V2 goes more negative and V1 goes more positive as the pressure increases. Output changes approximately 2 mV to 8 mV with a change in pressure of 1 psi. You can see that over the range of 30 psi there will be a change of 60 mV to 240 mV and that some amplification is going to be required. Power-supply voltage is from about 5 V to 12 V.

The National Pressure Transducer Handbook (from National Semiconductor, 1981 ed.) contains recommended interface circuits for the transducer. It places a strong emphasis on temperature compensation. For environments in which there will be no radical changes in temperature, however, you can dispense with the temperature-compensation electronics and greatly simplify the circuit. Furthermore, supplying the excitation voltage directly to the VT terminal (instead of to the VE terminal) increases the sensitivity of the device. I measured about 10 mV per psi with a 9-V supply when I used the circuit shown in figure 23.

At normal ambient pressure, the output of V1 referenced to ground is about +4.71 V, the output of V2 is +4.55 V, and the differential, of course, is 0.16 V.

The output of the LX0503A in this case went to a ×10 noninverting differential op amp. The static output was about 1.6 V. Testing was far from ideal. I used a rubber bulb to increase the pressure via a piece of plastic tubing slipped over the inlet port. Maximum readings obtained were 2.4 V, indicating a pressure of about 22 psi. The output of the device is linear, and I have no doubt that further testing would reveal it to be an accurate pressure transducer.

The LX-series pressure transducers come in a number of different ranges and two versions: absolute (such as the LX0503A) and differential. The differential type measures the

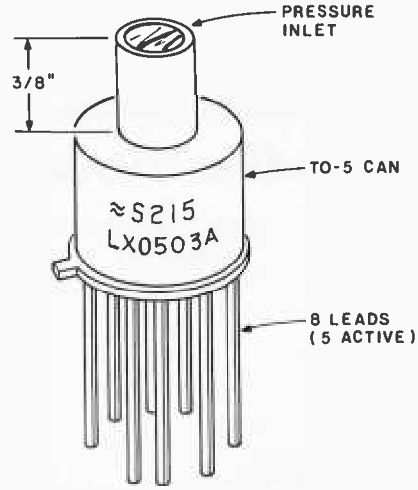
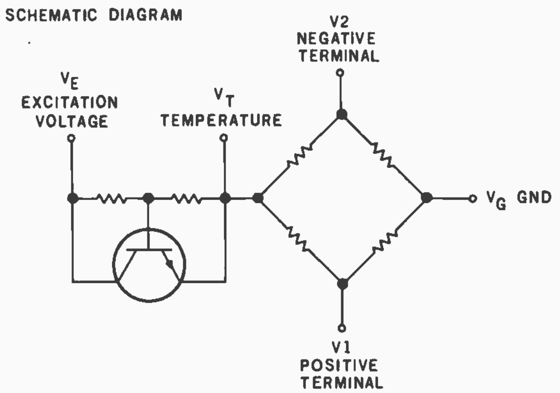


Figure 21: *National Semiconductor LX0503A pressure transducer has a T0-5 metal-can transistor with an inlet pressure port on top. Connect the port via plastic tubing to the location at which the pressure is to be measured. Pressure reference is a vacuum.*



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SYMBOL	LX05XX	LX06XX
V_E	3	5
V_T	7	1
V_1	6	3
V_2	5	4
V_G	8	2

Figure 22: *Schematic diagram of LX0503A shows that the device is essentially a bridge with a piezoelectric element. The temperature-compensation circuit may be bypassed for noncritical applications.*

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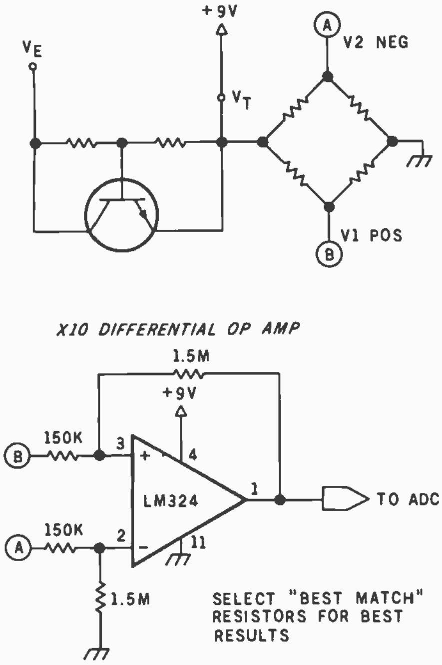

Figure 23: *The output of the LX0503A is fed into a ×10 op amp. Output in this case is from two terminals that create the differential.*

pressure difference between two inlet ports; the absolute type is referenced to a vacuum. Available pressure ranges for either type are 0-30, 0-100, 0-1000, and 0-3000 psi.

You might consider designing a barometer driven by the LX0503A. With suitable biasing and another stage or two of amplification, a sensitive working barometer is possible.

In Conclusion

I've concluded the 12-part series on the TRS-80 with a small sampling of some of the inexpensive switches, transducers, and other devices that you can use to interface your Model I/III or Color Computer to the real world. There's no reason that your small computer couldn't monitor temperature, pressure, ambient light and other physical quantities and effectively control your home without an outlay of thousands of dollars. All three systems offer unlimited opportunities for control and monitoring of their surroundings. It's up to you to put some of these ideas in practice! ■

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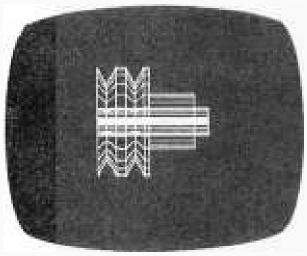

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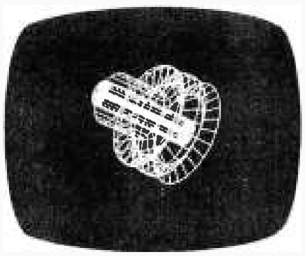

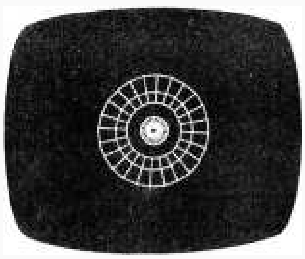

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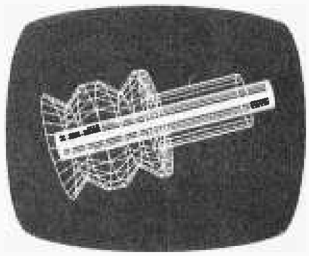

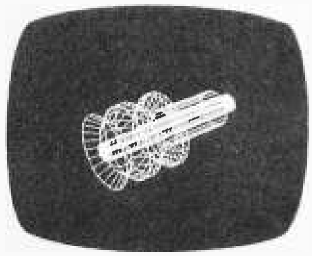

other popular microcomputers will be available soon.) Because it's an entry-level system, the Space Tablet is being used creatively in ways not normally associated with larger, far more costly CAD/CAM systems . . . molecular modeling, physical therapy programming, cell structure analysis, weapons research, medicine, art, architectural planning and, of course, design and engineering. Additional applications are being discovered by OEM purchasers. And, for those needing a 2-dimensional digitizer, the Space Lift arm can be held as a pen, or stylus, to trace slides, X-rays, pictures, graphs, maps and more. We see it as a tool to unleash the imagination.

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A Graphics Primer

Microcomputers can create a surprising variety of graphics.

Gregg Williams
Senior Editor

Computer graphics—those words conjure up images from movies like *TRON* and *Star Wars* or the sophisticated animation used in television ads. True, it took Nelson Max several seconds *per frame* of computation on a Cray I maxicomputer to create an animated film called *Carla's Island*. But that doesn't mean that you and your microcomputer are completely left out. Every arcade-like game you play on your microcomputer is an example of computer graphics, as is every pie chart created by a business-related program. In fact, it's possible that your microcomputer has picture-drawing capabilities you don't know about.

My purpose in this article is to sketch the contours of microcomputer-based graphics in broad strokes, you might say. I've included a bibliography of graphics articles that have appeared in BYTE as well as a selective list of vendors of graphics-related devices.

Raster-Scan Video Images

If you have a computer, you almost certainly have some graphics capability, and that probably means some kind of raster-scan graphics. Raster-scan graphics are those produced by a video display that is similar to a normal television display. Simplifying vastly, in a raster-scan video display an electron beam traces many horizontal lines across the face of the video display (in the United States, 262 lines, noninterlaced, to be exact). By modulating the strength of the electron beam, the signal sent to the video display can create an image on the screen by building it up line by line (see figure 1). Of course, the circuitry connecting the computer and the video display must decode the desired image and send the appropriate signal to the video display at a very high speed (in the U. S., one "line" of data every 63.5 μs). The video display doesn't care what kind of decoding the computer makes as long as it sees a standard video signal. Because of this, different computers can create different kinds of video graphics. Most computers can create character graphics and/or pixel graphics in either monochrome or color, and sometimes both.

At this point, I should mention briefly that there are several types of video monitors used to display color graphics. In order of increasing quality and expense, they are: an unmodified color television, a composite video monitor, and an RGB monitor. An unmodified color television is used with many microcomputers simply because the user probably already owns one. A composite-video monitor accepts a combined color signal, minus the radio-frequency modulation used to transmit it over the airwaves; these monitors cost more than ordinary color televisions, but they provide a better picture. An RGB monitor takes as input three signals and sends them to three separate electron guns—one for each of the primary additive colors: red, green, and blue. It is still more expensive than the other two kinds of displays, but it has the best picture of the three.

Character graphics are universally available on microcomputers. The simplest form of character graphics is composed of characters themselves—the various letters, numbers, punctuation marks, and other symbols that the computer uses to communicate with you. If you don't have any other kind of graphics, you can certainly do some simple graphics using @ signs, exclamation points, underlines, and letters. In fact, in the early days of microcomputers character graphics were all hobbyists had!

Now, though, most microcomputers have *character subcell* graphics, in which the area normally used to display a character is broken into several rectangular or square subcells (e.g., three rows by two columns for the Radio Shack TRS-80 Model III). To make character subcell graphics

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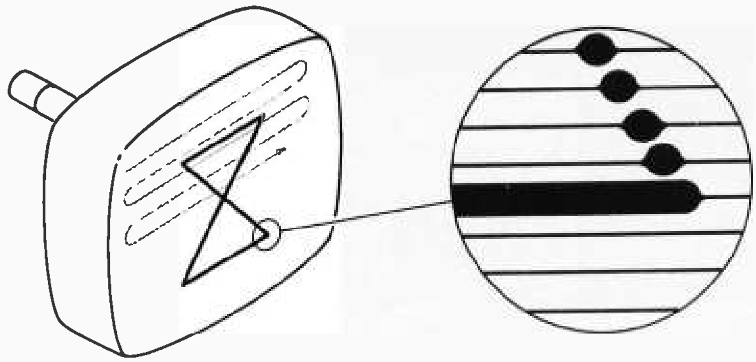

Figure 1: *A raster-scan image. In a raster-scan display, an electron beam is repeatedly swept across the video display tube in a series of horizontal lines, as shown by the arrow running back and forth across the face of the display (the dotted line indicates that the electron beam is turned off as it returns to the left margin of the display). By varying the intensity of the beam, the controlling electronics can create an arbitrary image on the display.*

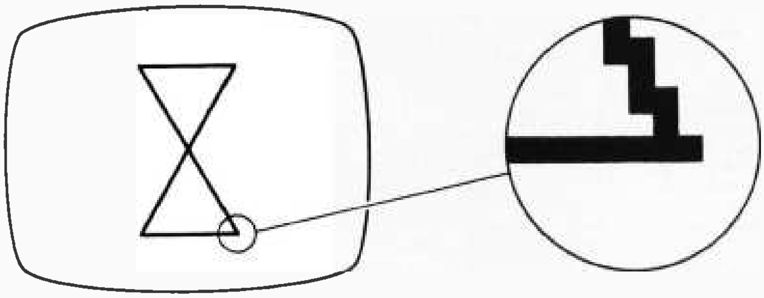

Figure 2: *A pixel image. Here, the video display is subdivided into a row-and-column array of square pixels (picture elements), which can be turned on to create an arbitrary image. Notice the "stair-step" effect on diagonal lines.*

work, you have to be sure that every on/off combination of subcells can be displayed—otherwise, you may need a subcell pattern that can't be displayed, limiting the usefulness of the graphics. If you're lucky, the computer will have built-in software that will turn an arbitrary subcell on or off; otherwise, you'll have to do it yourself—calculate which character the subcell is, determine which character position the current subcell combination is, determine which character the *new* combination is, and change the character at the given position. Computers that have only character subcell graphics include the TRS-80 Model III, the Timex/Sinclair 1000, and the Commodore VIC.

Before talking about *pixel graphics*, a few words on the pixel. An abbreviation for the phrase "picture element," a pixel is the smallest unit of video display that, when packed in a contiguous row-and-column arrangement, can be used to create an arbitrary image (see figure 2). A pixel is usually square or rectangular, although it may appear to be round if it is small enough. Pixels can assume at least two colors (one of them is usually black). If it has only one color other than black, a pixel can be used to create monochrome graphics; otherwise, it can be used to create multicolor graphics.

Different computers use different kinds of pixel graphics. The Apple II, for example, has two pixel graphics modes, called low-resolution and high-resolution (often abbreviated as LORES and HIRES). Although "low" and "high" are only relative terms, we should note that Apple II low-resolution graphics have 48 by 40 pixels (i.e., 48 rows of 40 pixels each) with 16 colors available; its high-resolution graphics have a stated resolution of 192 by 280 pixels (192 rows of 280 pixels each) with 4 colors (plus black and white). The Atari 400/800 has several graphics modes with up to 4 colors in a given mode; its highest-resolution mode is monochromatic, with a stated resolution of 320 by 192 pixels. (The number of pixels per row is actually half of that stated by the manufacturer, due to limitations inherent in the television sets used to display the video image.)

Strictly speaking, the TRS-80 Model III uses subcell character graphics, but we can call them pixel graphics because the software included in ROM (read-only memory) makes the subcells act like pixels—they can be individually turned on or off. An advantage that offsets the "coarse" graphics of the TRS-80 Model III is that the standard TRS-80 character set of letters, numbers, and symbols can be intermixed with the subcell character graphics. With most pixel graphics modes, on the other hand, you must build up alphanumeric characters by turning on individual pixels.

If your microcomputer doesn't have a graphics mode (most CP/M systems don't), all is not lost. Some microcomputers have add-on boards that provide high-resolution monochrome or multicolored graphics to a given system. (See the accompanying text box for the names of companies that sell such products.)

Pros and Cons

What are the advantages and disadvantages of raster-scan displays? The only advantage I can think of is their universality in microcomputer systems. To some extent, what you learn about raster-scan displays on one machine can be adapted to another machine. On the other hand, they have several disadvantages. First, they use large amounts of memory; each pixel must be represented in memory by one or more bits (one for monochrome, two for up to four colors, three for up to eight colors, and so on). Although memory continues to decline in price, it still can contribute significantly to the total cost of a system if high-resolution graphics are used. NEC In-

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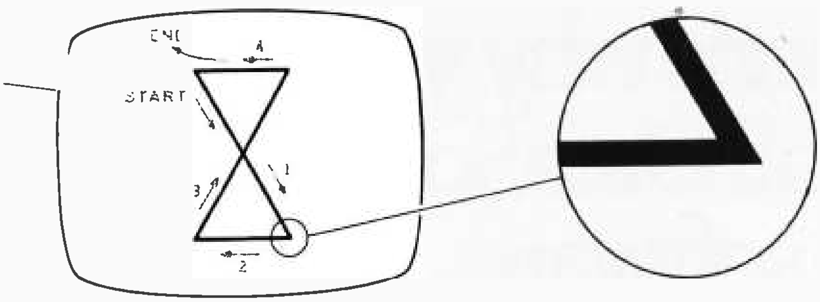

Figure 3: *A vector image. Here, the electron beam does not trace out closely spaced parallel horizontal lines. Instead, the controlling electronics move the electron beam to directly paint the desired image onto the face of the video display tube. (The numbered arrows show the order in which the line segments of the image are drawn.) Notice the lack of "stair-steps" on diagonal lines.*

formation Systems' new Advanced Personal Computer, for instance, has a graphics option with 1024 by 1024 pixel, 8-color graphics—it uses almost 400K bytes of memory and costs about $800. In some computers (the Apple II and the NEC PC-8001, for example), the designers used less memory than otherwise would have been necessary by limiting the number of colors possible for adjacent pixels. This does save memory, but it occasionally causes odd imperfections in the graphics display, the causes of which are not immediately obvious.

Another major disadvantage of raster-scan graphics has to do with the software needed to manipulate graphic images. If you want finer-resolution graphics, you will have to change more bits to create or move an image. What's more, the bits to be moved are scattered throughout memory. These two factors contribute to increasing the amount of computation needed to change an image to astronomical proportions. The disadvantage has prompted such companies as Texas Instruments and Atari to invent new ways of moving small graphics images (called *sprites* and *players*, respectively) by changing as few as two bytes. Thus the microprocessor uses a much smaller percentage of its time simply moving the image.

Another noticeable weakness of raster-scan displays is their inability to draw diagonal lines well. Although this problem is minimized with higher-resolution displays, you can usually see the "stair-step" effect in diagonal lines on even the finest-resolution displays.

Vector Graphics

This method of graphics displays is currently in use only in "homebrew" microcomputer systems and coin-operated video arcade games. Vector

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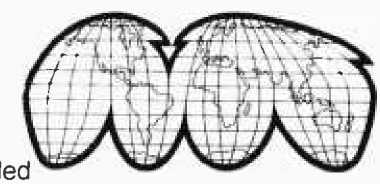

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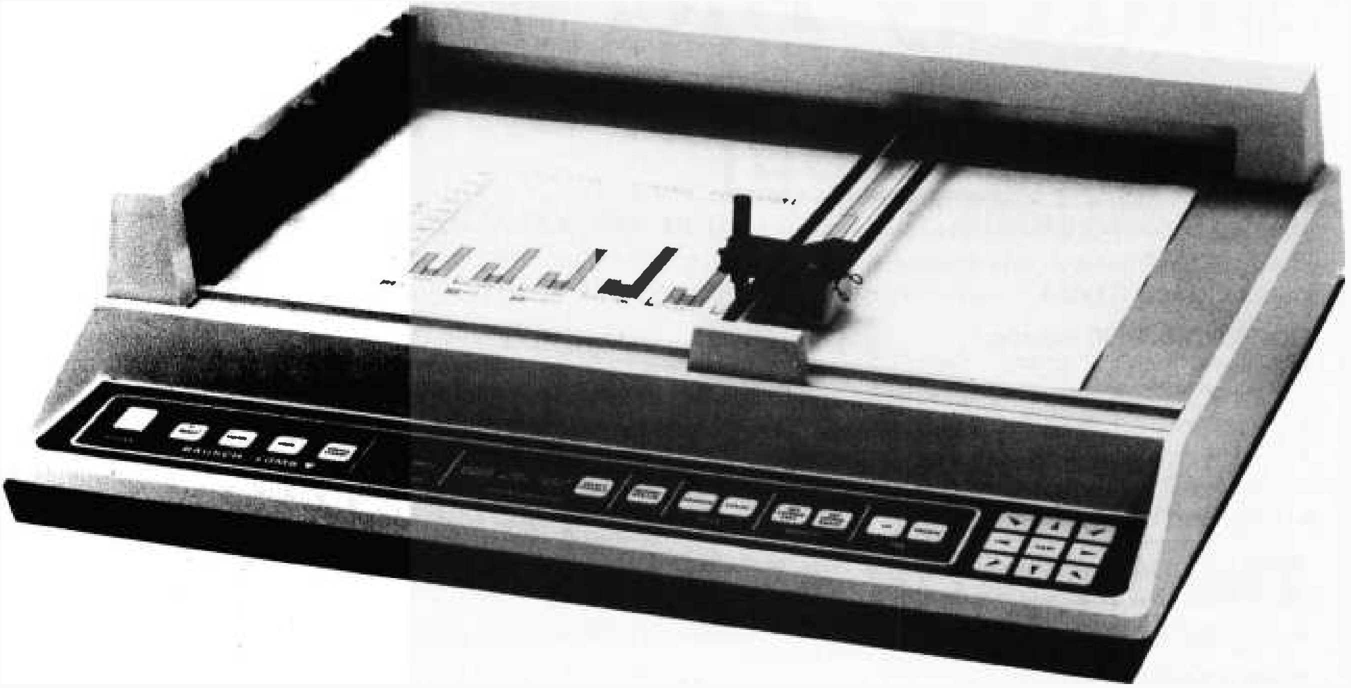

Photo 1: *A flatbed plotter; shown here is the Houston Instrument DMP-29. (Photo courtesy of Bausch and Lomb; see vendor text box for address.)*

graphics (not to be confused with a microcomputer company of the same name) are created by using a video display tube that can draw straight lines between any two points (see figure 3); this is in contrast to a raster-scan display, which is limited to drawing a screen of closely spaced horizontal lines. One of the best-known early video games, Space War, used a large computer connected to an oscilloscope display to create a video game in which two ships fight each other while circling a sun. A subsequent coin-operated version of the same game can still be found in some video arcades, and the popular Battle Zone three-dimensional tank combat game by Atari also uses vector graphics. An article in BYTE (see the selected bibliography at the end of this article) gave the plans for a vector graphics interface that connects an oscilloscope to the parallel port of a computer.

The mechanics of creating a video image for a vector graphics display are quite different from that of a raster-scan display. Each point in a vector graphics display can be expressed by a pair of numbers (i.e., *x* and *y* coordinates), and the electron beam can be either on or off. The computer must give the display a stream of number pairs and beam in-

The finer the resolution of raster-scan graphics, the more bits need to be changed to create or move an image.

tensities, each followed by a short delay. If the beam is on, a line is drawn from the previous to the next point on the screen; if it is off, the beam is simply moved to a new point in anticipation of drawing a line from the new point to a third point. Because the video image on the oscilloscope (or similar video-display tube) lasts for only a fraction of a second, the computer must continuously send out the current list of information to keep an unflickering image on the screen. A more sophisticated interface could do the *refresh* (redisplay) of the video image, thus freeing the main microprocessor from a continuous drain on its computational resources.

The advantages of a vector graphics display include its speed, the amount of detail possible (depending on the quality of the oscilloscope and the precision of the digital-to-analog signal used to change a digital signal to the analog voltage needed by the oscilloscope), and the quality of its diagonal lines. Disadvantages of a vector graphics display include a limitation to monochrome display, a computational drain on the microprocessor that increases with more complicated images (alleviated somewhat by an "intelligent" interface), and problems with image flicker when the image crosses a given threshold of complexity.

Plotters

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plotter moves the pen over a stationary, flat sheet of paper (see photo 1); the pen must be able to move in two directions. In a drum plotter, the paper is wrapped around a cylinder that rotates to move the paper in one direction, while the pen moves along an axis that is parallel to the center line on which the cylinder rotates.

"Smart" plotters can automatically draw letters, numbers, and geometric shapes.

Flatbed plotters have the option of using multiple pens (to create multiple color drawings), which many drum plotters can't do. On the other hand, a drum plotter to handle a sheet of a given size will take up less desk space than a similar flatbed plotter.

Ultimately, plotters work by drawing straight lines the computer specifies. If the lines are short enough, the line drawn looks curved. Some plotters can draw "pure" diagonal lines, but most are limited to drawing in eight directions (up, down, right, left, and four 45-degree diagonals); depending on the smallest step size the plotter is capable of, diagonal lines may exhibit the "stair-step" quality associated with raster-scan displays.

One very important feature to look for is the amount of "intelligence" the plotter has. Less expensive units are likely to be "dumb"—that is, they are usually limited to one of eight direction pen movement commands. More expensive "smart" plotters will automatically draw letters, numbers, and geometric shapes of various sizes when you give them the appropriate command. Such "intelligence" is often worth paying extra for. Be sure to ask the vendor what software is available for the plotter—if the answer is "none," find out how much work it will take you to write the software you need to make the plotter work.

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13	CHECKBK1	Checkbook maintenance program
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15	MULTMON	Computes time needed for money to double, triple, etc.
16	SALVAGE	Determines salvage value of an investment
17	RRVARIN	Rate of return on investment with variable inflows
18	RRCONST	Rate of return on investment with constant inflows
19	EFFECT	Effective interest rate of a loan
20	FVAL	Future value of an investment (compound interest)
21	PVAL	Present value of a future amount
22	LOANPAY	Amount of payment on a loan
23	REGWITH	Equal withdrawals from investment to leave 0 over
24	SIMPDISK	Simple discount analysis
25	DATEVAL	Equivalent & nonequivalent dated values for oblig.
26	ANNUDEF	Present value of deferred annuities
27	MARKUP	% Markup analysis for items
28	SINKFUND	Sinking fund amortization program
29	BONDVAL	Value of a bond
30	DEPLETE	Depletion analysis
31	BLACKSH	Black Scholes options analysis
32	STOCVAL1	Expected return on stock via discounts dividends
33	WARVAL	Value of a warrant
34	BONDVAL2	Value of a bond
35	EPSEST	Estimate of future earnings per share for company
36	BETAALPH	Computes alpha and beta variables for stock
37	SHARPE1	Portfolio selection model-i.e. what stocks to hold
38	OPTWRITE	Option writing computations
39	RTVAL	Value of a right
40	EXPVAL	Expected value analysis
41	BAYES	Bayesian decisions
42	VALPRINF	Value of perfect information
43	VALADINF	Value of additional information
44	UTILITY	Derives utility function
45	SIMPLEX	Linear programming solution by simplex method
46	TRANS	Transportation method for linear programming
47	EOQ	Economic order quantity inventory model
48	QUEUE1	Single server queueing (waiting line) model
49	CVP	Cost-volume-profit analysis
50	CONDPROF	Conditional profit tables
51	OPTLOSS	Opportunity loss tables
52	FQUOQ	Fixed quantity economic order quantity model
53	FQEOWSH	As above but with shortages permitted
54	FQEOQPB	As above but with quantity price breaks
55	QUEUECB	Cost-benefit waiting line analysis
56	NCFANAL	Net cash-flow analysis for simple investment
57	PROFIND	Profitability index of a project
58	CAP1	Cap. Asset Pr. Model analysis of project
59	WACC	Weighted average cost of capital
60	COMPBAL	True rate on loan with compensating bal. required
61	DISCBAL	True rate on discounted loan
62	MERGANAL	Merger analysis computations
63	FINRAT	Financial ratios for a firm
64	NPV	Net present value of project
65	PRINDLAS	Laspeyres price index
66	PRINDPA	Paasche price index
67	SEASIND	Constructs seasonal quantity indices for company
68	TIMETR	Time series analysis linear trend
69	TIMEMOV	Time series analysis moving average trend
70	FUPRINF	Future price estimation with inflation
71	MAILPAC	Mailing list system
72	LETWRT	Letter writing system-links with MAILPAC
73	SORT3	Sorts list of names
74	LABEL1	Shipping label maker
75	LABEL2	Name label maker
76	BUSBUD	DOME business bookkeeping system
77	TIMECLCK	Computes weeks total hours from timeclock info.
78	ACCTPAY	In memory accounts payable system-storage permitted
79	INVOICE	Generate invoice on screen and print on printer
80	INVENT2	In memory inventory control system
81	TELDIR	Computerized telephone directory
82	TIMUSAN	Time use analysis
83	ASSIGN	Use of assignment algorithm for optimal job assign.
84	ACCTREC	In memory accounts receivable system-storage ok
85	TERMSPAY	Compares 3 methods of repayment of loans
86	PAYNET	Computes gross pay required for given net
87	SELLPR	Computes selling price for given after tax amount
88	ARBCOMP	Arbitrage computations
89	DEPRSF	Sinking fund depreciation
90	UPSZONE	Finds UPS zones from zip code
91	ENVELOPE	Types envelope including return address
92	AUTOEXP	Automobile expense analysis
93	INSFILE	Insurance policy file
94	PAYROLL2	In memory payroll system
95	DILANAL	Dilution analysis
96	LOANAFFD	Loan amount a borrower can afford
97	RENTPRCH	Purchase price for rental property
98	SALELEAS	Sale-leaseback analysis
99	RRCONVBD	Investor's rate of return on convertable bond
100	PORTVAL9	Stock market portfolio storage-valuation program

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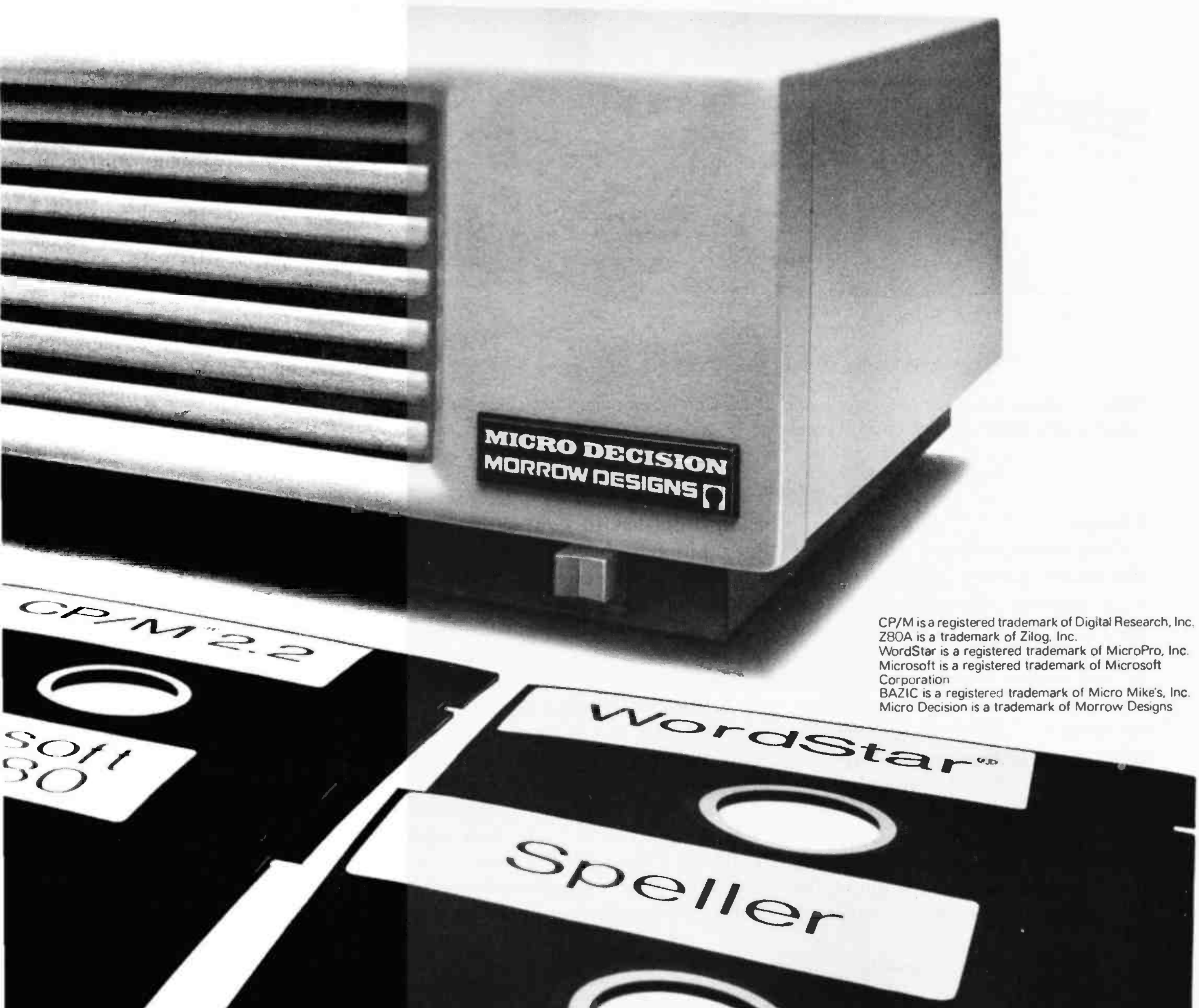

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Photo 2: *Game paddles. These are for the Atari (left) and the Apple II (right).*

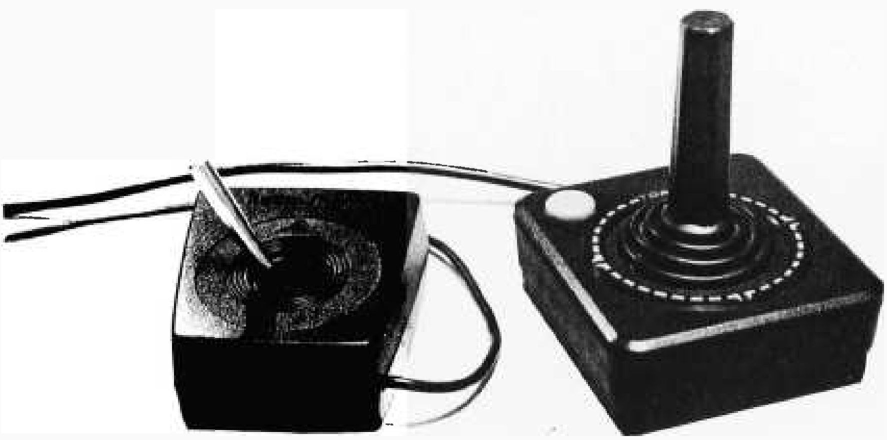

Photo 3: *Joysticks. At the left is the Radio Shack Color Computer joystick (resistive); at right is the Atari joystick (switch type).*

Printers

Computers that have printers can also create printed graphics. Character graphics, the same kind that you can do on your video screen with alphanumeric symbols, are possible on any printer. Some printers can print special graphics characters that are unique to a given computer (for example, some Commodore-supplied printers can print the special Commodore PET graphics symbols). Many dot-matrix printers, however, have a *bit-mapped graphics* mode that lets you control each pin of the print head as the printer makes a sweep from left to right across one line position of the page. The head of a dot-matrix printer contains several needles (usually seven or eight) that strike against the ribbon as the head moves across the line. In a bit-mapped graphics mode, the computer sends the printer bytes of data that are translated into instructions to the individual needles (if the head has only seven or eight needles, one byte of data usually represents one vertical "stack" of seven or eight dots that represent a one-dot-wide slice of the print line). With the appropriate software, a raster graphics image (as it is stored in memory) can be transferred to a printer one horizontal slice at a time. Color graphics printers and software are becoming available for microcomputers (see the vendor text box), making printed color graphics images feasible for some microcomputers.

Input Devices

Now let's turn to devices you use to tell the computer what kind of graphic image you want. Some of these devices are not graphics related per se, but I mention them because they are often used in graphics applications.

The most prosaic input device for graphics is the keyboard. You can use your choice of cursor, letter, and control characters to tell software to manipulate a graphics image. Unfortunately, a keyboard is usually the least satisfactory way of interacting with graphic images, but it is one that is guaranteed to be available on any computer.

Paddles and joysticks are two input devices associated with microcomputers. A paddle (see photo 2) is simply a knob like the volume control switch on your television. A paddle involves no on-off switch, but it usually contains a potentiometer (a variable resistor) whose resistance varies with the position of the knob. Some computers (the Apple II and the Atari, for example) have built-in circuitry that translates the position of the paddle knob into a numeric value, usually between 0 and 255 (the highest possible 8-bit value). Graphics software running in the computer can then translate this into some kind of movement along one axis (for example, up-down or right-left).

A joystick is similar to a paddle in that it gives the computer directional information, but it gives information about two perpendicular axes, thus making it able to specify any arbitrary movement within a two-dimensional plane. In physical appearance, a joystick (see photo 3) resembles a small box with a short stick appearing perpendicular from the square face of the box. This stick can be moved a given distance in two

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dimensions; in use, a program using a joystick should respond in some action that is motivated by the direction indicated by the joystick.

Joysticks come in two basic designs. The first, which is used with the Apple II computer, is basically two paddle potentiometers linked mechanically so that only up-down movement turns one potentiometer and only right-left movement turns the other. A second kind of joystick, used by the Atari 400 and 800 computers, is actually a set of four switches, one for each basic direction (up, down, right, and left). This kind of joystick is both cheaper to make and more durable, but it provides less information. Unlike the potentiometer joystick, which provides both direction and magnitude information that is continuously variable, the switch joystick provides direction only (no magnitude), and only eight directions at that (the four major directions and four diagonals); whatever direction is indicated (and there are many gradations possible with the potentiometer joystick), the switch joystick chooses the closest direction of the eight it can supply.

Advanced Input Devices

The input devices mentioned above—keyboard, paddles, and joysticks—are usually available or standard on most microcomputers, and many people have some or all of them on their microcomputers (paddles and joysticks are popular because many computer games use them).

Digitizers, light pens, trackballs, and "mice"—which I'll cover next—are not universally available and are usually used only for specific applications.

The *digitizer* (also known as a graphics tablet or pad) enables the computer to get two-dimensional position information about the position of a "pen" on a writing surface of a given size. There are four main kinds of digitizers: electromagnetic, magnetorestrictive, sonic, and resistive.

Electromagnetic digitizers use a writing surface embedded with a fine mesh of vertical and horizontal wires. (The number of wires per inch determines the accuracy of the graphics tablet.) A complicated electronic interface senses the proximity of the metal tip of the pen or cursor and the vertical and horizontal wires. From this, it returns an x-y coordinate pair that tells the computer where the pen is in relation to a fixed reference point. (In a variation of this scheme, the pen sends out an electromagnetic pulse that the wires sense.) Like most digitizers, this one can give the microcomputer information in one of several different forms.

Magnetorestrictive digitizers (see photo 4a) use a similar scheme, except that the pulse traveling down the wire is a pulse of current that creates a traveling magnetic field. The pen or cursor used contains a small wire loop that then senses the field and computes the cursor coordinates from that information. One disadvantage of this technology, however, is that magnetic storage media, like floppy disks and magnetic tapes, must be kept away from the tablet surface.

Sonic digitizers use a pen or cursor

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Novation	d-CAT	$170.00
Novation	Auto-Cat	$229.00
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DC Hayes	Micro Modem II (Apple)	$320.00
DC Hayes	Micro Modem 100	$320.00
Signalman	Mark I	$89.00
UDS	UDS 103 LP (300 Bd)	$185.00
UDS	UDS 202 LP (1200 Bd)	$245.00
UDS	UDS 212 LP (1200 Bd)	$495.00
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Citoh	1550 Prowriter II (Parallel & Serial)	$825.00
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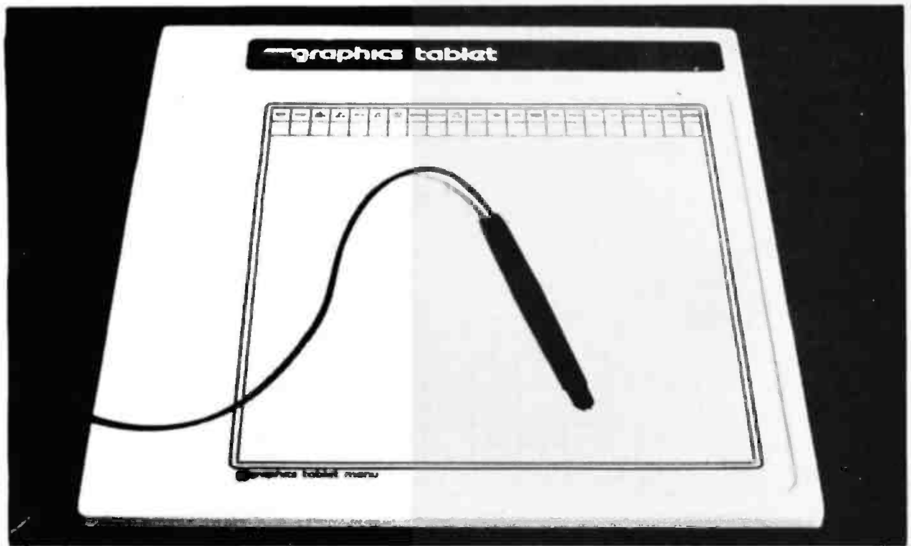
4a



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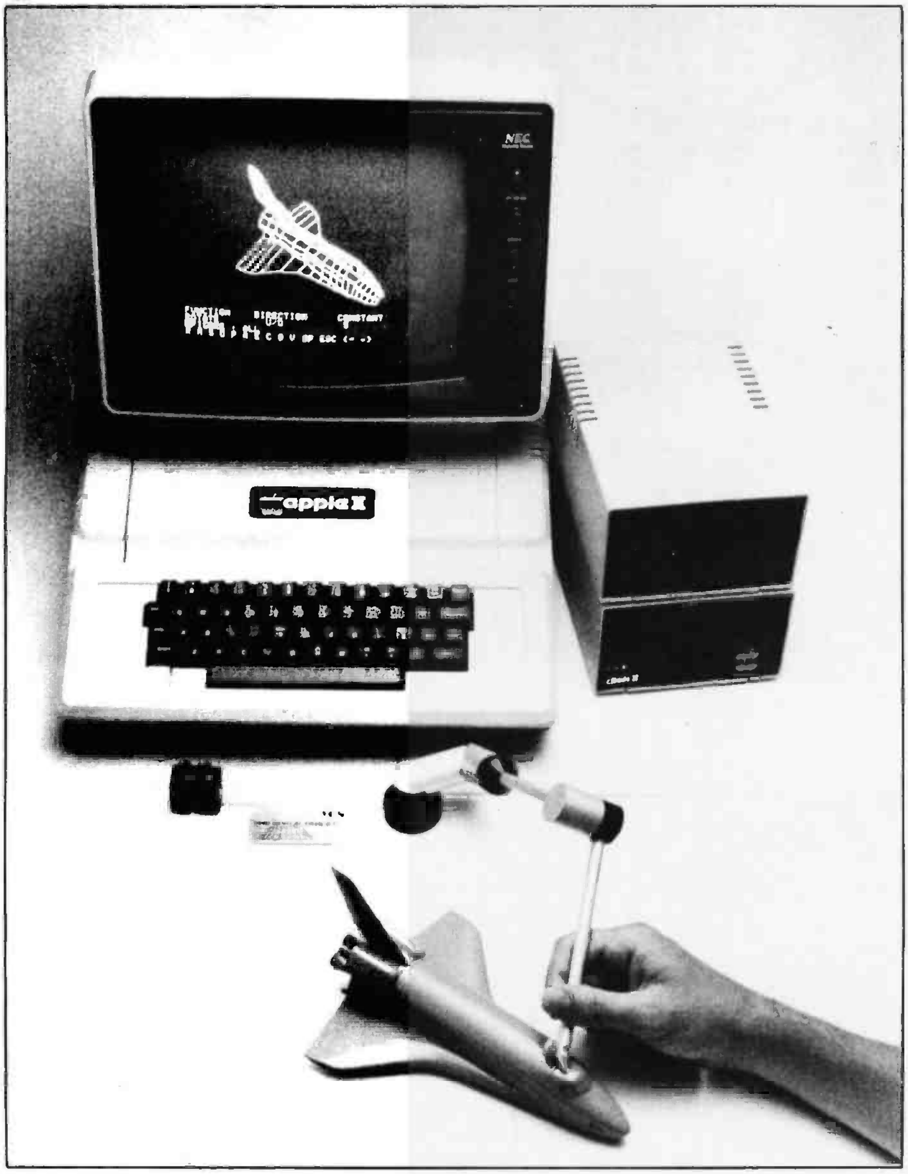

Photo 4: *Digitizers. Pictured are the electromagnetic Apple Graphics Tablet (photo 4a, courtesy of Apple Computer Inc.) and the mechanical three-dimensional digitizer from Micro Control Systems (photo 4b, courtesy of MCS). Manufacturer addresses can be found in the vendor text box.*

that emits an ultrasonic noise; the sound is detected by two ultrasonic sensors that give the digitizer enough information to determine the location of the input device. Sonic digitizers sacrifice some accuracy for reduced cost and/or increased digitizing area. (In particular, most electromagnetic or magnetorestrictive digitizers have an accuracy of 0.001 inch, while sonic digitizers usually have an accuracy of 0.01 inch. However, this is not much of a sacrifice, because a human operator usually cannot achieve a repeatable accuracy of less than 0.05 inch, a value halfway between the accuracies of the two technologies.)

Unfortunately, the digitizers mentioned above are too expensive for most microcomputer owners; they usually cost $800 and up, depending on the resolution of the output and the size of the writing surface. Fortunately, most people don't need as much resolution as these digitizers give. The *resistive* digitizer (see photo 4b) was created for people who want to do digitizing but don't have $800 or more to spend. It has a pen or stylus on the end of an arm whose joints have very accurate potentiometers in them. Each potentiometer offers a resistance to the connected microcomputer, which "reads" them as it would the potentiometers in a paddle or joystick. Then the microcomputer, with the aid of software, converts the angular measurements of the arm joints to a final *x-y* coordinate value.

Resistive digitizers sacrifice accuracy and speed for low cost, although the cost of the software needed to make the digitizer useful seems to be driving the price of some resistive digitizers up. However, one company (Micro Control Systems; see vendor text box) offers a resistive digitizer that returns the location of a point in *three*, as opposed to two, dimensions—something that no electronic digitizer offers.

Light pens resemble normal writing pens, but they are connected to the computer by a wire. In use, they essentially tell the computer where they are pointing on the screen (usually in *x-y* coordinates); in some cases, they give data on whether the

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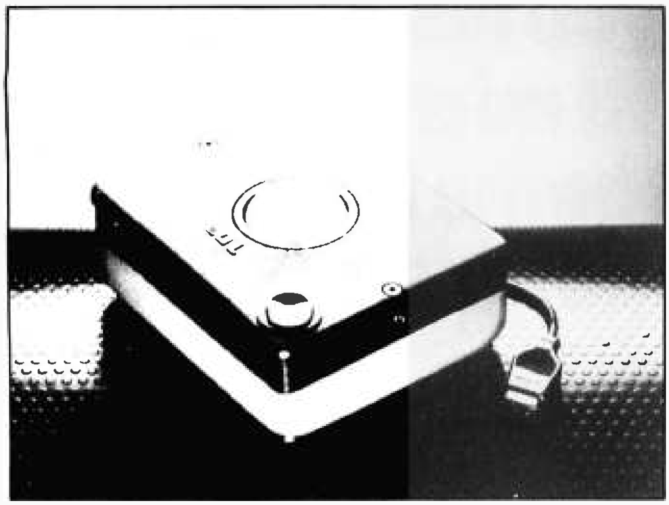

Photo 5: *A trackball. The Wico Command Control trackball is shown here. (Photo courtesy of Wico; see vendor text box for address.)*

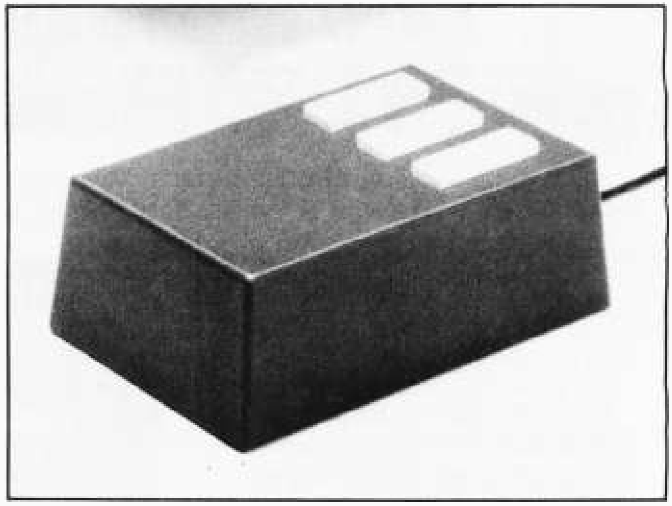

Photo 6: *A "mouse." Shown here is the Hawley X063X mouse. (Photo courtesy of The Mouse House; see vendor text box for address.)*

pen is touching the screen and whether a button on the barrel of the pen is being pressed.

Some people have the mistaken notion that light pens emit light that is picked up by the video screen. In fact, the opposite is true—either visible light (on cheaper units) or the electron beam itself (on more expensive units) is detected by a sensor embedded in the tip of the pen, and either software or hardware calculates the position of the pen.

Most microcomputer light pens are very simple inside—usually some kind of photodetector that is read as a variable resistance by circuitry that expects to see a paddle or joystick. Software is used to calculate the position of the pen, whose resolution is usually limited to the number of rows and columns of characters on the video display. In addition, the scanning routine (which, if it is in BASIC, can be rather slow) runs a character-sized block of brightness across the screen row by row and waits for a signal from the pen itself indicating that the bright spot has reached the current location of the pen. These pens are relatively inexpensive, although the scanning method used may limit the pen's usefulness. The more precise methods that track the electron beam of the video display itself are considerably more expensive.

(One interesting variation of the light pen does not use light at all. Instead, a wire mesh is bonded to the front surface of the video display, and the pen works much like a digitizer to return position information to the computer. See the vendor text box for the company that makes this device.)

Trackballs (see photo 5) are fun to use, and, to date, they have been found only in military equipment and arcade video games (Atari's Centipede, for example). Now that the video arcade market is entering the home via microcomputers and programmable game systems, several companies are promising low-cost trackballs for the home market. Basically, a trackball is a small sphere (usually about the size of an orange or a grapefruit) housed beneath a flat surface that allows only a small portion of the ball sphere to project above it. To use the trackball, you place the accessible portion of the sphere directly under your palm. By rolling the sphere with the palm of your hand, you transmit vector information (i.e., direction and magnitude) about the direction of the ball's movement and the speed at which it is being rolled. Although trackballs can give output information in one of several ways, most commercial trackballs give separate trains of rectangular output pulses that indicate the amount of rotation in relation to two perpendicular (x and y) axes. The resolution of trackballs is measured as the number of pulses created in one revolution of the sphere around one of the major axes; these numbers range from 50 to 550 pulses per revolution, with 300 pulses being a popular number.

Several manufacturers make low-cost trackballs for home use (see the vendor text box). Some of these are direct replacements for the popular Atari joystick and so will return whichever one of eight standard directions that the rotation of the ball is closest to.

Trackballs are different from light pens and digitizers in that they give data on *movement*, not absolute position. If the software that reads the device constantly updates two variables that hold the current location of the cursor, the trackball can be used to manipulate the absolute position of the cursor. However, the information given by a trackball is often interpreted in some way by the program asking for the information; in other words, trackballs usually require more interface software than other peripherals.

The *mouse* is an input device Doug Englebardt invented in 1961 while he was working at SRI in Menlo Park, California. Named for a superficial resemblance to the rodent of the same name (see photo 6), the mouse has historically been associated with the artificial intelligence (AI) and computer graphics communities. Nevertheless, it is beginning to appear on less esoteric machines (the Xerox Star, for one) and will continue to do

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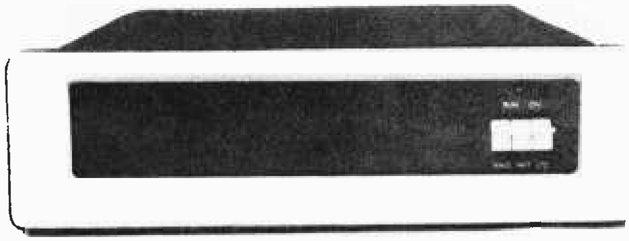

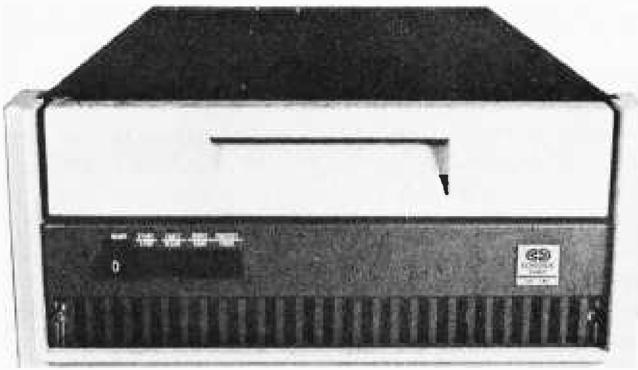

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Selected Vendors

Rather than attempt a comprehensive listing of all graphics products for microcomputers, I have assembled the following companies because their products are representative of various categories. In some cases, I included companies because they have exhibited interesting new products at recent shows. All inquiries should be directed to the companies themselves.

Raster-Scan Systems

High-resolution graphics retrofit for color and monochrome terminals: Digital Engineering, 630 Bercut Dr., Sacramento, CA 95814. (916) 447-7600.

High-resolution graphics boards for S-100 systems: Scion, 12310 Pinecrest Rd., Reston, VA 22091. (703) 476-6100.

Low-cost RGB monitor: Exidy Inc., 390 Java Dr., Sunnyvale, CA 94086. (408) 734-9410.

High-resolution monochrome retrofit for TRS-80 Models I and III: Mikee Electronics Corp., POB 3813, Bellevue, WA 98009. (206) 451-0574.

8086 computer with high-resolution color graphics option: NEC Information Systems Inc., 5 Militia Dr., Lexington, MA 02173. (617) 862-3120.

Low-cost graphics terminals: Data-Type Inc., 2615 Miller Ave., Mountain View, CA 94040. (415) 949-1053.

Plotters

Watanabe Instruments Corp., 3186-D Airway Ave., Costa Mesa, CA 92626. (714) 546-5344.

Flatbed plotters: Bausch and Lomb, Instruments and Systems Division, POB 15720, Austin, TX 78761. (512) 835-0900.

Drum plotters: Strobe Inc., 897-5A Independence Ave., Mountain View, CA 94043. (415) 969-5130.

Printers and Interface Cards

Color dot-matrix printer (Prism Printer): Integral Data Systems Inc., Milford, NH 03055. (603) 673-9100.

Intelligent printer interface for Prism and other dot-matrix printers: Interactive Structures Inc., 146 Montgomery Ave., Bala Cynwyd, PA 19004. (215) 667-1713.

High-resolution graphics interface card for the Apple II: Orange Micro Inc., 3150 E. La Palma, Suite G., Anaheim, CA 92806. (714) 630-3620.

Digitizers

Electromagnetic digitizers: Bausch and Lomb (see address above).

Magnetorestrictive digitizers: Apple Computer, 20525 Mariani Ave., Cupertino, CA 95014.

Magnetorestrictive and electromagnetic digitizers: Summagraphics Corp., 35 Brentwood Ave., Fairfield, CT, 06430. (203) 384-1344.

Electromagnetic digitizers: GTCO Corp., 1055 First St., Rockville, MD 20850. (301) 279-9550.

Sonic digitizers: Science Accessories Corp., 970 Kings Highway West, Southport, CT 06490.

Low-cost resistive digitizer: Versa Computing Inc., 3541 Old Conejo Rd., Suite 104, Newbury Park, CA 91320. (805) 499-4800.

Three-dimensional digitizer: Micro Control Systems, 230 Hartford Turnpike, Vernon, CT 06066. (203) 643-4897.

Light pens

High-resolution light pen for the Apple II: Gibson Laboratories, 406 Orange Blossom, Irvine, CA 92714. (714) 551-8553.

Touch pen using conductive metal mesh on video display face: Sun-Flex Company Inc., 20 Pimentel Ct., Novato, CA 94947. (415) 883-1221.

Trackballs

Low-cost trackballs for various microcomputers: Wico Consumer Division, 6400 West Gross Point Rd., Niles, IL 60648. (312) 647-7500.

Industrial-grade trackballs: Measurement Systems Inc., 121 Water St., Norwalk, CT 06854. (203) 838-5561.

Industrial-grade trackballs: Disc Instruments, 102 E. Baker St., Costa Mesa, CA 92626. (714) 979-5300.

Mice

Optical mice: Mouse Systems Corp., 655 S. Fairoaks Ave. D313, Sunnyvale, CA 94086. (408) 730-2132.

Electromechanical mice: The Mouse House, 1741 8th St., Berkeley, CA 94710.

so as its advantages become more widely known.

What is a mouse? Imagine a trackball turned upside down, with the exposed part of the sphere touching a flat surface. Now put two or three pushbuttons on what used to be the base of the trackball and shrink the entire assembly so that it fits comfortably in the human hand. Now you have a mouse. (Another variety, the *optical mouse*, has no moving parts and determines movement by sensing the lines of a rectangular grid placed beneath it.)

A mouse, like a trackball, is a relative positioning device that requires more interface software than other peripherals. The mouse is rolled on a flat surface, and the program using it usually has a cursor on the video display that follows the movement of the mouse. In many applications, the buttons are pressed to initiate some action. For example, in a word processor that uses a mouse, you can mark an area of text for, say, deletion by moving the cursor with the mouse and pressing a button. When you move the cursor with the mouse, all text between the marked point and the cursor dynamically changes to inverse video. When you move the cursor to the end of the text to be deleted, you press another button and the computer deletes all the text marked in inverse video.

I like the idea of mice, but I'm not sure why I prefer them to, say, trackballs. One nice thing about a mouse is that it doesn't take a lot of flat space to use. If you want to make a long movement, you simply make a short stroke with the mouse, pick it up, put it down at its original position, and repeat the stroke as many times as needed. For whatever reasons, the mouse has the potential to become the most important new peripheral of the 1980s. In a decade when microcomputers can possibly evolve into a form that everyone can use, any peripheral that allows you to "point" at what you want will help make that potential a reality. I suspect mice will become the most common pointing device for business and commercial microcomputers.

Commercial-grade mice are now

ailable in the $300 to $500 range (see the vendor text box), and their price will come down as they become more popular.

The Hidden Problem of Software

Without software, even the best microcomputer is an expensive and bulky paperweight, and nowhere is this more evident than with computer graphics. Good software creates good graphics images and responds to the rather terse signals input devices send it. Be aware that software is inevitably part of anything you want to do with graphics.

If you're lucky, somebody has already written the software you want. In the case of digitizers and light pens, for example, driving software often comes with the peripheral itself; in other cases—RGB monitors and trackballs, for example—software is usually not included. Sometimes the peripheral vendor or a third-party vendor sells the software you need. In a few cases, a peripheral behaves the same as another peripheral for which software has been written. (For example, some trackballs mimic the behavior of Atari joysticks, for which a lot of software exists.) If none of the above cases holds, you will have to write your own software. But before you rush out to buy that new trackball, ask yourself, "What do I want to use this for?" and "Am I willing—and able—to write the software myself?" As usual, unfortunately, hardware capabilities are far beyond those of software.

Conclusions

Clearly, many possibilities exist for using graphics with your microcomputer. I've listed the available devices, but it will take your imagination to create the graphics. As more sophisticated hardware and software become available and more affordable, graphics now reserved for minicomputers and mainframes will probably become available for microcomputers. Until then, we still have some very nice toys to play with. ■

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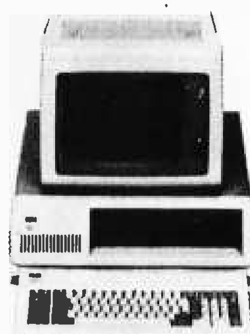

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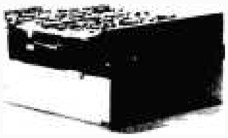

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In the present generation of computers, no other form of output rivals the popularity of the video terminal with its two-dimensional visual representation of data. This article will examine ways of making this two-dimensional output represent the three-dimensional real world. Techniques of showing perspective play an important role in making video output look three-dimensional. In this article, I will look briefly at the concept of perspective and then consider some techniques of achieving perspective in computer graphics. I will then present some program listings in BASIC and Pascal that show how to use these techniques in high-level languages.

About the Author
Andrew Pickholtz wrote this article while a senior at W. T. Woodson High School in Fairfax, Virginia. He is now a student at Harvard University. In summers, he has worked for Ferox Microsystems Inc. and at the IBM T. J. Watson Research Center.

Acknowledgments
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Ways of Representing Three Dimensions

People tried to portray the visual world on a flat screen long before the creation of the modern computer, and draftsmen today use several different methods of representing three-dimensional objects on paper: the orthogonal, the oblique, the isometric, and the perspective methods.

A computer can as easily produce a perspective drawing as an oblique or isometric drawing.

An orthogonal projection of an object is simply the "side view" of that object (see figure 1). "Side view" is in quotes because, as will later become clear, this representation is not exactly what the human eye would see if it were looking at the object; that is, this "view" is not a perspective projection.

Orthogonal representations of objects customarily give three projections: one from the top, one from the front, and one from the right-hand side. Each "view" gives information about a pair of axes; the "top view" gives information about the *x*-*y* pair, the "front view" about the *x*-*z* pair, and the "right-hand side view" about the *y*-*z* pair. Unfortunately, the untrained eye is reluctant to form a three-dimensional image from the three detached and seemingly independent illustrations used in orthogonal representation.

Oblique and isometric drawings (see figures 2 and 3, respectively) portray an object in a more realistic manner. Both the oblique and isometric representations depict a three-dimensional object in one illustration by fixing the axes in relation to the horizontal. In oblique pictorial, lines parallel to the *z* axis are vertical, lines parallel to the *x* axis are horizontal, and lines parallel to the *y* axis are consistently drawn at the same angle in relation to the horizontal. The axes in isometric pictorial are likewise fixed in relation to the paper.

The Perspective Method

While oblique and isometric representations are superior to orthogonal,


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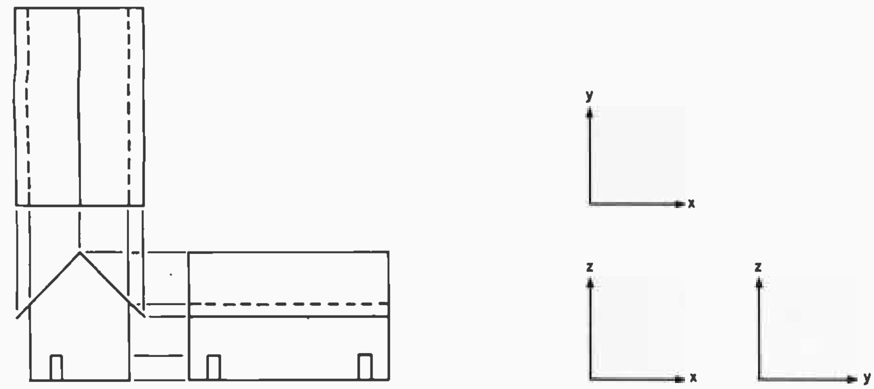


Figure 1: *An orthogonal representation of a house. An orthogonal drawing drops perpendiculars from each point on the object to three mutually perpendicular planes. Hidden edges are customarily drawn as dotted lines.*

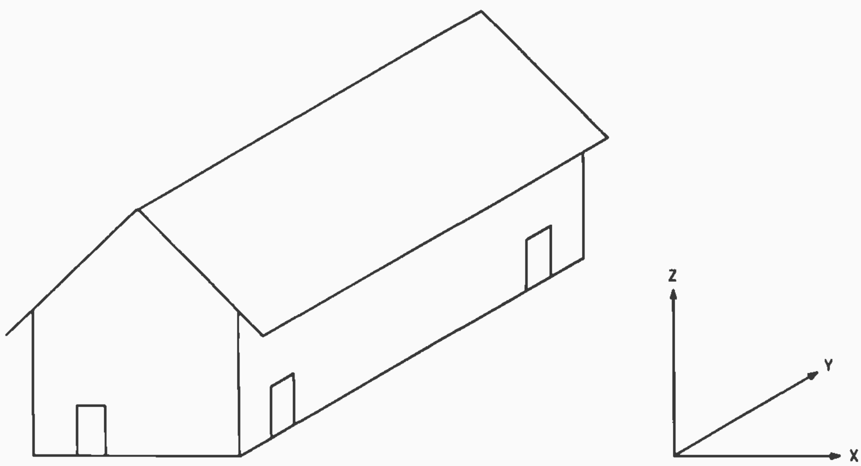


Figure 2: *An oblique representation of a house. An oblique drawing portrays three dimensions by drawing lines parallel to the third axis at a consistent angle to the horizontal, in this case at 30 degrees.*

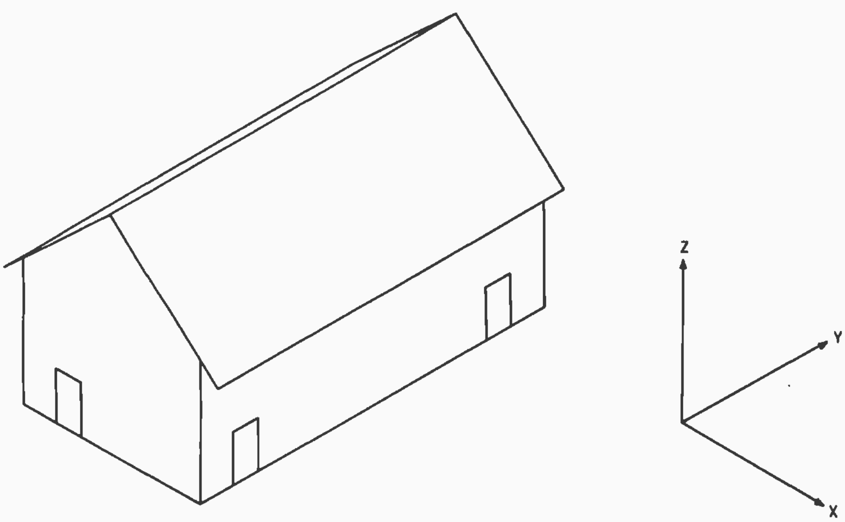


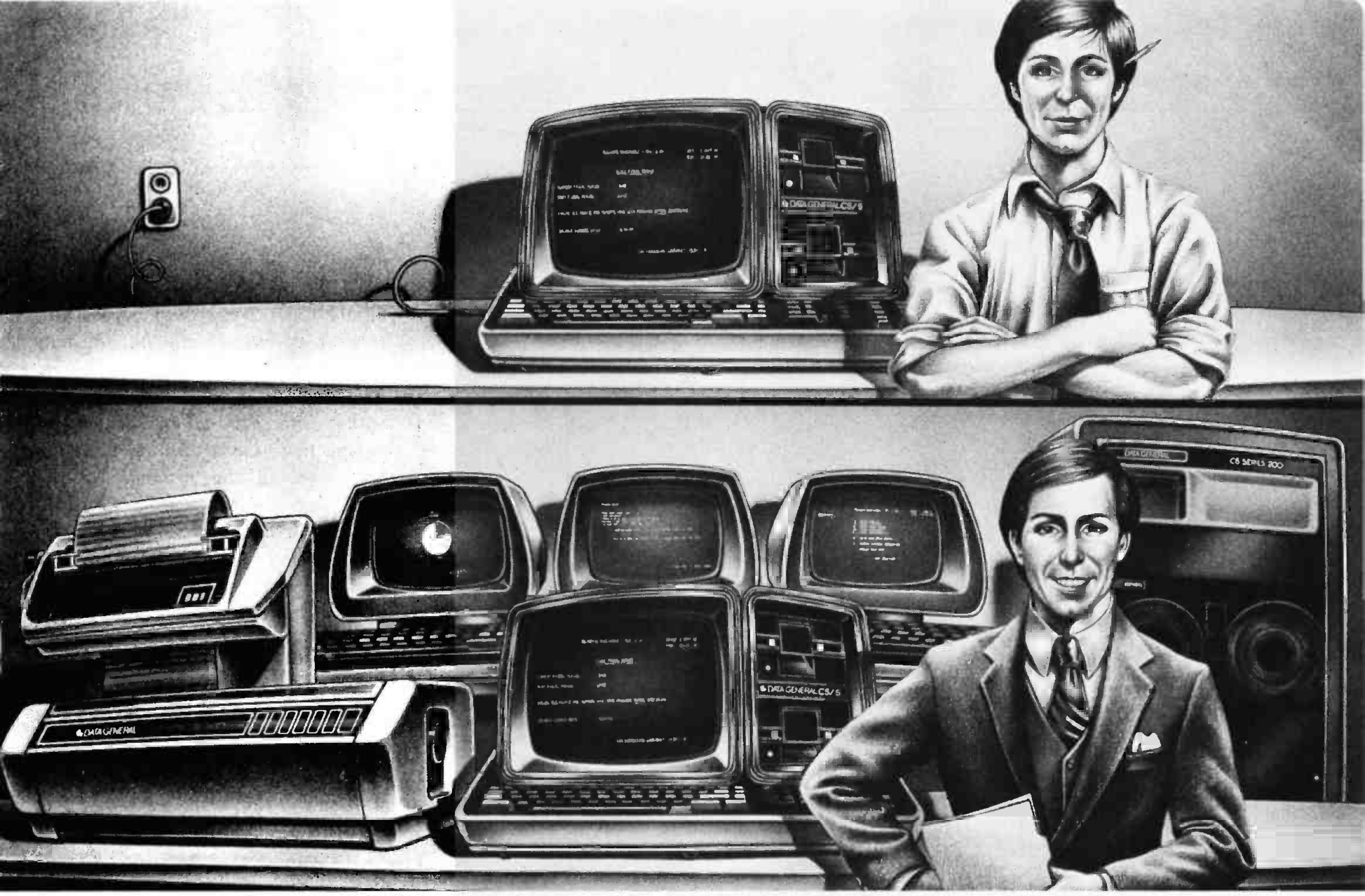
Figure 3: *An isometric representation of a house. Like an oblique representation, an isometric one draws lines that are parallel in three dimensions as parallels in two. The isometric method, however, offsets two axes from the horizontal.*

perspective pictorial is the only truly accurate method of illustrating an object. Two Florentine architects, Filippo Brunelleschi and Leon Battista Alberti, developed the ideas of perspective in the fifteenth century. Although many artists before them had noticed that objects in the distance appear smaller than objects in the foreground, Brunelleschi and Alberti were the first to accurately represent the apparent diminution of objects as they recede from the observer. Many other Italian artists and some Flemish artists had also experimented with perspective; however, their methods were empirical while Brunelleschi and Alberti worked with a geometric system. In fact, Alberti had written several papers on mathematics, and in 1435 wrote the first treatise on painting that dealt with the theory of art rather than just the techniques.

What makes perspective drawings superior to oblique and isometric is that perspective displays objects in the distance as smaller than objects that are closer; the rear door in figure 4, for example, is smaller than the front door. Perspective drawing also represents lines that are parallel in three dimensions as convergent on the picture plane. Thus, the axes in perspective drawings are always directed toward vanishing points. The *x*-axis and *y*-axis vanishing points in figure 4 lie on the horizon; an object in the distance would, as the eye expects, appear extremely small.

Figures 5a-5c illustrate another interesting fact about perspective: while the oblique (figure 5a) and isometric (figure 5b) representations of a wire-frame cube appear to spontaneously reverse in orientation, the perspective representation (figure 5c) does not. What prevents the spontaneous reversal in the perspective representation is that one of the perceived orientations of the perspective cube is erroneous; that is, it does not look "natural."

Although oblique and isometric drawings are not truly realistic, draftsmen use these two techniques more often than perspective. They do this for two reasons. First, oblique and isometric drawings conveniently



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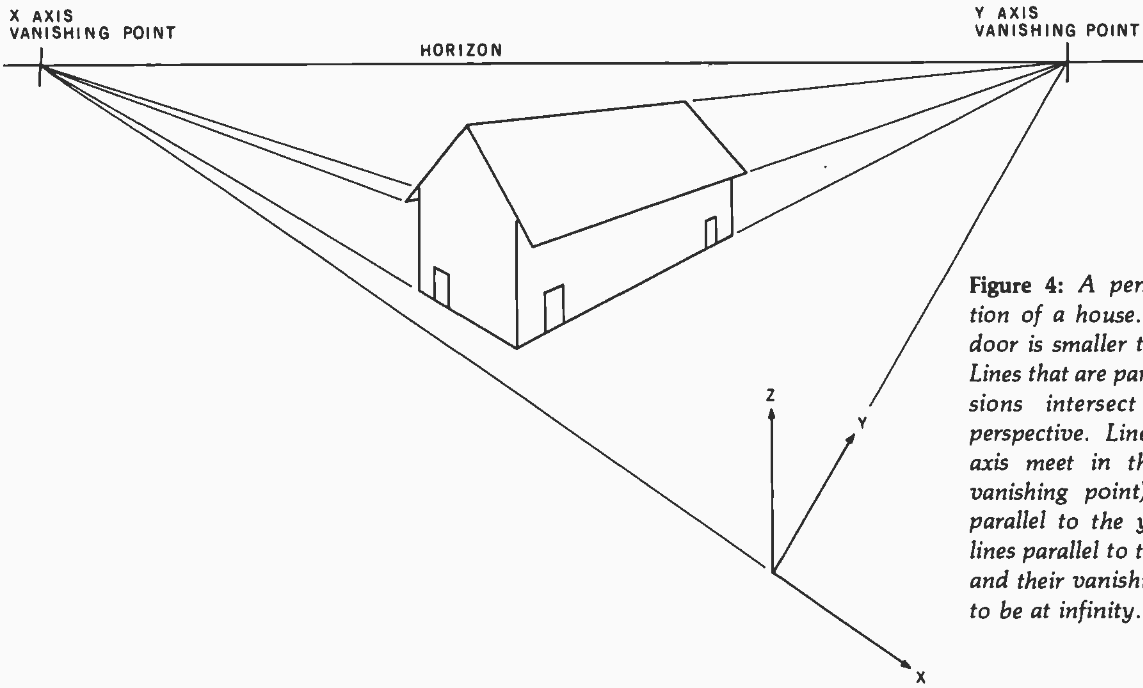

Figure 4: *A perspective representation of a house. Note that the rear door is smaller than the front door. Lines that are parallel in three dimensions intersect when drawn in perspective. Lines parallel to the x axis meet in the distance (at the vanishing point), and so do lines parallel to the y axis. In this case, lines parallel to the z axis are vertical and their vanishing point is assumed to be at infinity.*

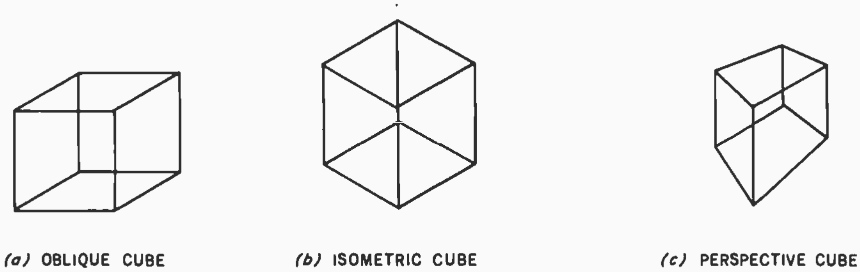

Figure 5: *Three representations of a cube. Figure 5a is an oblique representation, figure 5b is isometric, and figure 5c is a perspective. Both the oblique and the isometric representations appear to reverse in orientation spontaneously. The perspective does not.*

permit finding the measurements of an object by simply measuring the representation; second, drawing perspective is much more difficult. For a computer, however, it is just as easy to produce a perspective drawing as to produce an oblique or isometric drawing. Furthermore, as the object becomes more complex, the difference in speed between computer-drawn perspective and computer-drawn isometric becomes negligible.

Describing a Three-Dimensional Object

It is impossible to produce a perspective pictorial of an object without a description of the object. A good representation of the object can usually be achieved by assuming that the object is composed of a finite number of planar polygons. If the object is significantly curved, an adequate representation requires many polygons.

Figure 6 illustrates a data structure that describes a three-dimensional object. Each of the polygons, which can be called faces, is composed of edges. Each edge is composed of two vertices that are specified by three Cartesian coordinates. Each face also has several characteristics: color, texture, transmittance, glossiness, and reflectance. The edge shared by two faces is the intersection of their two sets of coordinates.

It is easier to represent an object if we assume that the object has clear faces. This simplification avoids the difficult problem of discovering hidden lines. Figure 7 shows the simpler data structure that this assumption permits to represent the wire-frame object previously represented in figure 6.

Specifying an Arbitrary Three-Dimensional View

We can think of a perspective pictorial of a three-dimensional scene as a view that a one-eyed pilot would see when looking through an empty picture frame (see figure 8). The picture frame is understood to lie in the picture plane. As the figure shows, the pilot's line of sight is defined to be the normal (perpendicular) to the picture plane that passes through the pilot's eye. The lines connecting the object with the pilot's eye are called projectors. The perspective pictorial is the intersection of the projectors and the picture plane.

Three general types of changes would affect the pilot's view of the scene: a change in the distance between the picture plane and the pilot's eye, a change in position of the aircraft, or a rotation of the airplane. If the picture plane is moved closer to the pilot's eye, the view would appear smaller in comparison to the picture frame. Likewise, if the picture frame is moved further away from the pilot's eye, the view would appear larger since the tetrahedral angle that the picture frame subtends (marks off) would be smaller. Thus, in order to specify any three-dimensional

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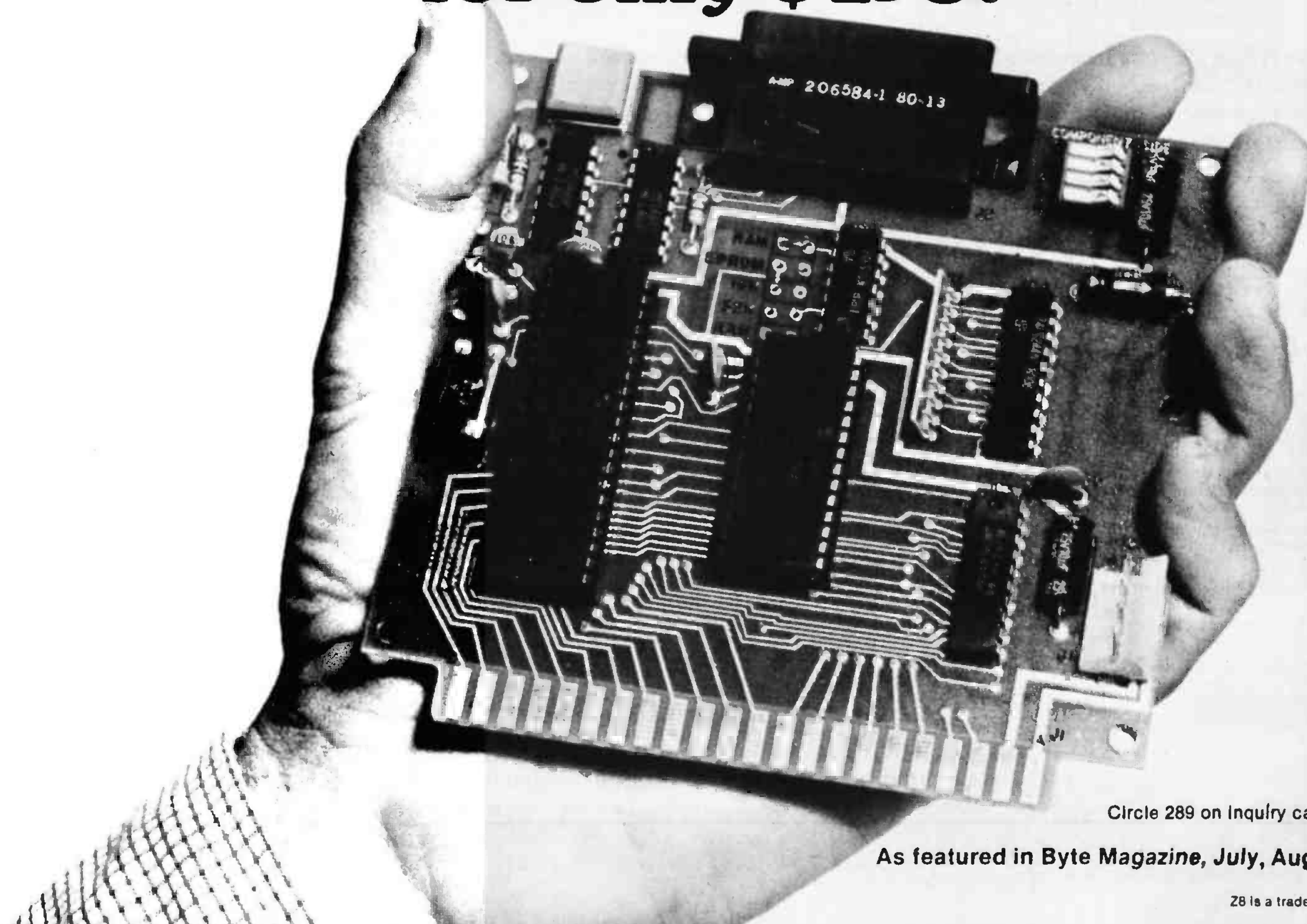

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As featured in Byte *Magazine, July*, August, 1981.

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EDGES $E_1 = V_1, V_4\quad E_2 = V_5, V_9\quad E_3 = V_2 V_{104}\ \cdots\ E_{NE} = V_{16} V_3$

FACES $F_1 = E_1 E_3 \cdots E_{118}\quad F_2 = E_{209} E_5 E_{19} \cdots F_{NF} = E_3 E_{52} \cdots E_{129}$

$COLOR_1$	$COLOR_2$	$\cdots$	$COLOR_{NF}$
$TEXTURE_1$	$TEXTURE_2$	$\cdots$	$TEXTURE_{NF}$
$GLOSSINESS_1$	$GLOSSINESS_2$	$\cdots$	$GLOSSINESS_{NF}$
⋮	⋮		⋮
$REFLECTANCE_1$	$REFLECTANCE_2$	$\cdots$	$REFLECTANCE_{NF}$

OBJECT $O_1 = F_1 F_2 F_3 \cdots F_{NF}$

Figure 6: *A data structure representing an object. The representation assumes that the object is composed of a finite number of polygons (also called faces). Each face has several characteristics (color, etc.) and is determined by the edges that it contains. Each edge is specified by its endpoints, which are the vertices of the object. Finally, the coordinates of each vertex must be specified. The object represented here is hypothetical.*

VERTICES $V_1\ (X_1, Y_1, Z_1)\quad V_2\ (X_2, Y_2, Z_2)\ \cdots\ V_{NV}\ (X_{NV}, Y_{NV}, Z_{NV})$

TRAILS
$T_1 = V_1 V_3 V_8 \cdots V_{186}$
$T_2 = V_9 V_{12} V_{136} \cdots V_1$
$T_3 = V_{13} V_{12} \cdots V_{13}$
⋮
$T_{NT} = V_4 V_{11} \cdots V_{22}$

OBJECT $O_1 = T_1 T_2 T_3 \cdots T_{NT}$

Figure 7: *A data structure representing a wire-frame object. This data structure assumes that the object has transparent faces. The object is composed of trails. Each trail is defined by the vertices that it contains. Each vertex is specified by its coordinates. The data structure shown represents a hypothetical object.*

view, we must know the distance between the picture plane and the observer's eye, the position of the observer, and the angular position of the observer's line of sight.

Figure 9 illustrates the linear and angular position of an observer. Three Cartesian coordinates specify the location of the observer. The coordinate axes that specify the observer's location are the same axes used to specify the vertices of the object. Describing a unique line of sight requires three angles—pitch, bank, and heading. A change in pitch is a rotation about the wings. A change in bank, or roll, is a rotation about the fuselage. And a change in heading, or yaw, is a rotation about a vertical line passing through the pilot; in other words, the heading is the compass direction of the airplane.

Since rotation is not a commutative operation—one in which a change in order will not change the results—we must declare an order of precedence for pitch, bank, and heading. The most physically appealing order is heading, pitch, and then bank. Using that order, we can determine a line of sight by first rotating a unit vector parallel to the *y* axis about the *z* axis in an amount specified by the heading. Next, we should rotate the new vector about the new position of the wings by an amount specified by the pitch. And finally, we should

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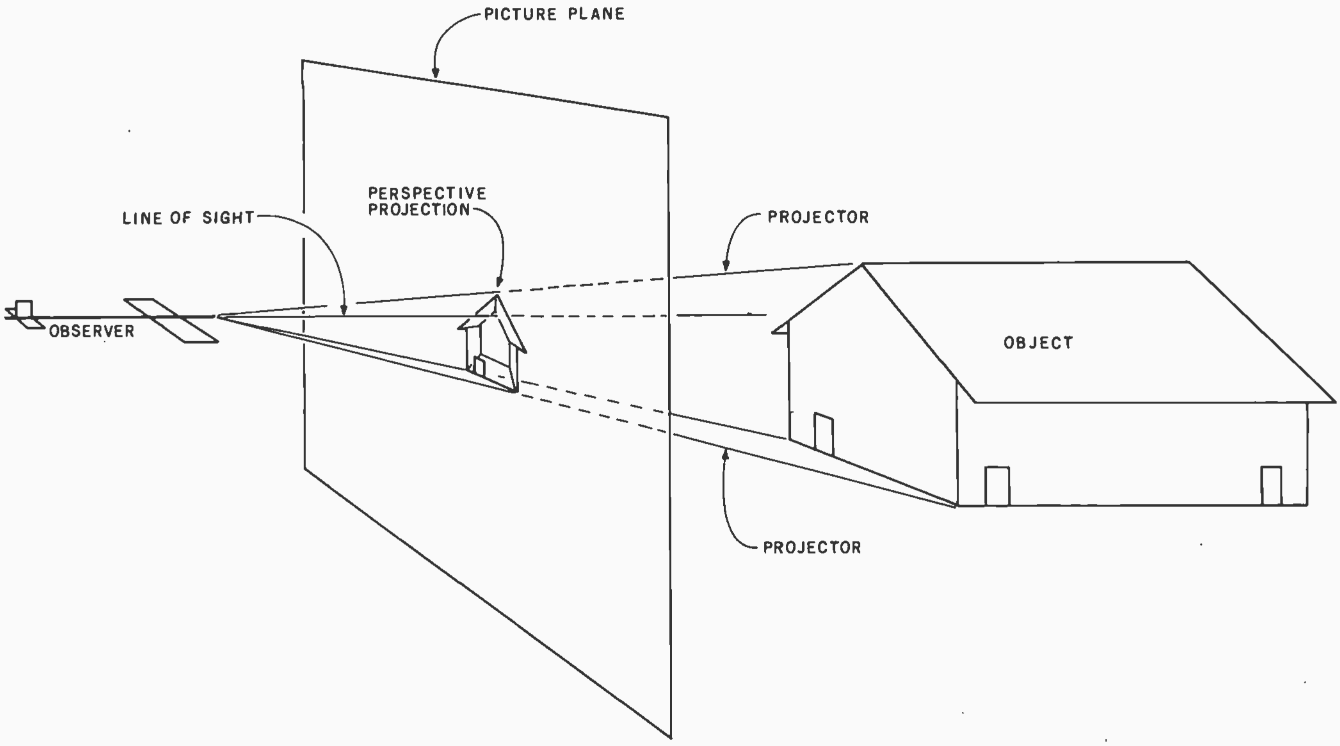

Figure 8: *Perspective projection of an object. The observer's line of sight is normal to the picture plane. The projectors of an object are the lines connecting the object to the observer's eye. The perspective projection consists of the intersections of the projectors and the picture plane. The distance between the observer and the picture plane controls the size of the perspective projection; the farther the picture plane is from the observer, the larger the projection.*

rotate this new vector about the newly positioned fuselage in an amount specified by the bank.

Solving for the Standard Position

Later, we will see that the computations required to create a perspective projection can be greatly simplified by translating and rotating the coordinate system so that the observer is at the origin, with the line of sight aligned with the positive y axis, and the wings aligned with the x axis. When the observer is in this standard position, the pitch, bank, and heading are defined to be zero. We can move the observer to the standard position only if we likewise move the three-dimensional scene so that the observer's view remains unchanged.

Assume that the observer is at the location (X_v, Y_v, Z_v) and has pitch, bank, and heading p, b, and h, respectively. Translating the observer to (0,0,0) and a point $Q(X,Y,Z)$ to $(X-X_v, Y-Y_v, Z-Z_v)$ does not alter

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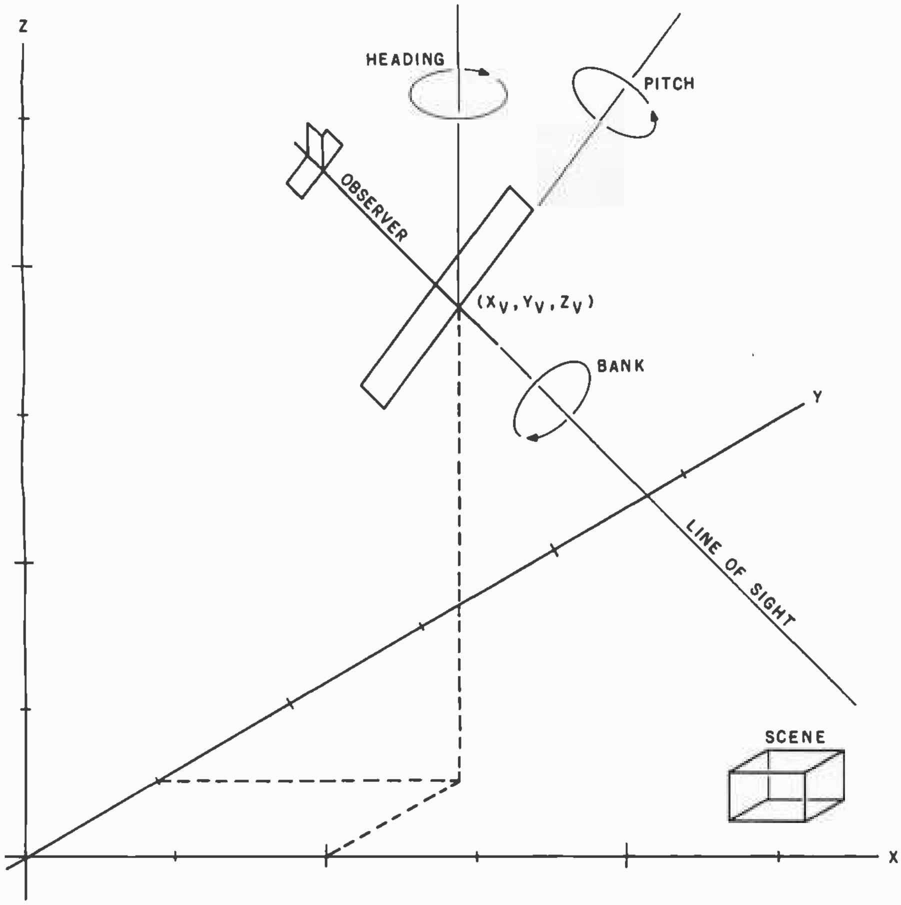

Figure 9: *Viewing parameters. In order to specify a unique view of an object in three dimensions, it is necessary to declare the observer's location and the angular position of the line of sight. The observer is at the point (X_v, Y_v, Z_v), and the line of sight is specified by the aircraft's pitch, bank, and heading.*

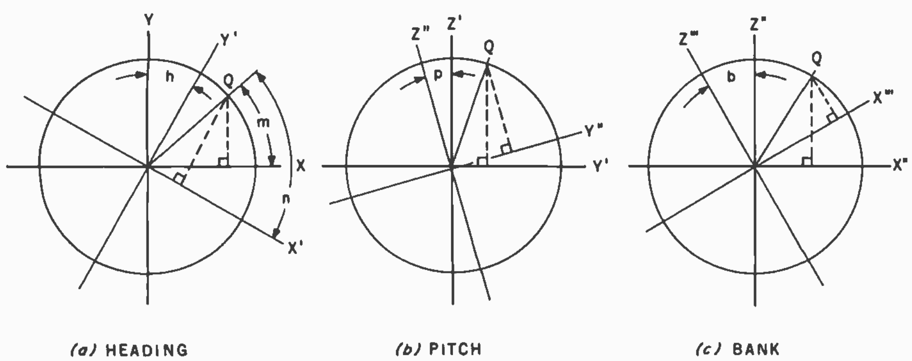

Figure 10: *Rotational transformation of a point. These figures illustrate the relationships between the coordinates of a point Q and the coordinates of Q in a Cartesian system where the observer is in the standard position. The standard position occurs when the observer is located at the origin, the line of sight is the positive y axis, and the "wings" lie on the x axis. In this position, the observer's pitch, bank, and heading are defined to be zero. See equations (1) through (9) in the text.*

the observer's view of the point, but simplifies the rotations that follow. Furthermore, a rotation of the coordinate axes will not affect the observer's perception of the point Q if the point's coordinates undergo an appropriate rotational transformation.

Since three rotations from the standard position determine a line of sight, three rotations of the coordinate axes are needed to bring the observer into the standard position of the rotated coordinate system. Again, the order of rotation is important. First, the x and y axes are rotated about the z axis by the amount of the heading, h, so that the airplane's fuselage is in the $y'z'$ plane (zero heading in the $x'y'z'$ system). Next, the y' and z' axes are rotated about the x' axis by the amount of the pitch, p, so that the fuselage lies on the y'' axis (zero heading and zero pitch in the $x''y''z''$ system). Finally, the x'' and z'' axes are rotated about the y'' axis by the amount of the bank, b, so that the pilot is in the standard position in the $x'''y'''z'''$ coordinate system (zero heading, zero pitch, and zero bank in the $x'''y'''z'''$ system).

With each rotation of the coordinate axes, the coordinates that specify any point will change. Figure 10 illustrates the relationships between the original coordinate system and the three different primed systems. Figure 10a shows that for any point $Q(X,Y,Z)$

$$\begin{aligned} X' &= R\cos(n) \\ &= R\cos(m+b) \\ &= R\cos(m)\cos(h) \\ &\quad + R\sin(m)\sin(h) \\ &= X\cos(h) - Y\sin(h) \end{aligned} \tag{1}$$

$$\begin{aligned} Y' &= R\sin(n) \\ &= R\sin(m+h) \\ &= R\sin(m)\cos(h) \\ &\quad + R\cos(m)\sin(h) \\ &= Y\cos(h) + X\sin(h) \end{aligned} \tag{2}$$

and

$$Z' = Z \tag{3}$$

We can see from figure 10b that

$$X'' = X' \tag{4}$$

$$Y'' = Y'\cos(p) + Z'\sin(p) \tag{5}$$

and

$$\text{os}(p) - Y' \sin(p) \qquad (6)$$

see from figure 10c that

$$X''' = X'' \cos(b) + Z'' \sin(b) \qquad (7)$$

$$Y''' = Y'' \qquad (8)$$

and

$$Z''' = Z'' \cos(b) - X'' \sin(b) \qquad (9)$$

Substituting (1), (2), and (3) into (4), (5), and (6), and then substituting these results into (7), (8), and (9) yields

$$\begin{aligned} X''' = {} & [\cos(b)\cos(h) \\ & - \sin(h)\sin(p)\sin(b)]\, X \\ & + [-\cos(b)\sin(h) \\ & - \sin(p)\cos(h)\sin(b)]\, Y \\ & + [\cos(p)\sin(b)]\, Z \end{aligned}$$

$$\begin{aligned} Y''' = {} & [\sin(h)\cos(p)]\, X \\ & + [\cos(p)\cos(h)]\, Y \\ & + [\sin(p)]\, Z \end{aligned}$$

and

$$\begin{aligned} Z''' = {} & [-\cos(h)\sin(b) \\ & - \sin(h)\sin(p)\cos(b)]\, X \\ & + [\sin(h)\sin(b) \\ & - \sin(p)\cos(h)\cos(b)]\, Y \\ & + [\cos(p)\cos(b)]\, Z \qquad (10) \end{aligned}$$

These equations can be represented using matrix notation, as shown in figure 11. By multiplying out the three matrices, these equations relate the coordinates of a point Q in the *xyz* system to the coordinates of Q in a system, $x'''y'''z'''$, where the observer is in the standard position. Keep in mind that the observer is assumed to be at the origin in the *xyz* system prior to these calculations. Of course, the observer is also at the origin of the $x'''y'''z'''$ system because of the definition of standard position.

$$\begin{array}{c} \\ \end{array} \qquad \text{BANK} \qquad\qquad \text{PITCH} \qquad\qquad \text{HEADING}$$

$$\begin{bmatrix} X''' \\ Y''' \\ Z''' \end{bmatrix} = \begin{bmatrix} \cos(b) & 0 & \sin(b) \\ 0 & 1 & 0 \\ -\sin(b) & 0 & \cos(b) \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos(p) & \sin(p) \\ 0 & -\sin(p) & \cos(p) \end{bmatrix} \begin{bmatrix} \cos(h) & -\sin(h) & 0 \\ \sin(h) & \cos(h) & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} X \\ Y \\ Z \end{bmatrix}$$

$$= \begin{bmatrix} \cos(b)\cos(h) - \sin(h)\sin(p)\sin(b) & -\cos(b)\sin(h) - \sin(p)\cos(h)\sin(b) & \cos(p)\sin(b) \\ \sin(h)\cos(p) & \cos(p)\cos(h) & \sin(p) \\ -\cos(h)\sin(p) - \sin(h)\sin(p)\sin(b) & \sin(h)\sin(b) - \sin(p)\cos(h)\cos(b) & \cos(p)\cos(b) \end{bmatrix} \begin{bmatrix} X \\ Y \\ Z \end{bmatrix}$$

Figure 11: *Equation (10) represented using matrix notation.*

Projecting into the Picture Plane

Once the observer is in the standard position, it is easy to compute the perspective of a point. Remember that the perspective of a point Q is the intersection of the picture plane and the projector line joining the observer and the point. Since the standard position is in use, the observer is located at the origin and the line of sight is the positive y''' axis.

We have to define a new coordinate system for the picture plane. The two axes in the picture plane are labeled *u* and *v* such that the *u* axis is parallel to the x''' axis and the *v* axis is parallel to the z''' axis. Thus, the observer interprets the *u* axis to be

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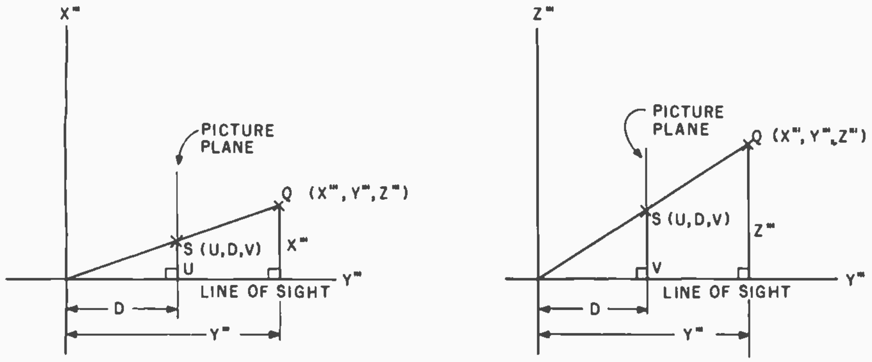

Figure 12: *Projecting a point. Once the observer is in the standard position, it is simple to compute the perspective projection of a point Q. The perspective projection of a point is the intersection of the point's projector and the picture plane. In this figure, D is the distance between the observer and the picture plane. See equations (11) through (14) in the text.*

horizontal and the *v* axis to be vertical. Figure 12 illustrates the relationship between the $x'''y'''z'''$ coordinates of a three-dimensional point *P* and the *u-v* coordinates of the point's projection in the picture plane. If *D* is the distance between the observer and the picture plane, from similar triangles

$$U = [DX''']/Y''' \quad (11)$$

and

$$V = [DZ''']/Y''' \quad (12)$$

When displaying a perspective drawing on a flat screen, it is often convenient to locate the intersection of the viewer's line of sight and the picture plane at the center of the screen. In this case the *u* and *v* axes are translated within the plane, and (11) and (12) take the form

$$U = \text{midh} + [\text{ppu}\, DX''']/Y''' \quad (13)$$

and

$$V = \text{midv} + [\text{ppu}\, DZ''']/Y''' \quad (14)$$

In these equations, (midh, midv) is the center of the viewing screen and ppu (pixels per unit) is a scaling factor to compensate for the fact that the unit of measurement of the screen is not the same as the unit of measurement in the coordinate axes.

It is often good to assume that the video monitor is the picture plane. In this case, the distance between the observer and the picture plane, *D*, is simply the distance between the computer operator and the terminal's screen. In this configuration, the viewing screen is truly a window through which to view the world. Since a perspective view of a three-dimensional line is always a two-dimensional line, we need only translate, rotate, and project two points for each edge of the scene. The line segment joining the two projected points will accurately represent the edge. However, if one of the endpoints of the segment lies outside the viewing screen, the line segment will have to undergo the process called "clipping." A clipping subroutine just ensures that only the part of the line segment that is within the boundaries of the screen will be drawn.

The Programs

Listing 1 and listing 2 are, respectively, BASIC and Pascal programs developed for the Apple II computer. The programs use the concepts discussed in this article to develop a perspective view of a three-dimensional object. In these programs, the observer can view the object, centered at the origin, from any point on a celestial sphere surrounding the object. The Pascal version includes capabilities for clipping and, in addition, for colored edges.

Figure 7 illustrates the data structure for both programs. In the BASIC version, the data is stored within the

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Listing 1: *An Applesoft BASIC program that produces a perspective view of a three-dimensional object.*

```
50  REM ---WRITTEN BY ANDREW PICKHOLTZ---
70  REM ---JANUARY 1981---
100  HOME
120  VTAB 9: HTAB 3
140  PRINT "PERSPECTIVE VIEW OF A 3-D OBJECT"
160  PRINT : PRINT
180  PRINT "WRITTEN BY ANDREW PICKHOLTZ - JAN 1981"
200  VTAB 18
220  PRINT " PADDLE #0 CONTROLS THE VIEWER'S PITCH"
240  PRINT "PADDLE #1 CONTROLS THE VIEWER'S HEADING"
280  PRINT : PRINT : HTAB 6: FLASH
300  PRINT "WAIT WHILE LOADING VERTICES"
320  NORMAL : FOR SC = 1 TO 3000: NEXT SC
340 X = Y = Z = X3 = Y3 = Z3 = AM = BM = CM = DM = EM = FM = GM = HM =
 IM = D = P =  B
 = H = U = V = U1 = V1 = 0
360  DIM V(50,3),E(100)
370  REM ---READ DATA---
380  READ NV
400  FOR P = 1 TO NV
420  READ V(P,1),V(P,2),V(P,3)
440  NEXT P
460  READ NE
470  FOR E = 1 TO NE
480  READ E(E)
490  NEXT E
500  HOME : HGR : HCOLOR= 0: HPLOT 0,0
510  REM ---COMPUTE OBSERVER'S PARAMETERS---
520 D = 75
540 P = 6.28 *  PDL (0) / 255 - 3.1416
560 B = 0
580 H = 6.28 *  PDL (1) / 255
600  GOSUB 20100
620 XV =  - D * CP * SH: REM  ---SEE SUB.---
640 YV =  - D * CP * CH
660 ZV =  - D * SP
700  REM ---PROJECT NE POINTS---
720  FOR E = 1 TO NE
800 X = V( ABS (E(E)),1)
820 Y = V( ABS (E(E)),2)
840 Z = V( ABS (E(E)),3)
860  GOSUB 20720
900  IF E(E) > 0 THEN  HCOLOR= 3: HPLOT U1,V1 TO U,V
920 U1 = U:V1 = V
940  NEXT E
999  REM ---PREPARE FOR NEW FRAME---
1000  VTAB 21: HTAB 8: PRINT "PERSPECTIVE OF A BLOCK"
1010  PRINT "PROGRAM WRITTEN BY ANDREW PICKHOLTZ"
1020  HTAB 8: PRINT "PITCH="; INT (57.2 * P);"  HEADING="; INT (57.2 * H)
1060  PRINT "BUTTON #1 TO END-#0 FOR P=    , H=    ";
1070  VTAB 24: HTAB 27: PRINT "    , H=    ";
1080  VTAB 24: HTAB 27: PRINT  INT (360 *  PDL (0) / 255 - 180);
1100  VTAB 24: HTAB 35: PRINT  INT (360 *  PDL (1) / 255);
1110  REM ---CHECK FOR BUTTON PRESS---
1120  IF  PEEK ( - 16287) > 127 THEN 500
1140  IF  PEEK ( - 16286) < 128 THEN 1070
1160  TEXT
1180  END
20000  REM --- 3D PROJECTION SUBS. ---
20100  REM --- SET UP MATRIX ELEMENTS GIVEN PITCH, BANK, HEADING ---
20120  REM  --- USE TRANSCENDENTAL FUNCTIONS AS FEW TIMES AS POSSIBLE ---
20140 CH =  COS (H):SH =  SIN (H)
20160 CP =  COS (P):SP =  SIN (P)
20180 CB =  COS (B):SB =  SIN (B)
20200  REM  --- SET UP MATRIX ---
20220 AM = CB * CH - SH * SP * SB
20240 BM =  - CB * SH - SP * CH * SB
20260 CM = CP * SB
20280 DM = SH * CP
20300 EM = CP * CH
20320 FM = SP
20340 GM =  - CH * SB - SH * SP * CB
20360 HM = SH * SB - SP * CH * CB
20380 IM = CP * CB
20400  RETURN
```

Listing 1 continued on page 492

program. In the Pascal version, the data must be entered into a disk file. Listing 3 is a simple program that will store the data for the Pascal system.

The first element of data for both programs is the number of vertices that compose the object. Each vertex is then specified by its three coordinates. The unit of measurement in the coordinate system is the centimeter. If you use a monitor that does not measure 12 inches diagonally, you should change the ppu described in equations (13) and (14) to assure a truly accurate representation of distance. The programs assign a number to each vertex that is in the data file; the first vertex is number one, the second number two, and so on.

Following the vertices is the number of lines that are to be projected. This number also indicates how many numbers remain in the file. All of the remaining numbers refer to vertices that are to be projected. If the number is a positive integer, the programs draw a white line from the previously projected vertex to the vertex specified by the integer. The Pascal version will draw colored lines if you append a decimal point and a digit to the integer; point one specifies the color green, point two the color violet, and three and four specify orange and blue, respectively. A negative integer indicates that only the indicated vertex should be plotted, not a line as before.

Both programs have a subroutine (SETUP in the Pascal listing; line 20000 in the BASIC) that computes the elements of matrix in figure 11. You input the pitch and heading of the observer by using the Apple's paddles. The observer's bank is set to zero. Since the observer is on a celestial sphere of radius 75 centimeters, the location of the observer can be computed using a conversion from spherical to rectangular coordinates. Thus:

viewer's x coordinate

$$= -75 \cos(p) \sin(h)$$

viewer's y coordinate

$$= -75 \cos(p) \cos(h)$$

viewer's z coordinate

$$= -75 \sin(p)$$

Circle 247 on inquiry card.

Circle 122 on inquiry card.

Listing 1 continued:

```
20600  REM --- SUB. TO TRANSFORM A 3D POINT TO A 2D ---
20620  REM --- X,Y,Z IS THE 3D POINT WHICH IS TRANSFORMED INTO U,V ---
20640  REM --- XV,YV,ZV ARE THE COORDINATES OF THE VIEWER ---
20660  REM --- D IS THE DISTANCE BETWEEN THE OPERATOR'S EYE AND THE SCREEN IN CM
---
20680  REM --- GOSUB 20100 EVERY TIME THE VIEWERS PITCH, BANK, OR HEADING CHANGES
---
20700  REM --- TRANSLATE SO THAT VIEWER IS AT THE ORIGIN ---
20720 X = X - XV
20740 Y = Y - YV
20760 Z = Z - ZV
20780  REM --- ROTATE SO THAT THE VIEWER IS LOOKING DOWN THE Y-AXIS ---
20800 X3 = AM * X + BM * Y + CM * Z
20820 Y3 = DM * X + EM * Y + FM * Z
20840 Z3 = GM * X + HM * Y + IM * Z
20860  REM ---PROJECT INTO 2D SCREEN---
20880 U = 135 + 13.5 * D * X3 / Y3
20900 V = 80 - 11.5 * D * Z3 / Y3
20920  RETURN
30000  REM ---NUMBER OF VERTICES---
30020  DATA  8
30040  REM ---VERTEX COORDINATES---
30060  DATA  5.25,-2,3.25
30080  DATA  -5.25,-2,3.25
30100  DATA  -5.25,-2,-3.25
30120  DATA  5.25,-2,-3.25
30140  DATA  5.25,2,3.25
30160  DATA  -5.25,2,3.25
30180  DATA  -5.25,2,-3.25
30200  DATA  5.25,2,-3.25
31000  REM --- NUMBER OF EDGES---
31020  DATA  16
31040  REM --- EDGES ---
31060  REM ---NEG. EDGES START NEW CURVE---
31080  DATA  -1,2,3,4,1,5,6,7,8,5
31100  DATA  -2,6,-3,7,-4,8
```

Note that the distance between the observer and the picture plane (DIS or D) is equal to the distance between the observer and the center of the object (the radius of the sphere). Therefore, the dimensions of the perspective of the object will approximate those of the object itself.

The second subroutine in each program (PROJECT, or line 20600) does the computations needed to project each point. Thus, each subroutine first transforms the point into the triple-primed system. Then, each projects the point into the picture plane using formulas (13) and (14). The program has to call this second subroutine every time a point is projected. The program has to call the first subroutine only when the viewing parameters change.

Using the Programs

The BASIC program in listing 1 is ready to run as is. Lines 30000-31100 of listing 1 contain the data for a rect-

Text continued on page 500

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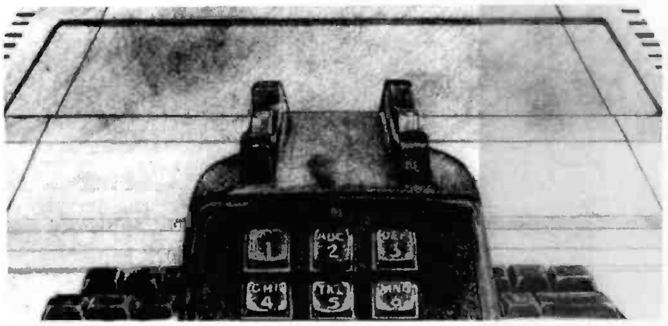

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Listing 2: *Object3d, an Apple Pascal program that produces a perspective view of a three-dimensional object.*

```
(*$S+*)  (* SWAPPING OPTION *)

PROGRAM OBJECT3D;

(* WRITTEN BY ANDREW PICKHOLTZ - JANUARY 1981 *)
(* PROJECT THE IMAGE OF A 3-D OBJECT INTO THE SCREEN *)

USES TURTLEGRAPHICS, APPLESTUFF, TRANSCEND;

CONST
  MIDH = 135;   (* SCREEN CENTER *)
  MIDV = 95;
  PPCMH = 13.5; (* POINTS PER CM *)
  PPCMV = 11.5;
  MAXVER = 300;
  MAXEDG = 200;
  PI = 3.1416;

TYPE
  RANGVER = 1..MAXVER;
  RANGEDG = 1..MAXEDG;
  POINT3D = ARRAY [(X,Y,Z)] OF REAL;
  POINT2D = ARRAY [(U,V)] OF REAL;
  MANY3D = ARRAY [RANGVER] OF POINT3D;


VAR
  EDGE : ARRAY [RANGEDG] OF REAL;
  VERTEX : MANY3D;
  DATAFILE : FILE OF REAL;
  OBJCTNAME : STRING;
  OBSCOOR : POINT3D; (*OBSERVER'S COORDINATES*)
  P,B,H : REAL;
  SP,CP,SB,CB,SH,CH : REAL;
  AM,BM,CM,DM,EM,FM,GM,HM,IM : REAL;
  NUMVER : RANGVER;
  NUMEDG : RANGEDG;
  DIS : REAL;
  DONE : BOOLEAN;

PROCEDURE TITLE;
BEGIN
  PAGE (OUTPUT);
  GOTOXY (3,6);
  WRITELN ('PERSPECTIVE VIEW OF A 3-D OBJECT');
  WRITELN; WRITELN;
  WRITELN ('WRITTEN BY ANDREW PICKHOLTZ - JAN 1981');
  GOTOXY (1,16);
  WRITELN ('PADDLE #0 CONTROLS OBSERVER''S PITCH');
  WRITELN ('PADDLE #1 CONTROLS OBSERVER''S HEADING');
  WRITELN;
  WRITE ('OBJECT (FILE) TO BE DISPLAYED? ');
END;



PROCEDURE READDATA;
VAR I : RANGVER;
  J : RANGEDG;
FUNCTION LOAD:REAL;
BEGIN
  LOAD := DATAFILE↑;
  GET (DATAFILE);
END;
BEGIN
  READLN (OBJCTNAME);
  RESET (DATAFILE,OBJCTNAME);
        (* LOAD VERTICES *)
  NUMVER := TRUNC (LOAD);
  FOR I:= 1 TO NUMVER DO
  BEGIN
    VERTEX [I,X] := LOAD;
```

Listing 2 continued on page 496

Circle 271 on inquiry card.

Circle 183 on inquiry card.

Circle 315 on inquiry card.

Listing 2 continued:

```
    VERTEX [I,Y] := LOAD;
    VERTEX [I,Z] := LOAD;
  END;
        (* LOAD EDGES *)
  NUMEDG := TRUNC (LOAD);
  FOR J:= 1 TO NUMEDG DO
  BEGIN
    EDGE [J] := LOAD;
  END;
  CLOSE (DATAFILE);
END; (*READDATA*)

PROCEDURE SETUP;
CONST EPSILON = 2.5E-2;
BEGIN
      (* PITCH, BANK, HEADING, DISTANCE *)
  DIS:=75;
  P:=2*PI*PADDLE(0)/255-PI;
  IF ABS(P) < EPSILON THEN P:=0;
  B:=0;
  H:=2*PI*PADDLE(1)/255;
      (* TRANSCENDENTAL FUNCTIONS *)
  SP:=SIN(P); CP:=COS(P);
  SB:=SIN(B); CB:=COS(B);
  SH:=SIN(H); CH:=COS(H);
      (* MATRIX COMPONENTS *)
  AM := CH*CB-SH*SP*SB;
  BM := -SH*CB-CH*SP*SB;
  CM := CP*SB;
  DM := SH*CP;
  EM := CP*CH;
  FM := SP;
  GM := -CH*SB-SH*SP*CB;
  HM := SH*SB-CH*SP*CB;
  IM := CP*CB;
      (* OBSERVER'S COORDINATES *)
  OBSCOOR[X] := -DIS*CP*SH;
  OBSCOOR[Y] := -DIS*CP*CH;
  OBSCOOR[Z] := -DIS*SP;
END;

PROCEDURE PROJECT (PT3D : POINT3D;VAR PT2D : POINT2D);
VAR ROTPT : POINT3D;
BEGIN
          (* TRANSLATE SO THAT OBSERVER IS AT ORIGIN *)
  PT3D[X] := PT3D[X] - OBSCOOR[X];
  PT3D[Y] := PT3D[Y] - OBSCOOR[Y];
  PT3D[Z] := PT3D[Z] - OBSCOOR[Z];
          (* ROTATE SO THAT OBSERVER IS LOOKING DOWN Y-AXIS *)
  ROTPT[X] := AM*PT3D[X] + BM*PT3D[Y] + CM*PT3D[Z];
  ROTPT[Y] := DM*PT3D[X] + EM*PT3D[Y] + FM*PT3D[Z];
  ROTPT[Z] := GM*PT3D[X] + HM*PT3D[Y] + IM*PT3D[Z];
          (* PROJECT INTO PICTURE PLANE AT DISTANCE DIS *)
  PT2D [U] := MIDH + PPCMH*DIS*ROTPT[X]/ROTPT[Y];
  PT2D [V] := MIDV + PPCMV*DIS*ROTPT[Z]/ROTPT[Y];
END;

PROCEDURE DRAW;
VAR
  J : RANGEDG;
  SCRNPT : POINT2D;
BEGIN
  SETUP;
  FOR J := 1 TO NUMEDG DO
  BEGIN
          (* DELETE FRACTIONAL PART AND PROJECT *)
    PROJECT ( VERTEX[ABS(TRUNC(EDGE [J]))], SCRNPT );
          (* IF EDGE IS NEG THEN LINE IS NOT DISPLAYED *)
    IF EDGE [J] < 0
      THEN PENCOLOR (NONE)
          (* FRACTIONAL PART OF EDGE DETERMINES COLOR *)
      ELSE
      CASE TRUNC(10*(EDGE [J]-TRUNC(EDGE [J]))) OF
        0 : PENCOLOR (WHITE);
        1 : PENCOLOR (GREEN);
        2 : PENCOLOR (VIOLET);
        3 : PENCOLOR (ORANGE);
        4 : PENCOLOR (BLUE);
      END;
      MOVETO (ROUND(SCRNPT[U]), ROUND(SCRNPT[V]));
  END;
END; (*DRAW*)
```

Listing 2 continued on page 498

Listing 2 continued:

```
PROCEDURE NEWFRAME;
CONST  RADDEG = 57.2;
VAR ADVANCE : BOOLEAN;
      S : STRING;
      PDL : REAL;
BEGIN
        (* COMMENTS AROUND OBJECT *)
  PENCOLOR (NONE);
  MOVETO (15,183);
  WSTRING ('PERSPECTIVE VIEW OF A ');
  WSTRING (OBJCTNAME);
  MOVETO (10,174);
  STR (ROUND (P*RADDEG),S);
  WSTRING ('PITCH = ');
  WSTRING (S);
  MOVETO (180,174);
  STR (ROUND (H*RADDEG),S);
  WSTRING ('HEADING = ');
  WSTRING (S);
  MOVETO (10,2);
  WSTRING ('BUTTON #1 ENDS - #0 FOR ');
        (* UPDATE COMMENTS - CHECK BUTTONS *)
  REPEAT
    MOVETO (178,2);
    WSTRING ('              ');
    MOVETO (178,2);
    PDL := PADDLE(0)/255*360-180;
    STR (ROUND (PDL),S);
    WSTRING ('P=');
    WSTRING (S);
    MOVETO (227,2);
    PDL := PADDLE(1)/255*360;
    STR (ROUND (PDL),S);
    WSTRING ('H=');
    WSTRING (S);
    ADVANCE := BUTTON (0);
    DONE := BUTTON (1);
  UNTIL ADVANCE OR DONE;
  FILLSCREEN (BLACK);
END;
```

```
BEGIN
  TITLE;
  READDATA;
  INITTURTLE;
  REPEAT
    DRAW;
    NEWFRAME;
  UNTIL DONE;
  PAGE (OUTPUT);
  TEXTMODE;
  WRITELN;
  WRITELN ('DONE...');
END.
```

Listing 3: *A Pascal program that stores data for use by Object3d, the program given in listing 2.*

```
PROGRAM FILEWRITE;

(* PROGRAM TO INSERT DATA INTO A FILE *)

VAR
  FILENAME : STRING;
  DISK : FILE OF REAL;
  NUMBER : REAL;

BEGIN
  WRITELN;
  WRITE ('NAME OF OBJECT (FILE)? ');
  READLN (FILENAME);
  WRITELN ('< CNTL-C >  TO STOP');
  WRITELN;
  REWRITE (DISK,FILENAME);
  REPEAT
    READLN (NUMBER);
    DISK^ := NUMBER;
    PUT (DISK);
  UNTIL EOF;
  CLOSE (DISK,LOCK);
END.
```

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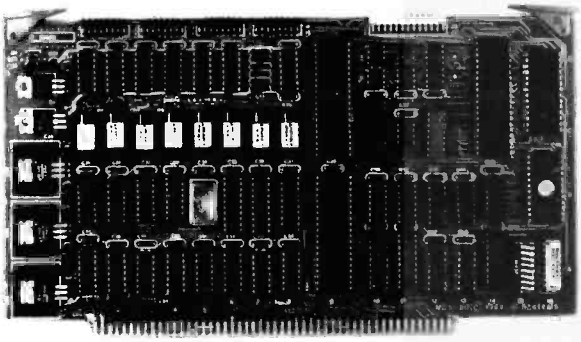

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Listing 4: *Changes for the BASIC program in listing 1 that will produce a perspective of a dodecahedron.*

```
]LIST

430 V(P,1) = 6 * V(P,1):V(P,2) = 6 * V(P,2):V(P,3) = 6 * V(P,3)
1000  VTAB 21: HTAB 4: PRINT "PERSPECTIVE OF A DODECAHEDRON"
30000  REM  ---NUMBER OF VERTICES---
30020  DATA  20
30040  REM  ---VERTEX COORDINATES---
30060  DATA  0,-.3568,.9342,.5774,-.5774,.5774
30080  DATA  .9342,0,.3568,.5774,.5774,.5774
30100  DATA  0,.3568,.9342,-.5774,.5774,.5774
30120  DATA  -.9342,0,.3568,-.5774,-.5774,.5774
30140  DATA  -.3568,-.9342,0,.3568,-.9342,0
30160  DATA  .3568,.9342,0,-.3568,.9342,0
30180  DATA  -.5774,-.5774,-.5774,0,-.3568,-.9342
30200  DATA  .5774,-.5774,-.5774,.9342,0,-.3568
30220  DATA  .5774,.5774,-.5774,0,.3568,-.9342
30240  DATA  -.5774,.5774,-.5774,-.9342,0,-.3568
31000  REM  --- NUMBER OF EDGES---
31020  DATA  40
31040  REM  --- EDGES ---
31060  REM ---NEG. EDGES START NEW CURVE---
31080  DATA  -1,2,3,4,5,6,7,8,1,5
31100  DATA  -14,15,16,17,18,19,20,13,14,18
31120  DATA  -8,9,10,2
31140  DATA  -13,9
31160  DATA  -15,10
31180  DATA  -4,11,12,6
31200  DATA  -17,11
31220  DATA  -19,12
31240  DATA  -16,3
31260  DATA  -7,20
31280  END
```

Listing 5: *A Pascal program that displays an accurately proportioned model of a DNA molecule.*

```
PROGRAM MAKEDNA;

(* PROGRAM TO COMPUTE DOUBLE-HELIX *)
(* ANDREW PICKHOLTZ - JAN 1981 *)

USES APPLESTUFF,TRANSCEND;

CONST
        (* DESCRIPTION OF DOUBLE-HELIX *)
        (* SEE J.D.WATSON, MOLECULAR BIOLOGY OF THE GENE *)
        (* SECOND EDITION, PAGES 261-262 *)
        (* ALL UNITS IN ANGSTROMS *)
  RADIUS = 10;
  HTURN = 34;      (* HEIGHT OF ONE TURN *)
  NNPT = 10;       (* NUMBER OF NUCLEOTIDES PER TURN *)
  OFFSET = 2.402; (* OFFSET FOR SECOND HELIX IN RADIANS *)
  PI = 3.1416;
  CMPA = 0.1569;  (* CM PER ANGSTROM FOR MAGNIFICATION *)
  NNUCL = 15;     (* HALF NUMBER OF NUCLEOTIDES TO DISPLAY *)

VAR
  NUCL : -NNUCL..NNUCL;
  I,J : INTEGER;
  DISK : FILE OF REAL;
  COLOR : REAL;
```

Listing 5 continued on page 502

Text continued from page 492:

angular parallelepiped (a prism whose bases are parallelograms), i.e., a block. Listing 4 has the changes that should be made to project a dodecahedron (a solid with 12 faces) instead of a block. To produce a full-screen dodecahedron, you must multiply the data elements in lines 30060-30240 by 6. Once compiled, the Pascal program in listing 2 will display any object that is represented in a disk file. The program in listing 3 will load data into a file.

Objects can also be created by the computer. For example, listing 5 contains a Pascal program that will create an accurately proportioned model of a DNA molecule. The double helix is represented by 62 vertices connected by more than 100 straight lines.

Photo 1 is an actual photograph of a real dodecahedron. Photos 2 through 6 show examples of the use of the programs. Photo 2 displays computer-drawn perspectives from various viewing positions. Similarly, photo 3 shows the wire-frame perspective of a block. Photo 4 shows drawings of an object that you are more likely to encounter, a house. You can see that these photos exhibit the properties of true perspective that were shown in figure 4. The DNA molecule shown in photo 5 is even more interesting. The orientation of the double helix displayed in photo 5a is like those found in many textbooks.

Pascal draws an object significantly faster than does BASIC. On the system used, however, the speed at which the object is drawn and the screen erased is not nearly fast enough to produce the appearance of smooth motion, let alone freedom from flickering (this would require a minimum of 30 frames per second). Thus, although the programs have the inherent capability of displaying a continuous change in view of the object, either a faster machine or a more efficient compiler, or both, would be necessary to achieve this result.

Extensions, Anyone?

The most obvious extension to wire-frame perspective is to remove from the display the lines and sur-

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Listing 5 continued:

```
PROCEDURE DUMP (DATA : REAL);
BEGIN
  DISK↑ := DATA;
  PUT (DISK);
END;
BEGIN
  WRITELN;
  WRITELN ('WRITING');
  REWRITE (DISK,'DOUBLE-HELIX');
         (* NUMBER OF POINTS *)
  DUMP (2*(2*NNUCL+1));
  FOR NUCL := -NNUCL TO NNUCL DO
  BEGIN
         (* FIRST HELIX *)
    DUMP (CMPA*RADIUS* COS(NUCL*2*PI/NNPT));
    DUMP (CMPA*RADIUS* SIN(NUCL*2*PI/NNPT));
    DUMP (CMPA*HTURN/NNPT*NUCL);
         (* SECOND HELIX *)
    DUMP (CMPA*RADIUS* COS(NUCL*2*PI/NNPT+OFFSET));
    DUMP (CMPA*RADIUS* SIN(NUCL*2*PI/NNPT+OFFSET));
    DUMP (CMPA*HTURN/NNPT*NUCL);
  END;
         (* NUMBER OF EDGES *)
  DUMP (8*NNUCL);
  FOR J := 1 TO 2*NNUCL DO
  BEGIN
    I := 2*J-1;
    DUMP (-I);
    DUMP (I+2);
    COLOR := ((RANDOM MOD 4)+1)/10;
    DUMP (I+3+COLOR);
    DUMP (I+1);
  END;
  CLOSE (DISK,LOCK);
  WRITELN ('DONE...');
END.
```

faces that should be hidden, as shown in photo 6. A first step to accomplish this task of hidden-line removal is to define the faces of the object. We can do that by discarding the data structure represented in figure 7 in favor of the data structure in figure 6. The next step in hidden-line removal is to determine which faces shield the others.

Many methods of hidden-line removal are available. All require much more computer time than the wire-frame representation. One procedure, the depth-buffer algorithm, requires that the depth of every pixel on the screen be recorded. Before drawing a new point into the screen, the depth of the point to be displayed is compared with the depth of the existing pixel. The new point will be drawn only if it is closer to the observer than the existing screen point. Although this algorithm is relatively simple, it requires an enormous amount of computer memory.

Another method of hidden-line removal, the priority algorithm, requires that all the faces be sorted in the order that they are to be drawn into the screen. Thus, the faces in the foreground will block the faces behind them, since the foreground faces will be drawn last. One drawback of the priority algorithm is that it cannot draw cyclically overlapping polygons.

Wire-frame perspective could also

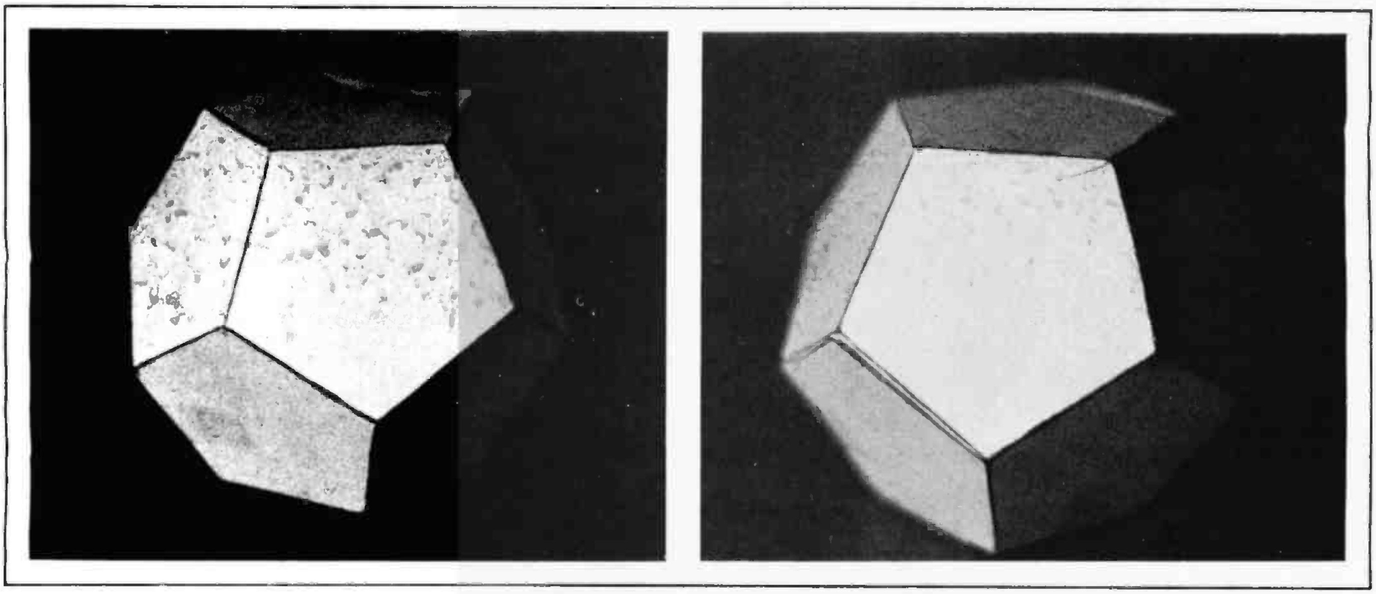

Photo 1: *A real regular dodecahedron.*

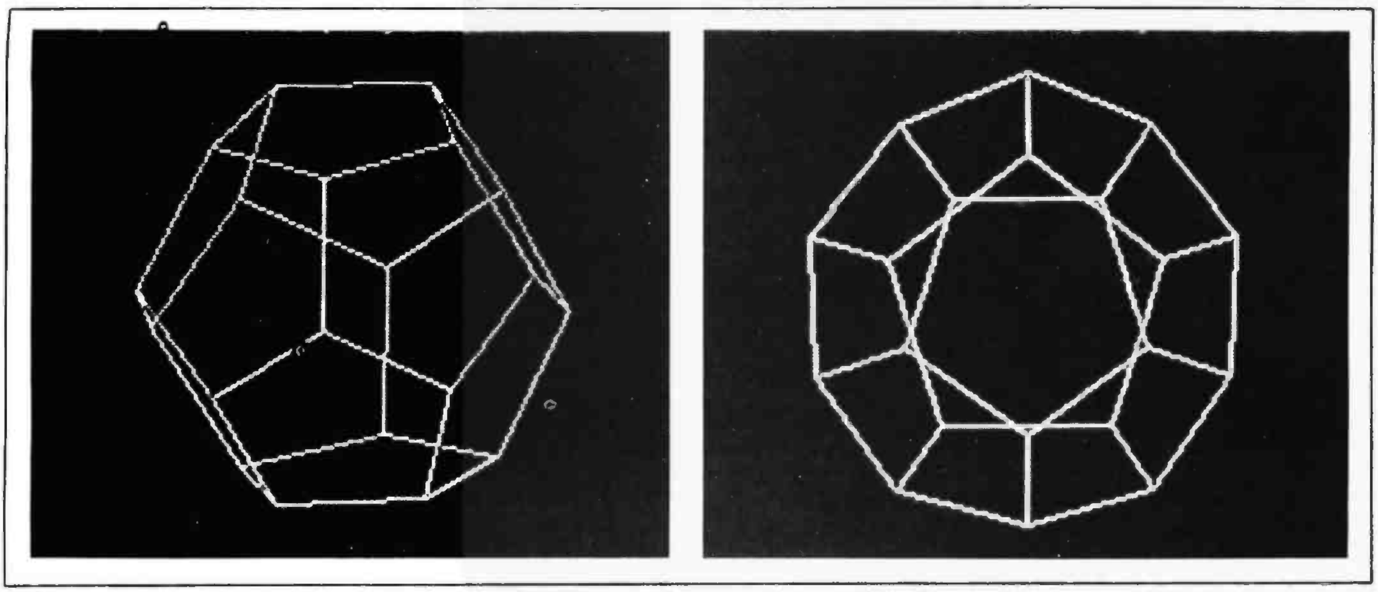

Photo 2: *A screen representation of a wire-frame dodecahedron. The video monitor was connected to an Apple II.*

be extended to draw curves rather than just straight lines. The Bezier and B-spline methods are among the many techniques for interpolating curves with a finite number of points.

The interposition of two perspective views of an object from slightly different positions can create the effect of stereo vision. One view could be drawn on the left-hand side of the screen and the other on the right-hand side. Alternatively, an anaglyph (a stereoscopic picture using two different colors, similar to three-dimensional movies now being shown on TV) can be produced by drawing one view in one color and the other slightly displaced view in another color. Of course, viewing glasses with correspondingly colored filters would be required to perceive the stereo effect of the anaglyph.

Many more difficult problems present themselves when searching for further extensions to the wire-frame perspective. Extraordinary realism in three-dimensional graphics can be achieved by including more of the physical characteristics of real objects, such as shading, shadowing, texture, reflectivity, and transparency. These characteristics could all improve the realism of a computer-drawn scene. Although an artist could produce a painting with all these characteristics, the computer-drawn scene could be manipulated interactively to present various alterations to the observer, such as different viewing angles, changes in scale, and even topological transformations of the scene.

Conclusion

The new generation of microcomputers that is now entering the marketplace will provide an abundance of opportunities for writing and viewing computer graphics. More powerful processors, higher-resolution monitors, and greater

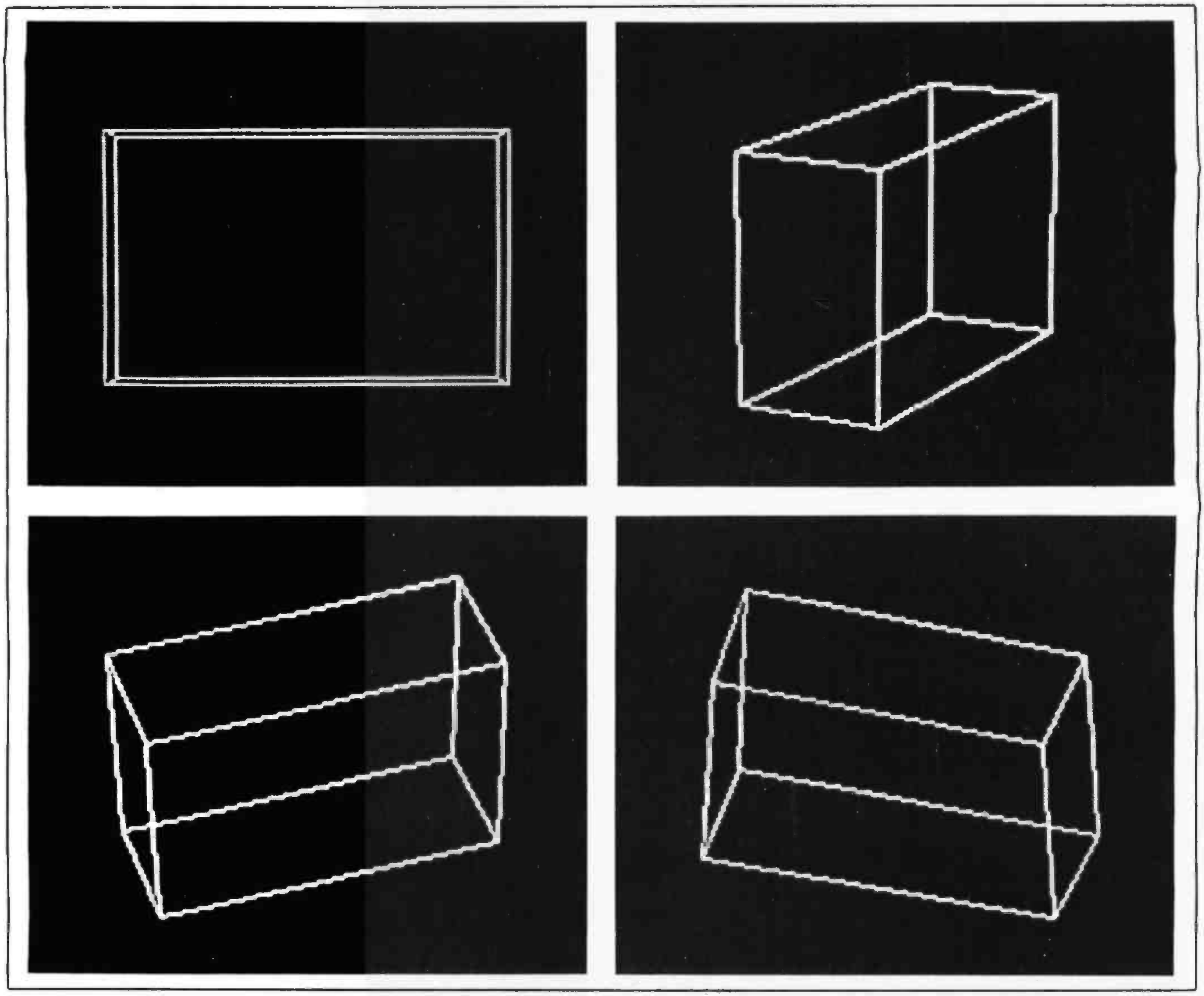

Photo 3: *Perspective view of a block from a variety of angles. Negative pitch produces views from above, and positive pitch produces a view from below.*

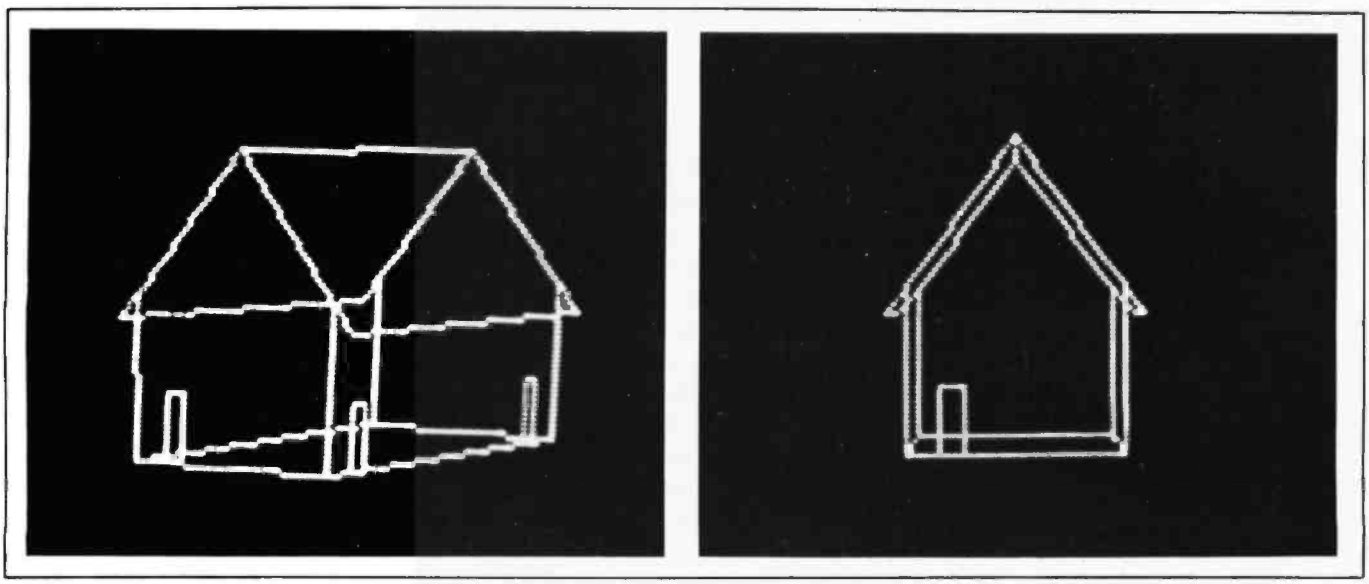

Photo 4: *Perspective view of a wire-frame house.*

memory-addressing capacity will enable programmers to use some of the techniques that were impossible on an Apple II. The same improvements will make computer graphics more exciting to both sophisticated and naive observers. I hope that this article not only interests today's Apple II owners, but also encourages them and others to write software that exploits the impressive graphics capabilities of the new machines. ■

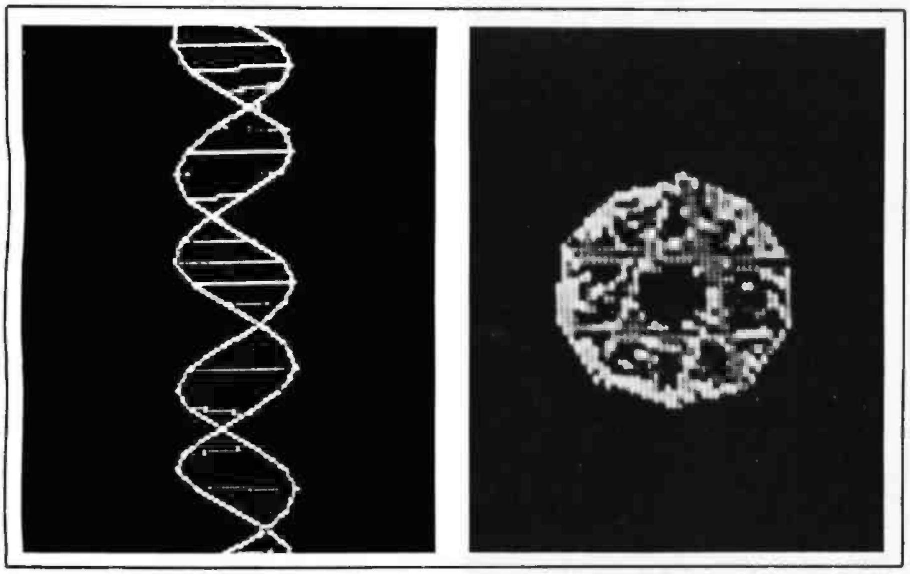

Photo 5: *Perspective view of a double helix. The observer's line of sight is perpendicular to the axis of the double helix, and then down the axis of the double helix.*

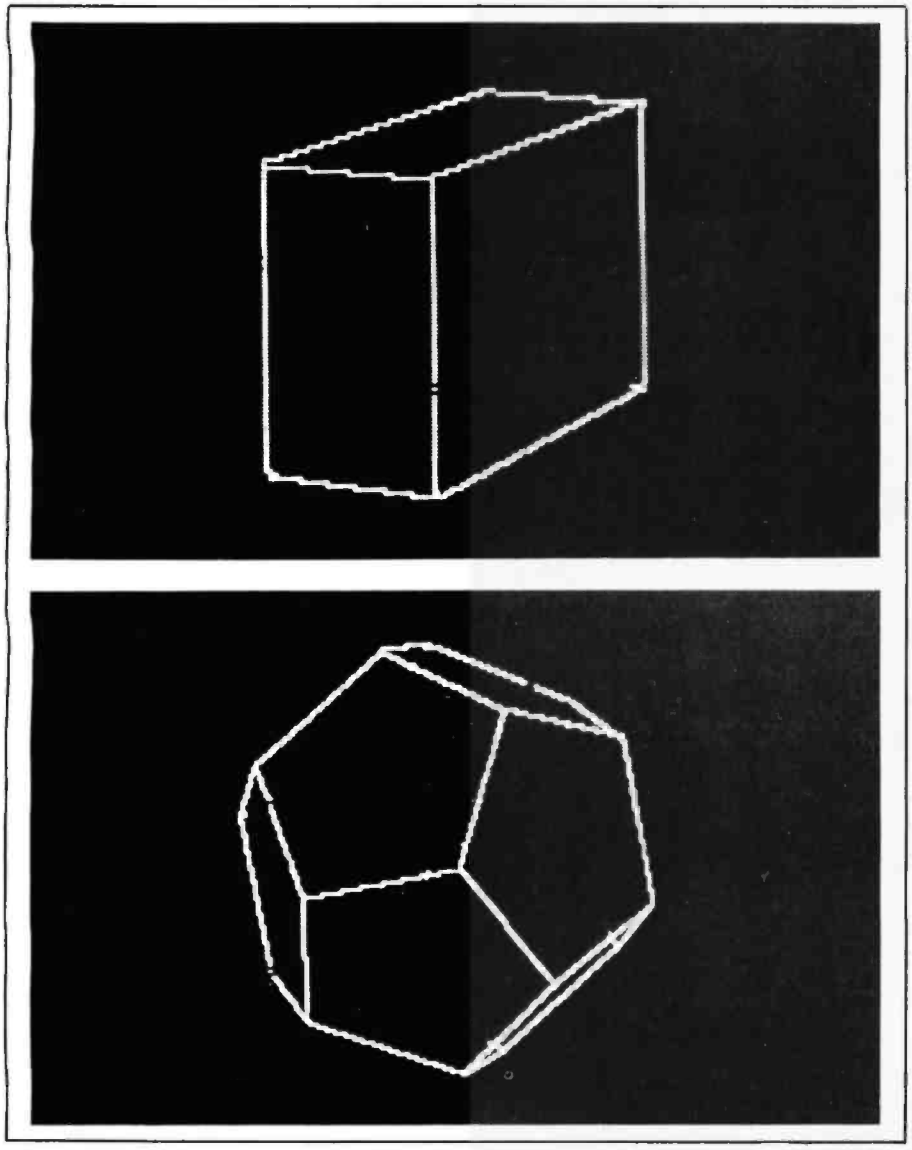

Photo 6: *Perspective of a block and a dodecahedron with lines that would be hidden by opaque surfaces removed from the representation (photos were manually produced).*

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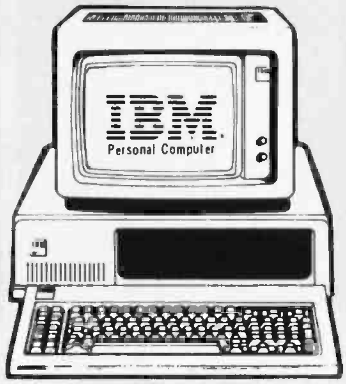

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Microvec

The Other Type of Video Display

Billy Garrett
POB 18806
Greensboro, NC 27419-8806

If you look closely at the video games in an arcade, you will see two main types of video displays. The "other" type of display is called a vector-graphics display (of course, the most common display is the raster type that operates like an ordinary television). The vector display is easily recognized because the displayed image is formed by line segments called vectors. The image resembles a stick figure or an engineering drawing. Because no low-cost vector displays are available commercially, I decided to design and build one for myself.

This article describes how the Microvec unit operates and how to build one. For less than $225, you can have a complete, stand-alone vector-graphics controller that can produce images like those in photos 1, 2, and 3. It will accept commands to draw lines with endpoints anywhere on a 256- by 256-element grid, and it can display any one of four "pages" of video information stored in memory. By connecting the controller to a common oscilloscope, you will have a vector-display unit that can be hooked to any computer. Interfaces specifically designed for use with the S-100 bus and the Radio Shack TRS-80 Model I computer are also described in this article.

Behind the Screens

Billy Garrett began work on the Microvec project as a junior at the University of South Carolina; the Engineering Department there was very helpful, and special thanks goes to Dr. Robert Pettes and Dr. Bill Eccles for their support and encouragement. The South Carolina Honors College, led by Dr. Mould, helped with the manuscript and photos. Due to the aid of Dr. Wierzba and Dr. Walters, work on the project achieved recognition at the IEEE's Region 3 Student Paper Contest, where it took third place. Norman McEntire encouraged the author to send the paper to BYTE in the form of a construction article. The photos in this article are by Howard Rhinehart.

The Arcade Syndrome

Whenever I finally tear myself away from a video-game arcade, I consider myself lucky to have any money left. By the time I arrive home, I'm ready to start designing my own video game. I have come to realize, however, that TRS-80 BASIC is too slow at handling graphics for my purposes; the only way to write an *interactive real-time* game that uses graphics extensively is to use machine language—a tedious process at best. Even worse is the limited resolution (128 by 48 picture elements) that the TRS-80 has to offer. Though other computers with higher resolution are available, I have found that the raster-scan display, as employed by all current home computers, can be difficult to use.

Raster Scan versus Vectors

A raster display is formed one line at a time, from the top of the screen to the bottom (about 525 horizontal lines for a standard TV picture). In a high-resolution raster-scan display, the image is formed by turning on many small dots, called pixels (picture elements). Because so many pixels are in a small area, the eye blurs them into what appears to be a solid form. Many raster-scan displays are available for personal computing use, and the price depends on the type and resolution of the display desired. Even though raster-scan displays are widely used, they are not ideally suited for *all* display applications.

In a vector-display system, an image on the screen is made up of individual *line segments*, rather than dots. A display of this nature is commonly found in an arcade as part of a game. This kind of display is also used to produce schematics, structural outlines of a building, and can even be used for the complicated task of real-time aircraft simulation. Its main advantage over the raster-scan technique is simplicity of use: only two points must be known in order to draw a line; in a raster-scan device, the line is composed of many pixels, each of which must be kept track of individually and turned on or off.

With a vector display, the host processor only needs to send the starting and ending points of a line, which leaves the host processor with much more free time. Rapid animation can be achieved through the use of a vector-graphics display by employing this extra computing time.

The Problems of a Vector-Graphics Display

The major drawbacks to designing a vector display are twofold. The first problem is refreshing the display in sufficiently short time intervals to prevent the vectors from flickering. The solution to this problem is the use of a dedicated microprocessor built on the same board as the vector-display controller to handle the refresh and I/O (input/output) operations. An alternate solution to this problem would have involved the use of discrete integrated circuits or DMA (direct memory access) techniques; this increases the complexity of the circuit greatly, nearly doubling the number of parts required by the dedicated microprocessor approach.

The second problem is that the display used is not like a normal television. Instead, a vector-graphics generator needs an x-y-type display. Fortunately, a low-grade oscilloscope can be used, but it must have a z-axis input that will either blank or intensify the display. (I had an old Heathkit scope that was just sitting idle; it serves as a fine display for the controller described here.) The bandwidth of the scope is not critical. As long as each channel is rated for 100 kHz or more and both channels are DC-coupled, it should work fine.

General Overview

The basic outline of the Microvec unit is shown in the block diagram in figure 1. The microprocessor is responsible for sending coordinates of every vector's endpoints to the D/A (digital-to-analog) converters. Coordinates of the beginning point are

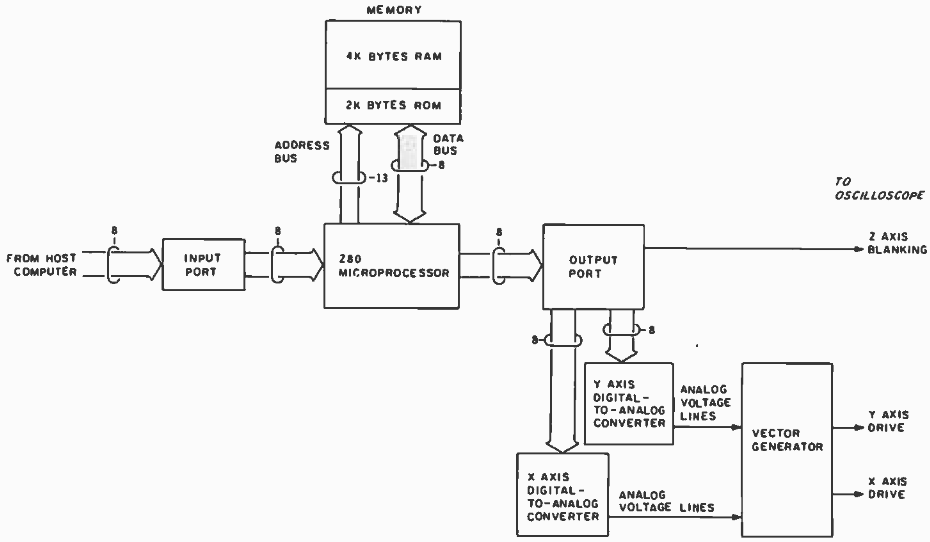


Figure 1: *Block diagram of Microvec. The Z80 microprocessor accepts commands from a host computer system in the form of endpoint coordinates for vectors to be drawn, and transfers them periodically to digital-to-analog converters that drive vector-generating circuitry.*

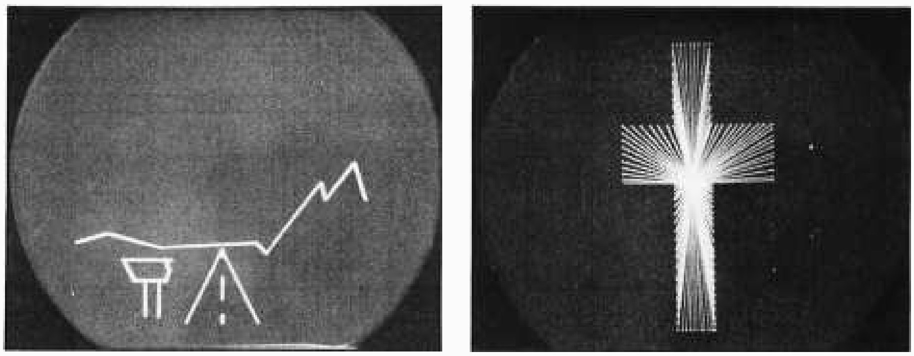


Photo 1: *Images produced by Microvec. These two photos are freehand "doodles" drawn by the author with a TRS-80 Level II BASIC program. The combination of a host computer and the vector controller's dedicated Z80 makes a very flexible and powerful system.*

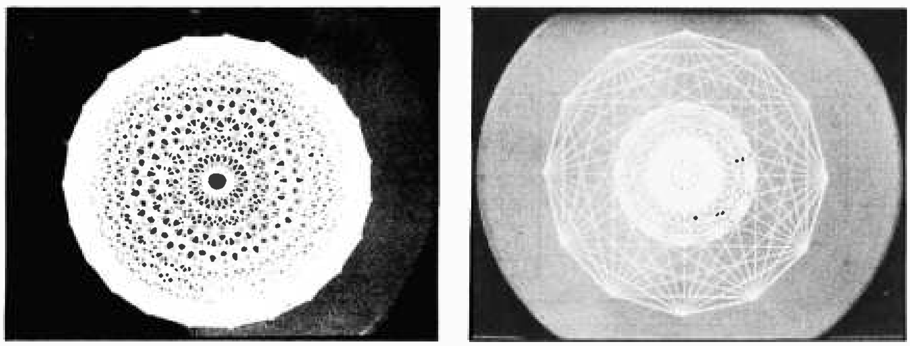


Photo 2: *Circle-forms produced by the LCIRCLE program. These images were designed by simply specifying different parameters before running LCIRCLE. (See listing 2.)*

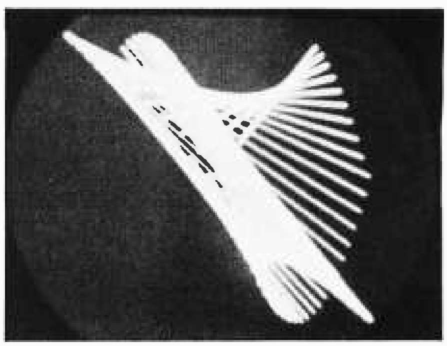


Photo 3: *An image drawn by the STICKS program. This is a vector-scan version of a program commonly used to demonstrate the high-resolution mode of Apple II computers. (See listing 4.)*

(2a)

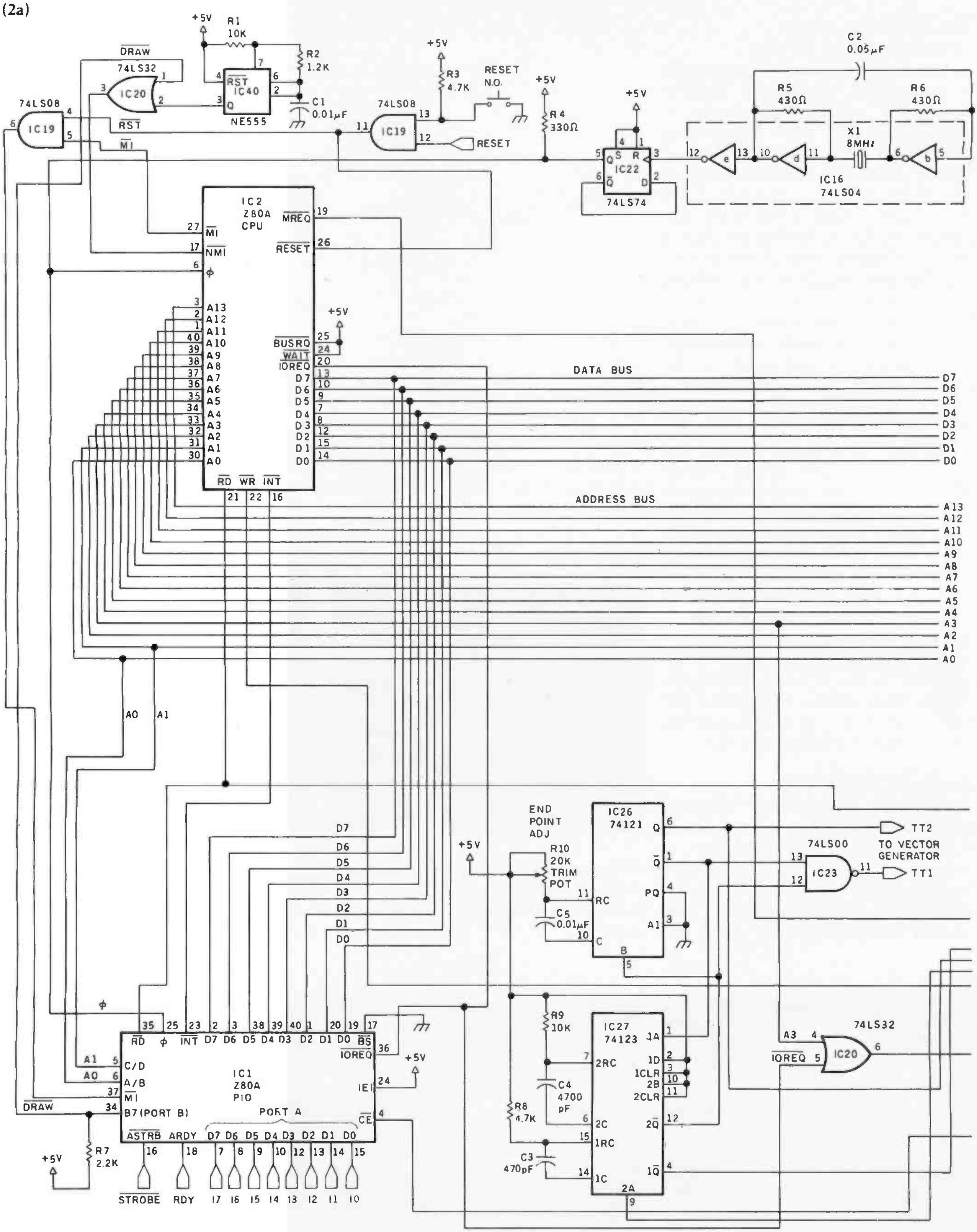


Figure 2: *Schematic diagram of the Microvec system. Figure 2a, the main part of the system, contains the microprocessor, memory, D/A converters (digital-to-analog converters), and vector-generating circuitry. The microprocessor refreshes the display by repeatedly sending all the coordinates in the current memory page to the D/A converters. (Four pages of memory are on board; each can contain 255 vectors.) When the first part of a vector's coordinate is sent to the D/A converters, a voltage is produced that is represen-*

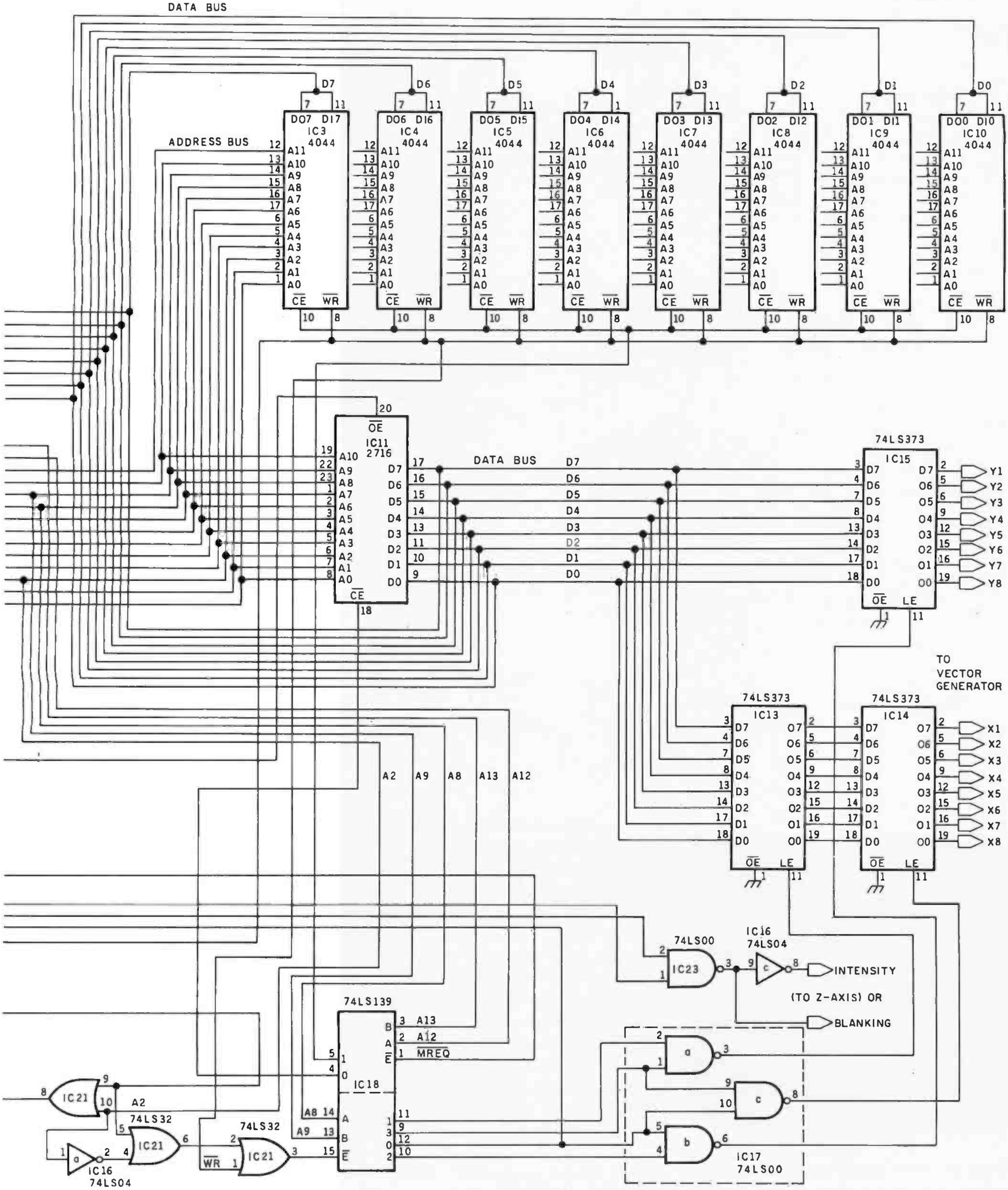
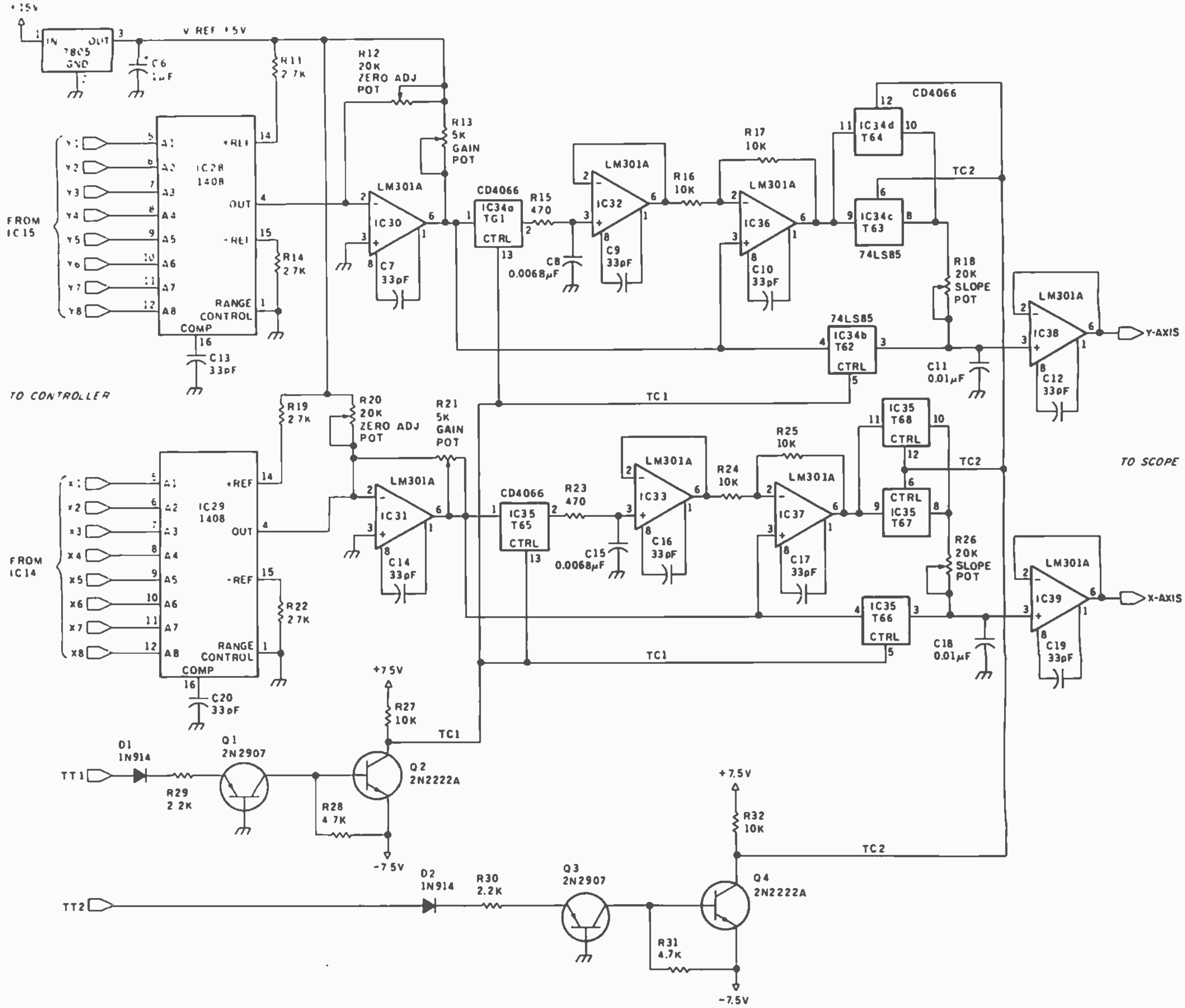


Figure 2a continued on page 512

tative of the starting point of the vector. A series of capacitors is charged to this voltage through a set of CMOS transmission gates. When the second part of the vector's coordinates is presented to the D/A converters, their output voltage becomes representative of the endpoint of the vector, and the voltage on the capacitors changes to this new value. The state of the transmission gates is changed so that the changing voltage on the capacitors is used to drive the display device (an oscilloscope).

(Figure 2a continued)



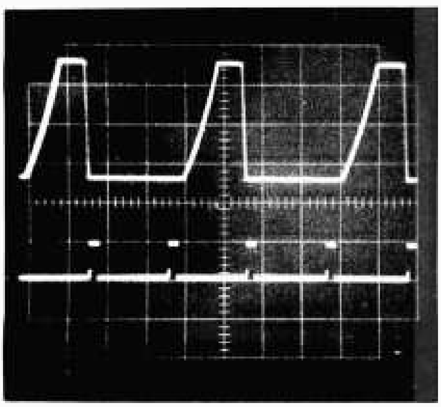


Photo 4: *Clock signals for the Microvec system. The upper trace is the 4-HMz system clock; the lower trace is the adjustable refresh clock. The refresh clock determines how the processor divides its time between refreshing the screen and processing the host computer's commands.*

converted to an analog voltage and passed to the vector generator, as are coordinates of the ending point. The vector generator does the actual drawing by varying the x and y voltage inputs to the oscilloscope so that the trace starts at one endpoint and finishes at the other. The microprocessor also accepts input from the host computer, which issues commands concerning what lines to draw or erase. The microprocessor then interprets the command and adjusts the memory and display accordingly. The memory for this unit is divided into two major subsections. The first, RAM (random-access read/write memory), is a place where the microprocessor stores coordinates for the lines to be drawn. The other type is EPROM (erasable programmable read-only memory), in which the microprocessor's control program resides.

Circuit Description

The complete schematic diagram for Microvec is shown in figure 2. The clock circuit for the system is made up of three inverters (from IC16, a 74LS04 hex inverter) and R5, R6, C2, and X1. The 8-MHz signal generated is then divided in half by IC22, a 74LS74 dual flip/flop. The resistor R4 is necessary to assure proper operation at 4 MHz. Pin 5 of IC22 is the master clock signal that is sent to both the microprocessor (IC2) and IC1, the PIO (parallel input/output) interface. The 555 timer, IC40, is the NMI (nonmaskable interrupt) clock. This controls the refresh rate of the display. At the 4-MHz system clock speed, a good refresh rate is obtained if R1 is 10 kΩ. See photo 4 for a look at this signal. The value of R1 may be decreased, but this will degrade the speed of the I/O operations. (In fact, if R1 is set too low, the

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The book starts from the absolute beginning with detailed information about the Logo system and basic commands for controlling the Logo turtle. Dozens of introductory turtle design suggestions offer each learner a way to create projects that are uniquely his or her own, while later chapters map out a rich universe of mathematical explorations in turtle geometry.

The second half of *Learning with Logo* goes beyond turtle graphics to present a set of interactive computer games, quiz programs, and language activities that introduce the learner to more advanced programming concepts.

Special sections throughout the book highlight the powerful ideas contained in each activity and warn about common bugs and pitfalls. For adults, "Helpers' Hints" explain important concepts more fully and offer practical teaching suggestions.

The book features detailed instructions for creating a Logo Procedures Disk (also available directly from the author) that contains sample programs and a number of "tool procedures" needed to carry out the projects in the book.

Daniel Watt has been involved in education as a curriculum developer, elementary school teacher, teacher trainer, and researcher. He worked for five years on a series of Logo research and development projects as a member of the MIT Logo Group. At present he is an editor with BYTE Publications and contributes regularly to Popular Computing *and* BYTE *magazines.*

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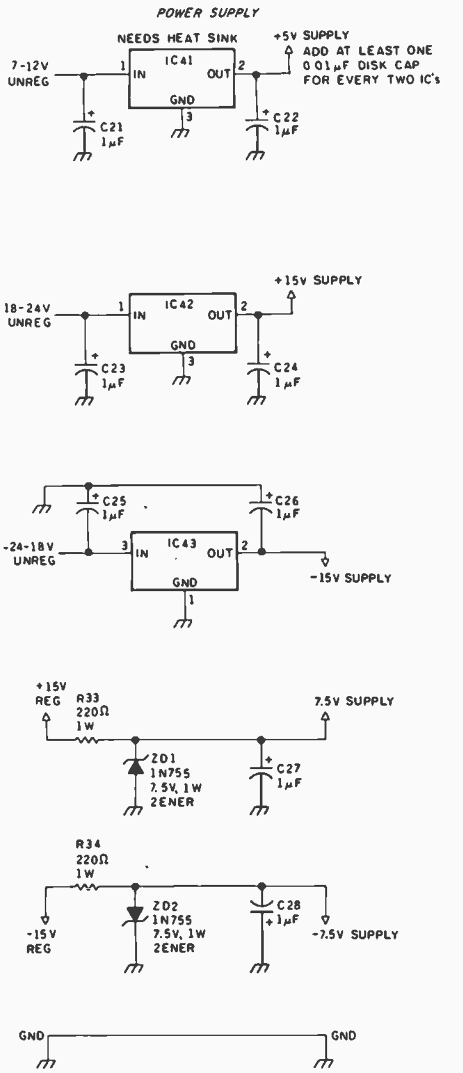
Circle 492 on inquiry card.

(2b)



Number	Type	Gnd	+5V	+15V	−15V	+7.5V	−7.5V
IC1	Z80A-PIO	11	26				
IC2	Z80A-CPU	29	11				
IC3	4044	9	18				
IC4	4044	9	18				
IC5	4044	9	18				
IC6	4044	9	18				
IC7	4044	9	18				
IC8	4044	9	18				
IC9	4044	9	18				
IC10	4044	9	18				
IC11	2716	12	21,24				
IC12	74LS240	10	20				
IC13	74LS373	10	20				
IC14	74LS373	10	20				
IC15	74LS373	10	20				
IC16	74LS04	7	14				
IC17	74LS00	7	14				
IC18	74LS139	8	16				
IC19	74LS08	7	14				
IC20	74LS32	7	14				
IC21	74LS32	7	14				
IC22	74LS74	7	14				
IC23	74LS00	7	14				
IC24	74LS85	8	16				
IC25	74LS85	8	16				
IC26	74121	7	14				
IC27	74123	8	16				
IC28	1408	2	13		3		
IC29	1408	2	13		3		
IC30	LM301A			7	4		
IC31	LM301A			7	4		
IC32	LM301A			7	4		
IC33	LM301A			7	4		
IC34	CD4066					14	7
IC35	CD4066					14	7
IC36	LM301A			7	4		
IC37	LM301A			7	4		
IC38	LM301A			7	4		
IC39	LM301A			7	4		
IC40	NE555	1	8				

Figure 2b *gives the specifics of power-supply filtering (be sure to see the power-supply connection table accompanying this figure).*

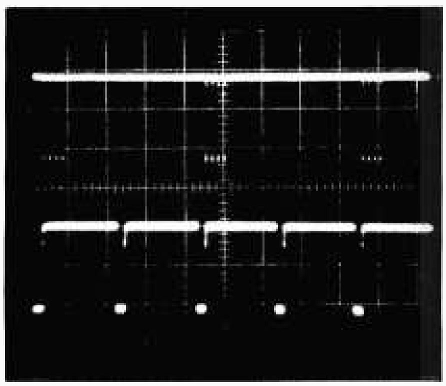


Photo 5: *Timing signals that operate the vector-generating portion of the circuit. The lower trace is the 4-MHz system clock; the upper trace shows the strobe signals sent to the enable pin of IC18, a decoder. The decoder provides four separate, properly timed signals to operate the latches and transmission gates that make up the vector generator.*

microprocessor will spend almost all its time doing video refresh, and the unit will be very sluggish in responding to commands.)

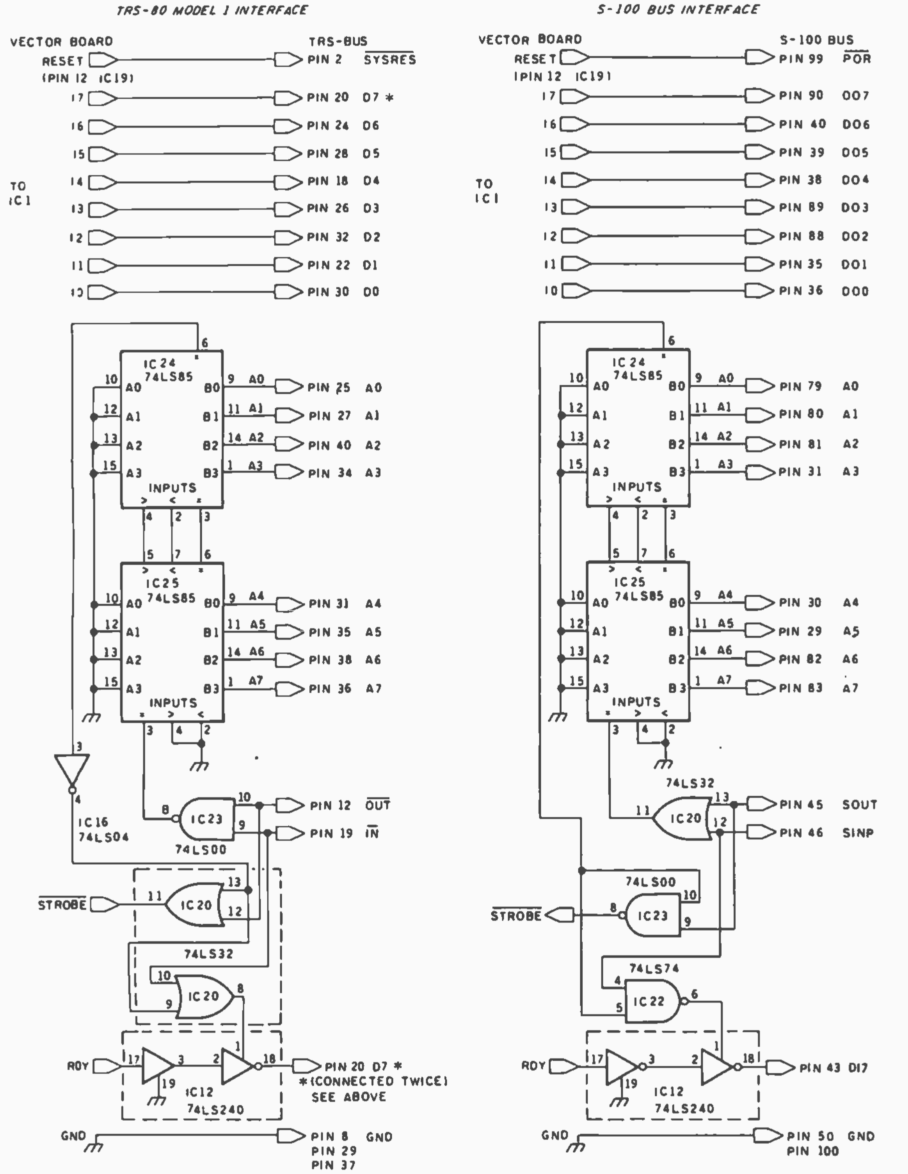
The microprocessor does have some control over the NMI requests. By raising pin 34 of IC1 high, the microprocessor can override the NMIs. This is essential to reset the system. The pins not shown for IC1 are part of "port B" and are not used in this design; therefore, they should be left disconnected. (Any other pins not shown are not used and should also be left alone.)

The memory, IC3 through IC11, is connected to the address bus. Each of these 4044 static memories is connected to *one* data line. Half of IC18, a dual 1-of-4 decoder, is used to select either the ROM (read-only memory) or the RAM.

The other half of IC18 decodes the strobes that are used to "fire" the vector generator. See photo 5 for a look at the enable signal on pin 15 of IC18. These four pulses are decoded by IC18 and are used to load and fire the vector generator. First, pin 9 of IC18 will pulse low, followed by pin 10, pin 11, and pin 12, in that order. This causes the proper bytes of data to be loaded into IC13, IC14, and IC15 (all are 74LS373 8-bit latches) and then sent on to the D/A converters. IC26 and IC27 (both are types of one-shots) handle the timing for the vector generator and are triggered by the last strobe, from pin 12 of IC18.

Because the *x* and *y* channels of the vector-generator circuitry are built identically, just the *y*-axis part of the circuit will be described. IC15 is connected to the D/A converter, IC28.

(2c) (2d)



Figures 2c and 2d *are interfaces to the Radio Shack TRS-80 Model I and the S-100 bus, respectively.*

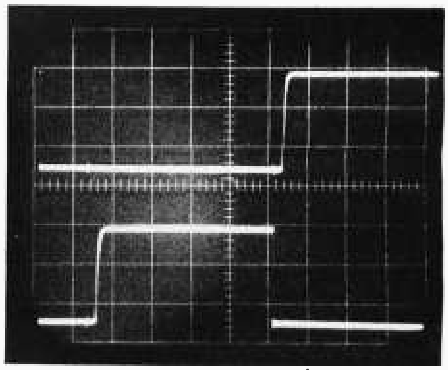


Photo 6: *Translated signals that operate the transmission gates.*

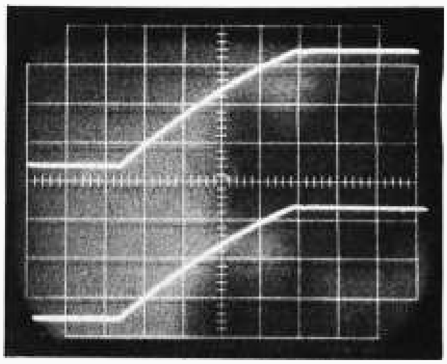


Photo 7: *Output voltages that drive the oscilloscope. The starting and ending points for these "ramps" are determined by the output of the digital-to-analog converters.*

The signal out of pin 4 is a current that is proportional to the input value on pins 5 through 12. The op amp, IC30, converts this current into a voltage that should range over about ±1 volt (V), depending on the gain adjustment, R13. The zero-adjustment potentiometer, R12, is used to set the midpoint of the D/A converter to 0 V. IC34 is a CMOS (complementary metal-oxide semiconductor) 4066 bilateral switch, sometimes called a TG (transmission gate). When its control input (i.e., pin 13) is at 7.5 V, it acts like a switch that has a contact resistance of about 80 ohms; however, when the control pin is at −7.5 V, its resistance is about 1 teraohm (10^{12} Ω), which is a fairly good disconnection! The two signals that control the TGs, TC1 and TC2, are shown in photo 6. Note that these signals are affected by the endpoint-adjustment potentiometer, R10. Therefore, the signals in your circuit will look like that but will not necessarily have exactly the same timing. The four transistors and the parts around them are necessary to translate the TTL-level signals from the one-shots into CMOS levels for use by IC34 and IC35.

Basically, drawing a line occurs through the following sequence of events. First, both D/A converters are given a byte representing the starting point of a line, and their outputs are given a chance to settle. While in this state, TGs 1, 2, 5, and 6 are on, and the other TGs are off. This allows C8, C11, C15, and C18 to charge up to the voltage produced by the corresponding D/A converter. Next, all the TGs are turned off for about 12 microseconds (μs). (Exact timing is determined by IC27, C4, and R9.)

The D/A converters are given the endpoint values and allowed to settle for 12 μs. Then, TGs 3, 4, 7, and 8 are turned on for between 50 and 90 μs (depending upon the endpoint-adjustment setting of R10). During this time, C11 and C18 either charge (if the final value is higher than the initial value) or discharge (if the final value is the lower). The result is that the output voltage takes some time to go from the value stored in the capacitors to the value being generated by the D/A converters. This produces a "ramp" waveform, as shown in photo 7.

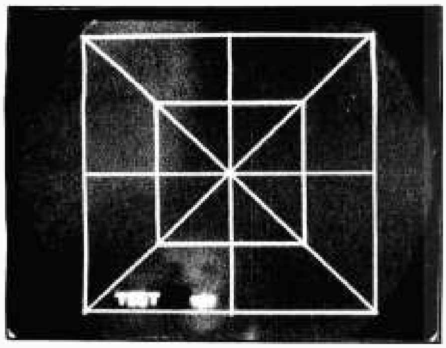


Photo 8: *The built-in test and alignment pattern. Microvec automatically stores these vectors in memory whenever it is turned on, reset, or when the TEST command is given.*

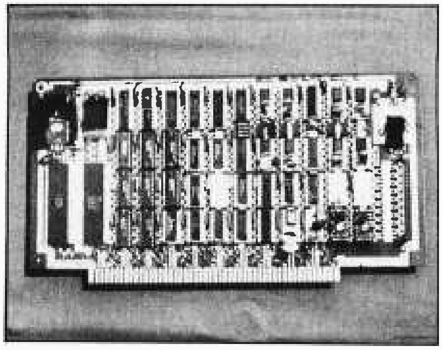


Photo 9: *The prototype Microvec unit constructed on a card for the S-100 bus. The author chose this method because his Radio Shack TRS-80 Model I currently has an interface to the S-100 bus.*

The charge rate is determined by the difference between the stored voltage and the final voltage. IC36 charges C11 through R18, and IC37 charges C18 through R26. Since the time constant (RC) of both sections must be equivalent, be sure C11 and C18 are very closely matched. The last op amp (IC38 and IC39) is used to buffer the output so that the scope will not affect the charging of C11 or C18.

Note in the photo that the outputs are not linear ramps. Instead, the capacitors charge in an exponential fashion (but since they both charge exponentially and have the same time constant, the display seems to produce straight lines). Only the most observant person is going to notice that the lines appear brighter toward the end of the line segment. Much more noticeable is that short vectors are brighter than longer vectors; this is because each vector is "on" for exactly the same length of time. That is why the letters in the words "TEST" in photo 8 are much brighter than the segments of the box. Although this is somewhat annoying, it is easy to get used to.

The power-supply regulators and zener diodes are connected in a normal way, as is shown in figure 2b. The two different host-computer interfaces are also quite simple. The data bus is attached to the "port A" inputs of the PIO, IC1. The lower 8 bits of the address bus are monitored by IC24 and IC25 (see figure 2c and figure 2d); the ICs are set up to enable I/O when the host addresses port 0. (If you want to change this address, simply alter the pattern on the "A" side of IC24 and IC25 pins 10, 12, 13, and 15.)

When the host processor writes to port 0, the data word is strobed into the PIO; and when the host processor reads port 0, bit 7 indicates whether the vector controller is ready for the next instruction. If bit 7 is high, it is okay to send; otherwise, wait until the line goes high. If data is sent faster than the Microvec unit can handle, it will simply ignore any bytes transferred while it is busy. Therefore, always make sure that your programs first check bit 7 of port 0 before sending any data.

Construction

Power-supply connections to the ICs are listed in figure 2. A separate listing of the other parts is provided in the text box "A Shopping List" on page 519. Make a photocopy of the schematic and as you attach each wire, check it off. That way, if you are interrupted or need to leave the board for a while, you will know where you are when you return. You will find that if you are not careful in the building phase, you will spend a great amount of your time tracking down wiring errors; thus, as a word to the wise, go slowly and double-check every wire. Note that the D/A converters have an unusual arrangement of their address pins in that A1 is the *most* significant bit rather than the *least* significant bit. Make sure that you connect the lines as shown.

As you can see from photo 9, the prototype is constructed on an S-100 wire-wrap board. If you do not plan to install your board in an S-100 system, I recommend that you use two separate boards and divide the circuitry into analog and digital parts. Building the circuit on two wire-wrap boards will help prevent noise from showing up in the generator's outputs and will make the two sections logically and physically separate. (My TRS-80 is connected to an S-100 bus through an interface board, so I constructed the vector-controller prototype on an S-100 card to operate on that bus.)

Here are a few more suggestions that may help make assembling the board a little easier:

- All the resistors, capacitors, transistors, and diodes can be mounted on DIP (dual-inline package) headers or plugged into a socket on the wire-wrap board, just like any IC. This makes it easy to try different parts by just pulling out the old part and pushing in the new—without any soldering.
- Be sure to use a heat sink for the 7805 voltage regulator and use at least one 0.01-microfarad (μF) disk capacitor for every other TTL IC. This reduces power ripple.
- To conduct the *x*-, *y*-, and *z*-axis signals off the board, you can wire directly to the pins of a socket, and then plug in a 16-pin DIP jumper that has flat ribbon cable already attached. Simply connect the free end of the wires to BNC connectors and mount them in your enclosure. When you need to work on the board, all you need do is unplug the DIP header and pull the board out of the bus.
- Note that both blanking and intensify signals are provided, although only one will be needed.

Make sure that you buy Z80A *4-MHz-rated* parts. At the time of this writing, no 2716 EPROM is rated for 4 MHz, but a 2716-1 has a 350-nanosecond (ns) access time and should work fine. After I built my board, I substituted parts rated at 2.5 MHz, and they seemed to work fine at the 4-MHz rate; but there is no guarantee that this will be the case for all 2.5-MHz parts over even a narrow temperature range.

Software

The program I have written to drive Microvec's Z80 divides the available memory into 255-vector "pages." This allows the user to display or work on any of the four pages independently. In this arrangement, the available memory is almost completely used. The memory for storing vectors could easily be expanded to 62 pages; however, that many extra pages would force the design to occupy several boards. Any one of the four different pages can be displayed while the user is editing that page (or any other page). This leaves at least two pages for storage.

Editing functions include commands for adding a new vector, deleting a given vector, clearing the entire page, deleting the last vector, and much more. See table 1 for a summary of the commands.

Figure 3 is a representation of the points available on the screen. If you want to draw a line across the bottom of the screen, you would need to send the following sequence of bytes: 4,0,0,255,0 (the first byte is the command—in this case, draw a line; the following 4 bytes give the starting point [0,0] and the ending point [255,0]). To erase that line, you could send the command 5,0,0,255,0; or you could simply send the command to delete the last vector: 6. This would have turned off the one line that was lit.

The commands DRAW, UNDRAW, CLEAR, and DELETE affect the MPAGE, which is the page you are editing. Use the command MODP to change the page number you want to work in. Initially, MPAGE is set to page 0. Use the command DISP to select DPAGE, the page you want displayed. DPAGE is initially set to 0. If you draw a line on one page and are displaying another, the displayed image will not change. The only way to watch the unit add or delete vectors is to set MPAGE and DPAGE to the same number.

The command TEST is the only command, other than RST, that will affect the display even if MPAGE and DPAGE are not the same. It produces the image in photo 8 by putting the vectors in memory; it does not reset the unit. The RST command does, however, reset the unit. Whenever Microvec is turned on, or reset to its initial state, it automatically performs a TEST command. Thus, the effect of RST is to both reset and test the unit. It takes a special command sequence to accomplish the RST function: 0,0,0,0,7,15. The "15" is a simple form of insurance; should a "7" code be sent accidentally, nothing will

A Shopping List

As a help, here is a condensed shopping list of necessary parts. The prices shown in this list are approximate and representative of parts available through mail-order ads in various issues of BYTE. Since this article was written, the prices will almost certainly have gone down on some of the parts.

The only hard-to-get part is the programmed EPROM. If you are lucky enough to have an EPROM programmer, you can "burn" the program into the EPROM yourself. If you want a 2716 programmed, there is a charge of $10 to copy the program on each 2716 (no other type EPROM), which must be erased. You will receive the latest version of the program. However, there is no guarantee expressed or implied. Additionally, a disk is available with all the programs in this article, plus several other programs and the source code to the EPROM, for $15. Send a check or money order (including $2 for postage and handling) to Garco, POB 18806, Greensboro, NC 27419-8806. If you order a copy of either the EPROM or the disk, you'll also receive any errata sheets and additional documentation. Because I'm also planning on providing a revised EPROM, I need to know how many people would be interested. Those that send in an order will be on a mailing list. This offer is subject to change at any time.

Quantity	Part	Amount
1	Z80A-CPU	$10.50
1	Z80A-PIO	8.60
8	4044 RAMs	31.92
1	2716-1 Preprogrammed	26.00
1	74LS240 Octal TS Inverter	1.65
3	74LS373 Octal Latches	4.35
1	74LS04 Hex Inverter	0.25
2	74LS00 Quad Nand Gates	0.50
1	74LS139 Dual 2-4 Decoder	0.75
1	74LS08 Quad And Gate	0.35
2	74LS32 Quad Or Gates	0.70
1	74LS74 Dual Flip/Flop	0.45
2	74LS85 4-Bit Comparators	2.30
1	74121 One-Shot	0.29
1	74123 Dual One-Shot	0.55
2	MC1408L8 8-Bit D/A Converters	11.90
8	LM301A Op Amps	3.12
2	4066 Quad Bilateral Switches	1.50
1	555 Timer	0.39
1	7805 5-Volt Regulator	0.89
1	78L05 Low-Power 5-Volt Regulator	0.79
1	7815 15-Volt Regulator	0.99
1	7915 −15-Volt Regulator	1.19
25	16-Pin WW Gold Sockets	17.25
4	20-Pin WW Gold Sockets	4.39
8	18-Pin WW Gold Sockets	7.92
2	40-Pin WW Gold Sockets	3.98
1	24-Pin WW Gold Socket	1.45
1	Vector WW Board 8800V DP	22.20
1	Reset Switch	1.50
1	8-MHz Crystal	1.99
27	Assorted Resistors	2.70
7	10-Turn Potentiometers	14.00
28	Assorted Capacitors	10.00
4	Transistors	2.00
2	1N914 Diodes	1.00
2	7.5-V 1-W Zener Diodes	1.00
1	16-Pin Jumper Cable (18-inch)	5.40
20	Despiking Caps (0.1 μF)	5.30
1	Heat Sink	0.75
1	Wire-Wrap Wire	9.95
	Total:	**$222.71**

Command Summary

Code	Number of Bytes	Name	Description
1	2	MODP	Modify page (MPAGE)
2	2	DISP	Display page (DPAGE)
3	1	CLEAR	Clear MPAGE
4	5	DRAW	Draw line in MPAGE
5	5	UNDRAW	Erase line in MPAGE
6	1	DEL	Delete last vector in MPAGE
7	2	RST	Reset if key is correct
8	1	TEST	Turn on test pattern

Table 1: *Summary of the commands to Microvec. The host system uses these commands to control the display of the four memory pages. In the table, MPAGE is the page being modified, while DPAGE is the page being displayed.*

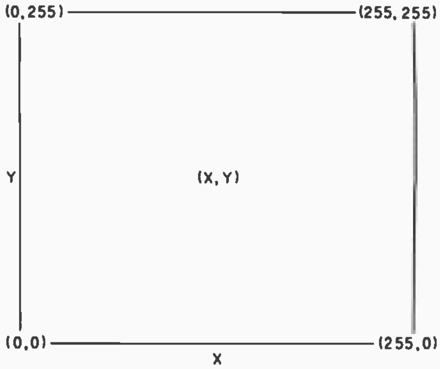


Figure 3: *Representation of the oscilloscope display screen. Microvec can draw vectors with endpoints at any of the coordinates shown.*

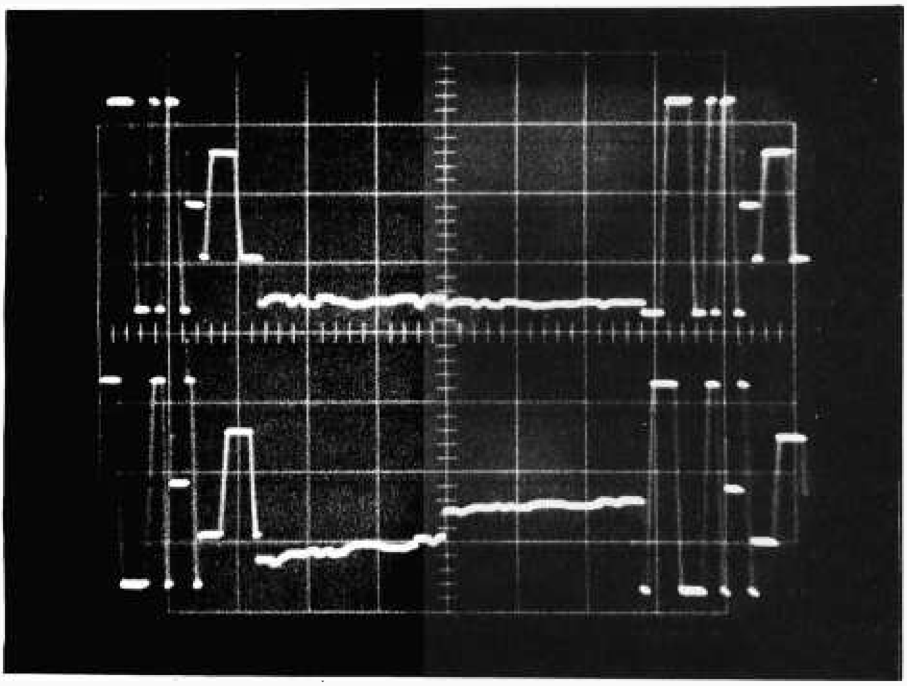


Photo 10: *Comparison of the x- and y-axis driving signals while Microvec is displaying the test pattern of photo 8.*

Listing 1: *Controlling software for Microvec's Z80 processor. This assembly-language program is stored in an EPROM installed on the Microvec circuit card; it allows the Z80 microprocessor to display vectors stored in memory and to accept commands from a host computer system.*

```
                ;************************************************************
                ;************************************************************
                ;***** Copyright (C) 1981 By Billy Garrett ****************
                ;*************** MICROVEC V1.0 ****************************
                ;************************************************************
                ;************************************************************
                ;
                TITLE Vector Graphics Generator Program   MICROVEC V1.0
0000'                   ASEG            ;Force the assembly at location 0 H
                        ORG    0000H    ;Start
                                        ;Startup routine
                ;
                .COMMENT ^
                This is a model of the registers inside of the Z80 and
                how they are used by this program.  There are some registers
                that have dedicated functions, and their contents must not
```

Listing 1 continued on page 521

happen to all your hard work. The "15" is just a key.

Almost any command you can imagine might be added to the Z80 controller program simply by altering the code in the EPROM. Currently, the program occupies about 800 bytes of the 2048 bytes available. This leaves plenty of room. The assembled program is shown in listing 1.

The program is highly dependent on the interrupt structure of the Z80. Simply stated, two types of interrupts are available to Z80 programmers: the highest priority one is the NMI. Whenever the NMI signal is active, and as soon as the processor finishes the current instruction, the interrupt is acknowledged. The address 66 hexadecimal is placed in the program counter; the program at this location causes the system to draw a line. The important point is that the processor is being interrupted about 10,000 times each second, so that even when the host system is not sending commands to the board, half the Z80's time is being used to redraw the display.

The second type of interrupt is called simply INT. It is used when the host system has information to transfer to Microvec. Because this signal can be "masked" by the Z80, the processor can be programmed to ignore or postpone it.

Calibration

Before installing any ICs, check the output of each voltage regulator. Make sure that their outputs are within 5 percent of their rated values. Then, turn the power off and adjust R12 and R20 to about 5 kΩ. Next, adjust R13 and R21 to about 2 kΩ. After

Text continued on page 527

Listing 1 continued:

```
                        be destroyed.  Also, there are only four (4) levels of stack
                        room available in this 4K byte version, so modifications must
                        not under any circumstances push anything more than 3 deep
                        onto the stack. This is because the NMI can occur at any time
                        and it requires one level of stack.

                           Main Register Set            Alternate Register Set
                        ------------------------------------------------------------
                        | A          | F          | A'           | F'          |
                        |     *      |    Flags   | Vector Count |    Flags    |
                        ------------------------------------------------------------
                        | B          | C          | B'           | C'          |
                        |   DPAGE    |   MPAGE    |   Byte Count |   Port #    |
                        ------------------------------------------------------------
                        | D          | E          | D'           | E'          |
                        |     *      |     *      |     OOH      |      ?      |
                        ------------------------------------------------------------
                        | H          | L          | H'           | L'          |
                        |     *      |     *      |   High  .  Pointer  '  Low |
                        ------------------------------------------------------------
                        | I          | R          |
                        |   07H      |     ?      |      *= General Purpose
                        ---------------------------           Registers
                        | IX                      |
                        |   MPAGE Base Address    |
                        ---------------------------
                        | IY                      |
                        |   MPAGE 1st Free Space  |
                        ---------------------------

0000    F3              INIT:   DI                      ;Disable interrupts
0001    31 2000                 LD      SP,2000H        ;Set stack pointer to top of memory
0004    AF                      XOR     A               ;Zero A
0005    32 1000                 LD      (NUMVO),A       ;Initialize memory locations
0008    32 1001                 LD      (NUMV1),A       ;to zero
000B    32 1002                 LD      (NUMV2),A       ;
000E    32 1003                 LD      (NUMV3),A       ;
                        ;
0011    21 0244                 LD      HL,MTEST        ;Load HL with the MTEST location
0014    22 1005                 LD      (MEM),HL        ;Store MTEST in page pointer
0017    3E 26                   LD      A,026H          ;Number of vectors in MTEST
0019    32 1004                 LD      (NUMVEC),A      ;stored in NUMVEC
                        ;
001C    06 F0                   LD      B,0F0H          ;Initialize the registers
001E    0E 05                   LD      C,05H           ;Output port number
0020    16 00                   LD      D,00H           ;Constant in D
0022    B2                      OR      D               ;Set zero flag (if necessary)
0023    D9                      EXX                     ;Exchange register sets
0024    08                      EX      AF,AF'          ;Including AF
                        ;
0025    AF                      XOR     A               ;Clear A
0026    4F                      LD      C,A             ;Load MPAGE to page 0
0027    47                      LD      B,A             ;Load DPAGE to page0
0028    DD 21 1007              LD      IX,PAGE0        ;Load modify page address in IX
002C    FD 21 1007              LD      IY,PAGE0        ;Load next free location in IY
                        ;
0030    3E 07                   LD      A,07H           ;
0032    ED 47                   LD      I,A             ;Set the interrupt high byte to 07
0034    ED 5E                   IM      2               ;Set maskable interrupt to mode 2
                        ;
0036    3E 4F                   LD      A,4FH           ;Set the PIO for channel A input
0038    D3 02                   OUT     (02H),A         ;Send control word to the PIO
003A    3E 87                   LD      A,87H           ;Set the PIO to generate interrupts
003C    D3 02                   OUT     (02H),A         ;Send it to the PIO
003E    21 07FE                 LD      HL,INRPTV       ;Load the address of the interrupt
0041    7D                      LD      A,L             ;vector into A
0042    D3 02                   OUT     (02H),A         ;Send it to the PIO
0044    DB 00                   IN      A,(00H)         ;Dummy read to set the READY line
0046    3E 0F                   LD      A,0FH           ;Instruction for the PIO
0048    D3 03                   OUT     (03H),A         ;port B to be output
004A    3E 00                   LD      A,00H           ;Send to port B
004C    D3 01                   OUT     (01H),A         ;Sets bit seven low on port B, and
                                                        ;Starts the CPU accepting NMI'S
004E    18 3E                   JR      FIRST           ;Now go to the main input routine
```

Draw Interrupt (NMI)

```
                                SUBTTL Draw Interrupt (NMI)
                        ;This routine uses the alternate register set and assumes
                        ;that the main program does not alter it.
                        ;The contents of the alternate register set are defined as:
                        ; A=Number of vectors left to draw in that page
                        ; B=Vector counter (when the two low bits of this register
                        ; are decoded, they are used to fire the vector generator
                        ; C=OUTPUT PORT=05H
                        ; D=00H, a constant used to speed up the process
                        ; HL=Pointer to vector in memory
                        ;
                                ORG     066H            ;Location of non-maskable interrupt
0066    08              INRPT:  EX      AF,AF'          ;Get alternate register set
0067    D9                      EXX                     ;Including BC,DE,HL
0068    28 19                   JR      Z,NOMORE        ;If zero jump to NOMORE
006A    ED A3                   OUTI                    ;Output four bytes
006C    00                      NOP                     ;NOPs necessary for delay
006D    00                      NOP                     ;so that the D/A converters
006E    00                      NOP                     ;have time to settle
006F    00                      NOP                     ;
0070    ED A3                   OUTI                    ;
0072    00                      NOP                     ;
0073    00                      NOP                     ;
0074    00                      NOP                     ;
0075    00                      NOP                     ;
0076    ED A3                   OUTI                    ;
0078    00                      NOP                     ;
0079    00                      NOP                     ;
007A    00                      NOP                     ;
007B    00                      NOP                     ;
007C    ED A3                   OUTI                    ;
007E    3D                      DEC     A               ;Decrement the number of vectors
007F    D9                      EXX                     ;Save the status of the registers
0080    08                      EX      AF,AF'          ;including AF
0081    ED 45                   RETN                    ;Return from non-maskable interrupt
0083    3A 1004         NOMORE: LD      A,(NUMVEC)      ;Reload A with the # of vectors
0086    B2                      OR      D               ;Set the zero flag if zero
0087    2A 1005                 LD      HL,(MEM)        ;Reset HL to the start of the page
008A    D9                      EXX                     ;Save status
008B    08                      EX      AF,AF'          ;
008C    ED 45                   RETN                    ;Return
```

Inwait Macro

```
                                SUBTTL Inwait Macro
                        INWAIT  MACRO                   ;Define macro INWAIT
                                LOCAL WAITON            ;Make waiton have different labels
                                SCF                     ;Set carry flag
                                EI                      ;Enable interrupts
                        WAITON: JR      C,WAITON        ;Wait on interrupt
                                ENDM                    ;End MACRO
```

Main Routine

```
                                SUBTTL Main Routine
                        FIRST:  INWAIT                  ;Wait on first input
008E    37                      SCF                     ;Set carry flag
008F    FB                      EI                      ;Enable interrupts
0090    38 FE           ..0000: JR      C,..0000        ;Wait on interrupt
0092    21 1007                 LD      HL,PAGE0        ;Now initialize the values
0095    F5                      PUSH    AF              ;Save AF for a moment
0096    AF                      XOR     A               ;Clear A
0097    32 1004                 LD      (NUMVEC),A      ;Zero the displayed values
009A    22 1005                 LD      (MEM),HL        ;Correct the memory start address
```

Listing 1 continued on page 522

Listing 1 continued:

```
009D  F1                   POP   AF          ;Restore AF
009E  C3 00A5              JP    SKIP        ;Skip first inwait, already done
                  ;
                  ;
                  INPUT:   INWAIT            ;Wait on input
00A1  37                   SCF               ;Set carry flag
00A2  FB                   EI                ;Enable interrupts
00A3  38 FE       ..0001:  JR    C,..0001    ;Wait on interrupt
00A5  11 0708     SKIP:    LD    DE,JTABLE   ;Load DE with jtable base address
00A8  E6 7F                AND   7FH         ;Make sure the value is positive
00AA  FE 09                CP    NUMCOM      ;Is the command greater than NUMCOM?
00AC  F2 00A1              JP    P,INPUT     ;If out of range, go back to input
00AF  87                   ADD   A,A         ;Shift A right
00B0  83                   ADD   A,E         ;Add the offset
00B1  5F                   LD    E,A         ;Put it back
00B2  1A                   LD    A,(DE)      ;Load A indirect
00B3  6F                   LD    L,A         ;Put low byte in L
00B4  13                   INC   DE          ;Point to next byte
00B5  1A                   LD    A,(DE)      ;Load A indirect again
00B6  67                   LD    H,A         ;Put the high byte in H
00B7  E9                   JP    (HL)        ;Jump indirect
```

Modify Page Command

```
                           SUBTTL Modify Page Command
                  MODP:    INWAIT            ;Perform inwait macro
00B8  37                   SCF               ;Set carry flag
00B9  FB                   EI                ;Enable interrupts
00BA  38 FE       ..0002:  JR    C,..0002    ;Wait on interrupt
00BC  E6 03                AND   03H         ;Mask off the top 5 bits
00BE  4F                   LD    C,A         ;Store new page number
00BF  87                   ADD   A,A         ;Multiply A by two
00C0  21 0700              LD    HL,TABLE    ;Set HL pointer to table
00C3  85                   ADD   A,L         ;
00C4  6F                   LD    L,A         ;
00C5  5E                   LD    E,(HL)      ;Load A indirect
00C6  23                   INC   HL          ;Point to next byte
00C7  56                   LD    D,(HL)      ;Load indirect
00C8  D5                   PUSH  DE          ;Push the start address on stack
00C9  DD E1                POP   IX          ;And put in IX
                  ;
00CB  21 1000              LD    HL,NUMV0    ;Load pointer with base address
00CE  79                   LD    A,C         ;Get MPAGE in A
00CF  85                   ADD   A,L         ;
00D0  6F                   LD    L,A         ;
00D1  6E                   LD    L,(HL)      ;Get the # of vectors in that page
00D2  26 00                LD    H,00H       ;Clear H
00D4  29                   ADD   HL,HL       ;Multiply the # of vectors by four
00D5  29                   ADD   HL,HL       ;
00D6  19                   ADD   HL,DE       ;Find end of mem and save in HL
00D7  E5                   PUSH  HL          ;put HL on stack
00D8  FD E1                POP   IY          ;put next free byte of MPAGE in IY
00DA  C3 00A1              JP    INPUT       ;Go back
```

Display Page Command

```
                           SUBTTL Display Page Command
                  DISP:    INWAIT            ;Wait on character
00DD  37                   SCF               ;Set carry flag
00DE  FB                   EI                ;Enable interrupts
00DF  38 FE       ..0003:  JR    C,..0003    ;Wait on interrupt
00E1  E6 03                AND   03H         ;Mask off top 5 bits
00E3  47                   LD    B,A         ;Load DPAGE into B
00E4  87                   ADD   A,A         ;Multiply by two
00E5  21 0700              LD    HL,TABLE    ;Load HL with table address
00E8  85                   ADD   A,L         ;
00E9  6F                   LD    L,A         ;
00EA  5E                   LD    E,(HL)      ;Load E indirect
00EB  23                   INC   HL          ;Point to next byte
00EC  56                   LD    D,(HL)      ;Load D indirect
00ED  21 1000              LD    HL,NUMV0    ;Load HL with pointer
00F0  78                   LD    A,B         ;Get DPAGE number in A
00F1  85                   ADD   A,L         ;
00F2  6F                   LD    L,A         ;
00F3  66                   LD    H,(HL)      ;Load H indirect
00F4  DB 01                IN    A,(01H)     ;Get the value in port B
00F6  F6 80                OR    080H        ;Set bit seven high
00F8  D3 01                OUT   (01H),A     ;Send it back to turn display off
00FA  7C                   LD    A,H         ;Restore A
00FB  32 1004              LD    (NUMVEC),A  ;Save the # of vectors in NUMVEC
00FE  ED 53 1005           LD    (MEM),DE    ;Load page pointer to mem location
0102  DB 01                IN    A,(01H)     ;Turn the display back on
0104  E6 7F                AND   07FH        ;
0106  D3 01                OUT   (01H),A     ;
0108  C3 00A1              JP    INPUT       ;Go back
```

Clear Current MPAGE

```
                           SUBTTL Clear Current MPAGE
010B  79          CLEAR:   LD    A,C         ;Load A with the # of the MPAGE
010C  21 1000              LD    HL,NUMV0    ;Pointer to bottom of table
010F  85                   ADD   A,L         ;
0110  6F                   LD    L,A         ;
0111  AF                   XOR   A           ;Clear A
0112  77                   LD    (HL),A      ;Zero that page's count
0113  78                   LD    A,B         ;Get DPAGE in A
0114  B9                   CP    C           ;Is it the same as MPAGE?
0115  20 04                JR    NZ,OK       ;If not then OK
0117  AF                   XOR   A           ;Otherwise clear A
0118  32 1004              LD    (NUMVEC),A  ;Zero the NUMVEC location
011B  DD E5       OK:      PUSH  IX          ;Put Bottom of MPAGE addr on stack
011D  FD E1                POP   IY          ;That's the next free address
011F  C3 00A1              JP    INPUT       ;Go back
```

Draw New Vector Command

```
                           SUBTTL Draw New Vector Command
0122  79          DRAWV:   LD    A,C         ;Load MPAGE in A
0123  21 1000              LD    HL,NUMV0    ;Load base address in HL
0126  85                   ADD   A,L         ;Add index
0127  6F                   LD    L,A         ;
0128  7E                   LD    A,(HL)      ;Load A indirect
0129  3C                   INC   A           ;Add one to the number of vectors
012A  C2 0140              JP    NZ,HERE     ;If not zero then ok
                           INWAIT            ;Otherwise, ignore the next
012D  37                   SCF               ;Set carry flag
012E  FB                   EI                ;Enable interrupts
012F  38 FE       ..0004:  JR    C,..0004    ;Wait on interrupt
                           INWAIT            ;four inputs
0131  37                   SCF               ;Set carry flag
0132  FB                   EI                ;Enable interrupts
0133  38 FE       ..0005:  JR    C,..0005    ;Wait on interrupt
                           INWAIT            ;
0135  37                   SCF               ;Set carry flag
0136  FB                   EI                ;Enable interrupts
0137  38 FE       ..0006:  JR    C,..0006    ;Wait on interrupt
                           INWAIT            ;
0139  37                   SCF               ;Set carry flag
013A  FB                   EI                ;Enable interrupts
013B  38 FE       ..0007:  JR    C,..0007    ;Wait on interrupt
013D  C3 00A1              JP    INPUT       ;Go back
                  ;
0140  57          HERE:    LD    D,A         ;Keep new number in D
0141  1E 04                LD    E,04H       ;Set up a counter for four inputs
                  ;
                  LOOP:    INWAIT            ;Wait for input
0143  37                   SCF               ;Set carry flag
0144  FB                   EI                ;Enable interrupts
0145  38 FE       ..0008:  JR    C,..0008    ;Wait on interrupt
0147  FD 77 00             LD    (IY+0),A    ;Save vector in next free space
```

Listing 1 continued:

```
014A   FD 23              INC   IY          ;point to the next free space
014C   1D                 DEC   E           ;Decrement count
014D   20 F4              JR    NZ,LOOP     ;Loop back
014F   72                 LD    (HL),D      ;Now, increase the number of vectors
0150   78                 LD    A,B         ;Load DPAGE in A
0151   B9                 CP    C           ;Is it MPAGE?
0152   C2 00A1            JP    NZ,INPUT    ;If not, then done
0155   7A                 LD    A,D         ;Otherwise, put the number in A
0156   32 1004            LD    (NUMVEC),A;Store in NUMVEC
0159   C3 00A1            JP    INPUT       ;Go back
```

Undraw Vector Command

```
                          SUBTTL Undraw Vector Command
015C   21 1000    UNDRAW: LD    HL,NUMVO    ;Load HL with a base pointer
015F   79                 LD    A,C         ;Get the MPAGE number in A
0160   85                 ADD   A,L         ;
0161   6F                 LD    L,A         ;
0162   7E                 LD    A,(HL)      ;Get the # of vectors in the MPAGE
0163   F5                 PUSH  AF          ;Save it
                          INWAIT            ;Wait on input
0164   37                 SCF               ;Set carry flag
0165   FB                 EI                ;Enable interrupts
0166   38 FE      ..0009: JR    C,..0009    ;Wait on interrupt
0168   57                 LD    D,A         ;Put X1 in D
                          INWAIT            ;Wait on input
0169   37                 SCF               ;Set carry flag
016A   FB                 EI                ;Enable interrupts
016B   38 FE      ..000A: JR    C,..000A    ;Wait on interrupt
016D   5F                 LD    E,A         ;Put Y1 in E
                          INWAIT            ;Wait on input
016E   37                 SCF               ;Set carry flag
016F   FB                 EI                ;Enable interrupts
0170   38 FE      ..000B: JR    C,..000B    ;Wait on interrupt
0172   67                 LD    H,A         ;Put X2 in H
                          INWAIT            ;Wait on input
0173   37                 SCF               ;Set carry flag
0174   FB                 EI                ;Enable interrupts
0175   38 FE      ..000C: JR    C,..000C    ;Wait on interrupt
0177   6F                 LD    L,A         ;Put Y2 in L
0178   F1                 POP   AF          ;Get AF back
0179   F6 00              OR    00H         ;Check for any vectors in page
017B   CA 00A1            JP    Z,INPUT     ;If not, go back
017E   DD E5              PUSH  IX          ;Otherwise, save IX for later
                  ;
0180   F5                 NOFIND: PUSH AF         ;Save AF
0181   DD 7E 00                   LD   A,(IX+0)   ;Load A with first entry
0184   BA                         CP   D          ;Is it the same as X1?
0185   28 0E                      JR   Z,FIND1    ;If so, jump to FIND1
0187   DD 23              WELL:   INC  IX         ;Increment IX by four
0189   DD 23                      INC  IX         ;
018B   DD 23                      INC  IX         ;
018D   DD 23                      INC  IX         ;
018F   F1                         POP  AF         ;Get AF back
0190   3D                         DEC  A          ;Decrement the counter
0191   20 ED                      JR   NZ,NOFIND ;Loop
0193   18 55              JR    ADONE       ;Go back if not found
                  ;
0195   DD 7E 01   FIND1:  LD    A,(IX+1)    ;Is the next entry Y1?
0198   BB                 CP    E           ;Find out!
0199   20 EC              JR    NZ,WELL     ;If not, jump to WELL
019B   DD 7E 02           LD    A,(IX+2)    ;Load A with the next entry
019E   BC                 CP    H           ;Is it X2?
019F   20 E6              JR    NZ,WELL     ;If not, jump to WELL
01A1   DD 7E 03           LD    A,(IX+3)    ;Load A with the next entry
01A4   BD                 CP    L           ;Could it be!!!?
01A5   20 E0              JR    NZ,WELL.    ;If not, jump to well
01A7   F1                 POP   AF          ;Otherwise, don't need AF any more
01A8   FD E5              PUSH  IY          ;Put IY on the stack
01AA   E1                 POP   HL          ;Put the end of the table into HL
01AB   DD E5              PUSH  IX          ;Put the found address on the stack
```

Undraw Vector Command

```
01AD   D1                 POP   DE          ;Put it in DE
01AE   37                 SCF               ;Set the carry flag
01AF   3F                 CCF               ;Complement the carry flag
01B0   ED 52              SBC   HL,DE       ;Subtract the end from the found loc.
01B2   7C                 LD    A,H         ;
01B3   FE 00              CP    00H         ;See if H is zero
01B5   20 05              JR    NZ,NOPE     ;Go to NOPE if it isn't
01B7   7D                 LD    A,L         ;
01B8   D6 04              SUB   04H         ;Correction factor
01BA   28 14              JR    Z,NOMOVE    ;If zero, then don't move anything
01BC   2B         NOPE:   DEC   HL          ;Decrease HL by four
01BD   2B                 DEC   HL          ;
01BE   2B                 DEC   HL          ;
01BF   2B                 DEC   HL          ;
01C0   C5                 PUSH  BC          ;Keep BC for a while
01C1   E5                 PUSH  HL          ;Push HL
01C2   C1                 POP   BC          ;Byte count into BC
01C3   DD E5              PUSH  IX          ;Place where vector was found
01C5   E1                 POP   HL          ;Put it in HL
01C6   23                 INC   HL          ;Add four to HL
01C7   23                 INC   HL          ;
01C8   23                 INC   HL          ;
01C9   23                 INC   HL          ;
01CA   DD E5              PUSH  IX          ;Put the found location
01CC   D1                 POP   DE          ;into the destination register
01CD   ED B0              LDIR              ;Move the vectors smoothly in place
01CF   C1                 POP   BC          ;Restore BC
01D0   FD 2B      NOMOVE: DEC   IY          ;And close up the end
01D2   FD 2B              DEC   IY          ;
01D4   FD 2B              DEC   IY          ;
01D6   FD 2B              DEC   IY          ;
01D8   79                 LD    A,C         ;Load MPAGE into A
01D9   21 1000            LD    HL,NUMVO    ;Load HL with the base address
01DC   85                 ADD   A,L         ;Add the offset
01DD   6F                 LD    L,A         ;
01DE   7E                 LD    A,(HL)      ;Get the number of vectors into A
01DF   3D                 DEC   A           ;Decrease the # of vectors by one
01E0   77                 LD    (HL),A      ;Save it back where it was found
01E1   5F                 LD    E,A         ;
01E2   78                 LD    A,B         ;Get the DPAGE
01E3   B9                 CP    C           ;Is it MPAGE?
01E4   20 04              JR    NZ,ADONE    ;If not, jump to ADONE
01E6   7B                 LD    A,E         ;Otherwise restore A
01E7   32 1004            LD    (NUMVEC),A;And place the new number in NUMVEC
01EA   DD E1      ADONE:  POP   IX          ;Restore IX to it's orignal value
01EC   C3 00A1            JP    INPUT       ;Go back
```

Delete Command

```
                          SUBTTL Delete Command
01EF   79         DEL:    LD    A,C         ;Get the MPAGE
01F0   21 1000            LD    HL,NUMVO    ;Get the base address
01F3   85                 ADD   A,L         ;
01F4   6F                 LD    L,A         ;Put it back
01F5   7E                 LD    A,(HL)      ;Get the # of vectors
01F6   F6 00              OR    00H         ;Is it zero?
01F8   CA 00A1            JP    Z,INPUT     ;If so, go back
01FB   3D                 DEC   A           ;Otherwise decrease the #
01FC   77                 LD    (HL),A      ;And put it back
01FD   57                 LD    D,A         ;
01FE   79                 LD    A,C         ;Load MPAGE in A
01FF   B8                 CP    B           ;Compare to DPAGE
0200   C2 0207            JP    NZ,DECR     ;Go back if not same
0203   7A                 LD    A,D         ;Get the # back
0204   32 1004            LD    (NUMVEC),A;And put in NUMVEC
0207   FD 2B      DECR:   DEC   IY          ;Decrease IY by four
0209   FD 2B              DEC   IY          ;
020B   FD 2B              DEC   IY          ;
020D   FD 2B              DEC   IY          ;
020F   C3 00A1            JP    INPUT       ;Go back
```

Listing 1 continued on page 524

Listing 1 continued:

Reset Command

```
                                 SUBTTL Reset Command
                         REST:   INWAIT          ;Get the next word
0212    37                       SCF             ;Set carry flag
0213    FB                       EI              ;Enable interrupts
0214    38 FE            ..000D: JR   C,..000D   ;Wait on interrupt
0216    FE 0F                    CP   0FH        ;Is it the key?
0218    CA 0000                  JP   Z,0000H    ;If so, RESET
021B    C3 00A1                  JP   INPUT      ;If not, go back
```

Test Command

```
                                 SUBTTL Test Command
021E    ED 5B 1005       TESTR:  LD   DE,(MEM)   ;Get the base address
0222    3A 1004                  LD   A,(NUMVEC);Save NUMVEC
0225    F5                       PUSH AF         ;
0226    3E 26                    LD   A,26H      ;Load the # of vectors
0228    32 1004                  LD   (NUMVEC),A;
022B    21 0244                  LD   HL,MTEST   ;And the address of MTEST
022E    22 1005                  LD   (MEM),HL   ;
0231    F1                       POP  AF         ;Save A in H
0232    67                       LD   H,A        ;
                                 INWAIT          ;Wait on next word
0233    37                       SCF             ;Set carry flag
0234    FB                       EI              ;Enable interrupts
0235    38 FE            ..000E: JR   C,..000E   ;Wait on interrupt
0237    F5                       PUSH AF         ;
0238    7C                       LD   A,H        ;
0239    ED 53 1005               LD   (MEM),DE   ;Restore display
023D    32 1004                  LD   (NUMVEC),A;
0240    F1                       POP  AF         ;
0241    C3 00A5                  JP   SKIP       ;And go back
```

Display Test Pattern

```
                                 SUBTTL Display Test Pattern
0244    00 00 FF 00      MTEST:  DB   00H,00H,0FFH,00H        ;Large square
0248    FF 00 FF FF              DB   0FFH,00H,0FFH,0FFH
024C    FF FF 00 FF              DB   0FFH,0FFH,00H,0FFH
0250    00 FF 00 00              DB   00H,0FFH,00H,00H
0254    00 00 FF FF              DB   00H,00H,0FFH,0FFH       ;Diagonals
0258    FF 00 00 FF              DB   0FFH,00H,00H,0FFH
025C    80 FF 80 00              DB   080H,0FFH,080H,00H      ;Crosshairs
0260    FF 80 00 80              DB   0FFH,080H,00H,080H
0264    40 40 40 C0              DB   040H,040H,040H,0C0H     ;Small box
0268    40 C0 C0 C0              DB   040H,0C0H,0C0H,0C0H
026C    C0 C0 C0 40              DB   0C0H,0C0H,0C0H,040H
0270    C0 40 40 40              DB   0C0H,040H,040H,040H
0274    20 08 20 10              DB   20H,08H,20H,10H         ;Large T
0278    1C 10 24 10              DB   1CH,10H,24H,10H
027C    28 08 28 10              DB   28H,08H,28H,10H         ;Large E
0280    28 08 2C 08              DB   28H,08H,2CH,08H
0284    28 10 2C 10              DB   28H,10H,2CH,10H
0288    28 0C 2A 0C              DB   28H,0CH,2AH,0CH
028C    30 08 34 08              DB   30H,08H,34H,08H         ;Large S
0290    34 08 34 0C              DB   34H,08H,34H,0CH
0294    34 0C 30 0C              DB   34H,0CH,30H,0CH
0298    30 0C 30 10              DB   30H,0CH,30H,10H
029C    30 10 34 10              DB   30H,10H,34H,10H
02A0    3C 08 3C 10              DB   3CH,08H,3CH,10H         ;Large T
02A4    38 10 40 10              DB   38H,10H,40H,10H
02A8    60 08 60 0C              DB   60H,08H,60H,0CH         ;Small T
02AC    5E 0C 62 0C              DB   5EH,0CH,62H,0CH
02B0    64 08 64 0C              DB   64H,08H,64H,0CH         ;Small E
02B4    64 08 66 08              DB   64H,08H,66H,08H
02B8    64 0C 66 0C              DB   64H,0CH,66H,0CH
02BC    64 0A 65 0A              DB   64H,0AH,65H,0AH
02C0    68 08 6A 08              DB   68H,08H,6AH,08H         ;Small S
02C4    6A 08 6A 0A              DB   6AH,08H,6AH,0AH
02C8    6A 0A 68 0A              DB   6AH,0AH,68H,0AH
02CC    68 0A 68 0C              DB   68H,0AH,68H,0CH
02D0    68 0C 6A 0C              DB   68H,0CH,6AH,0CH
02D4    6E 08 6E 0C              DB   6EH,08H,6EH,0CH         ;Small T
02D8    6C 0C 70 0C              DB   6CH,0CH,70H,0CH
```

Get Character Interrupt

```
                                 SUBTTL Get Character Interrupt
02DC    F3               GETCHR: DI              ;Disable interrupts
02DD    DB 00                    IN   A,(00H)    ;Input byte
02DF    3F                       CCF             ;Complement the carry flag
02E0    ED 4D                    RETI            ;And return
```

Table Page

```
                                 SUBTTL Table Page
                                 ORG  0700H      ;Make room for a ROM table
0700    1007             TABLE:  DW   PAGE0      ;First free space in PAGE0
0702    1403                     DW   PAGE1      ;First free space in PAGE1
0704    17FF                     DW   PAGE2      ;First free space in PAGE2
0706    1BFB                     DW   PAGE3      ;First free space in PAGE3
                         ;
                                                 ;                    Instruction #
0009                     NUMCOM  EQU  9          ;Number of commands + 1
0708    00A1             JTABLE: DW   INPUT      ;Pointer to INPUT      0
070A    00B8                     DW   MODP       ;Pointer to MODP       1
070C    00DD                     DW   DISP       ;Pointer to DISP       2
070E    010B                     DW   CLEAR      ;Pointer to CLEAR      3
0710    0122                     DW   DRAWV      ;Pointer to DRAWV      4
0712    015C                     DW   UNDRAW     ;Pointer to UNDRAW     5
0714    01EF                     DW   DEL        ;Pointer to DEL        6
0716    0212                     DW   REST       ;Pointer to RESET      7
0718    021E                     DW   TESTR      ;Pointer to TEST       8
                         ;
                                 ORG  07FEH      ;Place for INRPTV
07FE    02DC             INRPTV: DW   GETCHR     ;Save address of get character
                         ;
                                 SUBTTL RAM Memory Allocation
                                 ORG  1000H      ;Location of data
1000                     NUMV0:  DS   1          ;Number of vectors in PAGE0
1001                     NUMV1:  DS   1          ;Number of vectors in PAGE1
1002                     NUMV2:  DS   1          ;Number of vectors in PAGE2
1003                     NUMV3:  DS   1          ;Number of vectors in PAGE3
1004                     NUMVEC: DS   1          ;Number of vectors in current page
1005                     MEM:    DS   2          ;Pointer to current page
1007                     PAGE0:  DS   255*4      ;Room for 255 vectors--PAGE0
1403                     PAGE1:  DS   255*4      ;Room for 255 vectors--PAGE1
17FF                     PAGE2:  DS   255*4      ;Room for 255 vectors--PAGE2
1BFB                     PAGE3:  DS   255*4      ;Room for 255 vectors--PAGE3
                                 SUBTTL Macros And Symbols
                         ALL:    END  INIT       ;TTTHAT'S ALL FOLKS !!!!!!!!!
```

Macros And Symbols

```
Macros:
INWAIT

Symbols:
..0000  0090    ..0001  00A3    ..0002  00BA    ..0003  00DF
..0004  012F    ..0005  0133    ..0006  0137    ..0007  013B
..0008  0145    ..0009  0166    ..000A  016B    ..000B  0170
..000C  0175    ..000D  0214    ..000E  0235    ADONE   01EA
ALL     1FF7    CLEAR   010B    DECR    0207    DEL     01EF
DISP    00DD    DRAWV   0122    FIND1   0195    FIRST   008E
```

Listing 1 continued:

GETCHR	02DC	HERE	0140	INIT	0000	INPUT	00A1
INRPT	0066	INRPTV	07FE	JTABLE	0708	LOOP	0143
MEM	1005	MODP	00B8	MTEST	0244	NOFIND	0180
NOMORE	0083	NOMOVE	01D0	NOPE	01BC	NUMCOM	0009
NUMV0	1000	NUMV1	1001	NUMV2	1002	NUMV3	1003
NUMVEC	1004	OK	011B	PAGE0	1007	PAGE1	1403
PAGE2	17FF	PAGE3	1BFB	REST	0212	SKIP	00A5
TABLE	0700	TESTR	021E	UNDRAW	015C	WELL	0187

No Fatal error(s)

Listing 2: *The BASIC program LCIRCLE, for the TRS-80, used to create photo 2.*

```
10 REM LCIRCLE BY BILLY GARRETT
20 DEFINT P,I,K,J,X,Y
30 DIM X(25),Y(25)
40 B=710/113
50 C1=255/2:C=C1
60 INPUT"INPUT NUMBER OF POINTS ON CIRCLE (3-23)";J
70 M=B/J:J1=J-1
80 IFJ>23ORJ<3 GOTO 60
90 INPUT"DRAW OR UNDRAW (D OR U)";S$
100 IF S$="D" THEN COM=4:GOTO130
110 IF S$="U" THEN COM=5:GOTO160
120 GOTO 90
130 INPUT"DO YOU WANT TO CLEAR THE PAGE FIRST (Y OR N)";A$
140 IFA$="Y" THEN OUTO,3:GOTO160
150 IF A$<>"N" GOTO 130
160 INPUT"WOULD YOU LIKE TO CHANGE THE RADIUS (10-127.5)";C
170 IFC>C1ORC<10THEN160
180 FORP=0TOJ:D=M*P:X(P)=C*(COS(D)+1)+C1-C:Y(P)=C*(SIN(D)+1)+C1-C:NEXTP
190 FORI=1TOJ1:FORK=I+1TOJ
200 OUTO,COM:GOSUB250:OUTO,X(I):OUTO,Y(I):OUTO,X(K):OUTO,Y(K):NEXTK,I
210 INPUT"ALL DONE. DO YOU WANT TO DO IT AGAIN (Y OR N)";A$
220 IFA$="N"END
230 IFA$="Y" GOTO 60
240 GOTO 210
250 IFINP(0)<128GOTO250ELSERETURN
```

Listing 3: *BASIC programs used to create images in photo 11.*

(3a)

```
10 REM GRID BY BILLY GARRETT
20 INPUT"ENTER STEP RATE (1-254)";S
30 IF S<2 OR S>254 THEN 20
40 INPUT"DRAW OR UNDRAW";A$
50 IF A$="D" THEN C=4 : GOTO70
60 IF A$="U" THEN C=5 : GOTO90
70 INPUT"CLEAR PAGE (Y) ";A$
80 IF A$="Y" THEN OUTO,3
90 FOR A=0 TO 255 STEP S
```

Listing 3 continued on page 526

Listing 3 continued:

```
100 GOSUB140:OUTO,C:GOSUB140:OUTO,A:OUTO,0:OUTO,A:OUTO,255
110 GOSUB140:OUTO,C:GOSUB140:OUTO,0:OUTO,A:OUTO,255:OUTO,A
120 NEXT A
130 GOTO 20
140 IFINP(0)<128THEN140ELSERETURN
```

(3b)

```
10 REM SPHERE BY BILLY GARRETT
20 DEFINT J,I,C,X,Y
30 DIM X(255),Y(255)
40 B=710/113
50 C=255/2
60 INPUT"INPUT NUMBER OF PONITS ON CIRCLE (3-254)";J
70 IFJ>254ORJ<3 GOTO 60
80 INPUT"SCAN OR DRAW ONCE (S OR D)";P$
90 IF P$="S" S=5 :GOTO120
100 IF P$="D" S=4:GOTO120
110 GOTO80
120 M=B/J
130 FORP=OTOJ:D=M*P:X(P)=C*(COS(D)+1):Y(P)=C*(SIN(D)+1):NEXTP
140 INPUT"DO YOU WISH TO CLEAR THE DISPLAY (Y)";A$:IFA$="Y"OUTO,3
150 IF S=5 THEN 180
160 FORI=OTOJ-1:OUTO,4:OUTO,128:OUTO,128:OUTO,X(I):OUTO,Y(I):NEXTI
170 GOTO 190
180 FORI=OTOJ-1:OUTO,6:OUTO,4:OUTO,128:OUTO,128:OUTO,X(I):OUTO,Y(I):NEXTI:GOTO180
190 INPUT"ALL DONE. DO YOU WANT TO DO IT AGAIN (Y OR N)";A$
200 IFA$="N"END
210 IFA$="Y" GOTO 60
220 GOTO 190
```

(3c)

```
10 REM COCENTER BY BILLY GARRETT
20 DEFINT J,I,X,Y
30 DIM X(255),Y(255)
40 B=710/113
50 C1=255/2
60 INPUT"CLEAR PAGE (Y)";Y$:IFY$="Y"OUTO,3
70 INPUT"INPUT NUMBER OF POINTS ON CIRCLES, AND NUMBER OF CIRCLES TO DRAW";J,N
80 IFJ*N>255GOTO 70
90 M=B/J
100 FOR C2=C1 TO 10 STEP -127.5/N
110 FORP=OTOJ:D=M*P:X(P)=C2*(COS(D)+1)+C1-C2:Y(P)=C2*(SIN(D)+1)+C1-C2:NEXTP
120 FORI=OTOJ-1:OUTO,4:OUTO,X(I):OUTO,Y(I):OUTO,X(I+1):OUTO,Y(I+1):NEXTI
130 NEXTC2
140 INPUT"ALL DONE. DO YOU WANT TO DO IT AGAIN (Y OR N)";A$
150 IFA$="N"END
160 IFA$="Y" GOTO 40
170 GOTO 140
```

(3d)

```
10 REM BOXES BY BILLY GARRETT
20 DEFINT G,C,A
30 FOR G=64 TO 2 STEP-1
40 FOR C=4 TO 5
50 FOR A=0 TO 127 STEP G
60 B=255-A
70 GOSUB130:OUTO,C:OUTO,A:OUTO,A:OUTO,B:OUTO,A
80 GOSUB130:OUTO,C:OUTO,B:OUTO,A:OUTO,B:OUTO,B
90 GOSUB130:OUTO,C:OUTO,B:OUTO,B:OUTO,A:OUTO,B
100 GOSUB130:OUTO,C:OUTO,A:OUTO,B:OUTO,A:OUTO,A
110 NEXTA,C,G
120 GOTO 30
130 IFINP(0)<128THEN130ELSERETURN
```

(3e)

```
10 REM HOURGLASS BY BILLY GARRETT
20 INPUT"ENTER STEP RATE (1-254)";S
30 DEFINT A
40 OUTO,3
50 FOR A=0 TO 254 STEP S
60 OUTO,4:OUTO,A:OUTO,0:OUTO,255-A:OUTO,255
70 NEXT
80 GOTO 20
```

(3f)

```
10 REM SOLIDSIN BY BILLY GARRETT
20 M=710/113
30 INPUT"STEP,CYCLE";Q,B
40 INPUT"DO YOU WISH TO CLEAR THE DISPLAY (Y)";A$:IFA$="Y"OUTO,3
50 FOR A=1 TO 255 STEP Q
60 OUTO,4:OUTO,A:OUTO,127.5*(SIN(A*M/B)+1):OUTO,A:OUTO,0:NEXT
70 INPUT"DO YOU WANT TO TRY AGAIN (Y)";A$:IF A$="Y" THEN 20 ELSE END
```

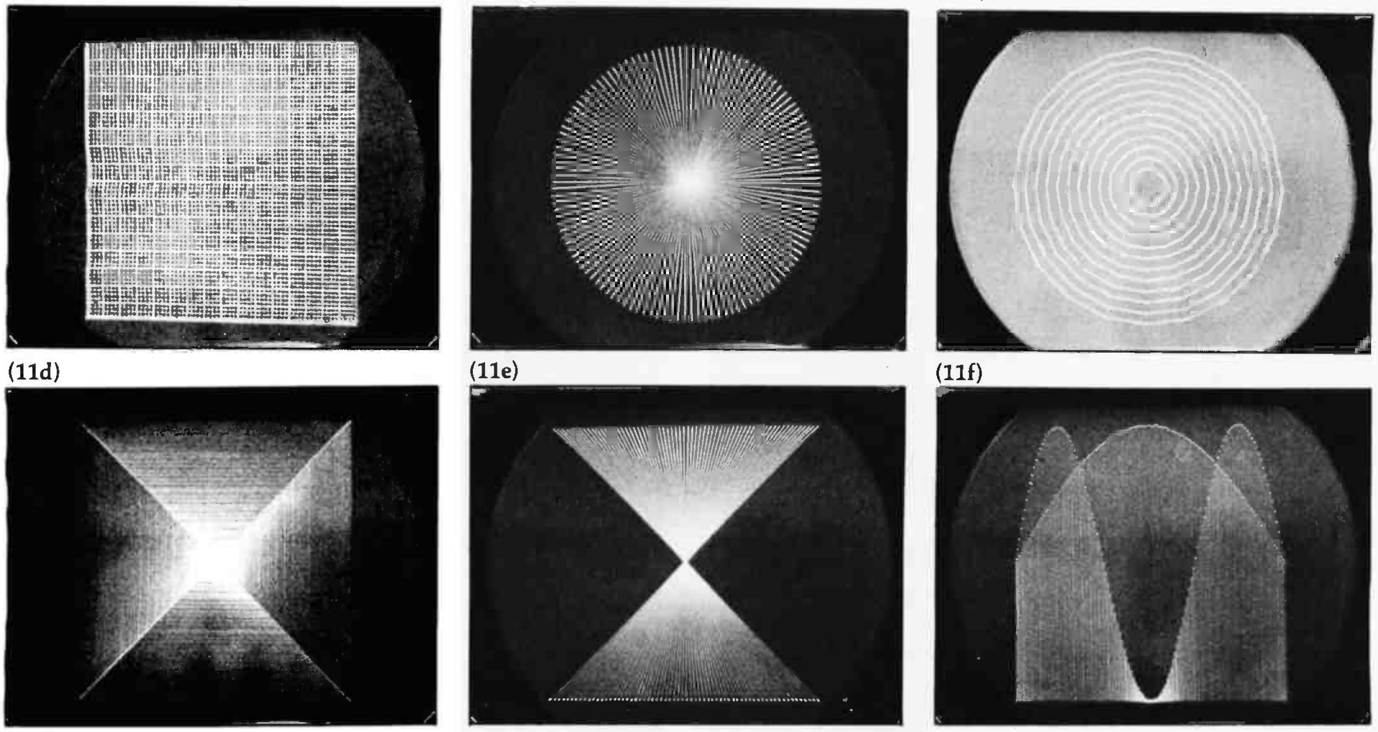
(3g)

```
10 REM SSINE BY BILLY GARRETT
20 DIM X(511)
30 M=355/113*2/255: C=127.5: B=1
40 FOR A=0 TO 511
50 X(A)=C*(SIN(A*M)+B)
60 NEXT A
70 INPUT"DO YOU WISH TO CLEAR THE DISPLAY (Y)";A$:IFA$="Y"OUTO,3
80 INPUT"STEP RATE (1-254)";S
90 FOR A=0 TO 255 STEP 255/S
100 IF A+S>255 GOTO 120
110 OUTO,4:OUTO,A:OUTO,X(A):OUTO,A+S:OUTO,X(A+S)
120 NEXT A
130 GOTO 70
```

Listing 4: *The BASIC program STICKS used to create photo 3.*

```
10 REM STICKS BY BILLY GARRETT
20 DEFINT A,S,X
30 DIM X(514)
40 M=355/113*2/255
50 FOR A=0 TO 513
60 X(A)=127.5*(SIN(A*M)+1):NEXT A
70 PRINT"HERE WE GO!!!"
80 FOR S=6 TO 256:OUTO,1:OUTO,S:OUTO,2:OUTO,S-1:OUTO,3
90 FOR A=0 TO 255 STEP 255/S
100 IF A+S > 255 THEN Q=510-(A+S) ELSE Q=A+S
110 OUTO,4:OUTO,X(A):OUTO,X(512-A):OUTO,Q:OUTO,X(A+S)
120 NEXT A,S
```

(11a) (11b) (11c) (11d) (11e) (11f)



(11g)

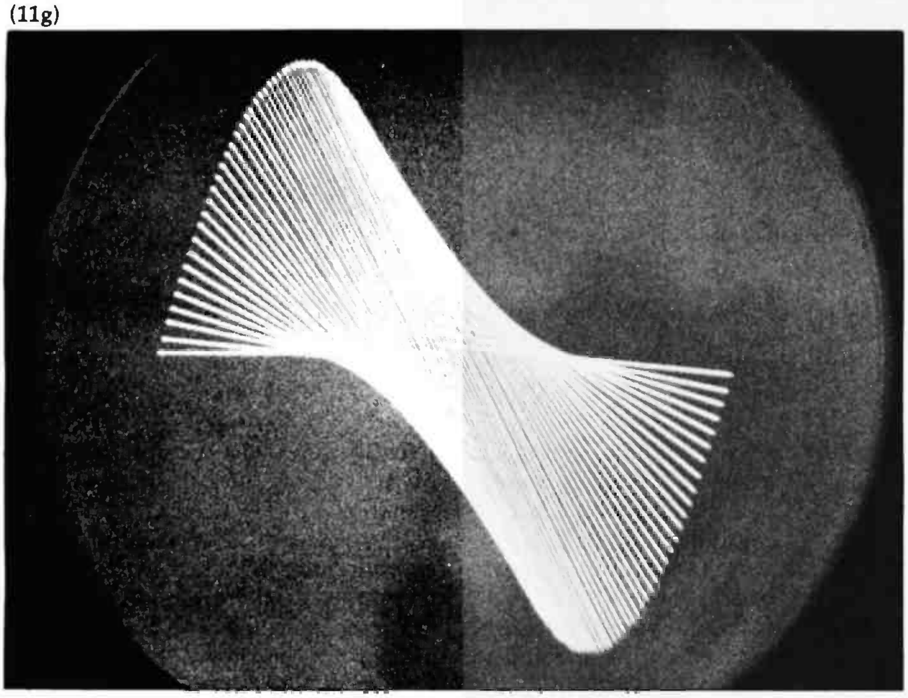


Photo 11: *Examples of the elementary images that can be produced by Microvec. Each of these images was produced by a corresponding program in listing 3: photo 11a is a drawing produced by GRID, a BASIC program for the TRS-80 (see listing 3a); photo 11b was drawn by a program called SPHERE (listing 3b); photo 11c is the product of COCENTER (listing 3c); photo 11d is an image created by BOXES (listing 3d); photos 11e, 11f, and 11g were produced by HOURGLASS (listing 3e), SOLIDSIN (listing 3f), and SSINE (listing 3g), respectively.*

Text continued from page 520:

that, adjust R18 and R26 to about 8.5 kΩ. Finally, adjust R10 to about 9 kΩ. Now, plug in the ICs, plug your board in, and hook the outputs up to your scope. Set the *x* and *y* channels of the scope to about 0.5 V/cm. Finally, turn on the power. If everything is working properly, you should be able to see the board trying to display a few vectors on the screen. Eventually, these will look like the image in photo 8. If nothing happens, or you are having problems, go on to the next section, concerning Murphy's Law.

Once you obtain some kind of display, adjust the gain and zero controls of each channel until you get an output signal roughly ±1 V centered about ground (see photo 10). Then, adjust the vector controller's slope controls until you see the diagonals intersect the middle. Next, vary the endpoint adjustment until the ends of the boxes just touch. You will have to play with the slope and endpoint adjustments for a while until the display looks right. Once you get your display looking like photo 8, you are almost finished. Next, increase the gain of each channel until the display begins to come apart. Then, back the gain down just a bit and adjust your oscilloscope so that the display fills the screen and the brightness is to your liking. If you get this far, you are doing very well.

Next, verify that all the commands work as described. A good check of the circuit board would be to run some of the programs in the later section of examples.

What to Do if Murphy's Law Is Enforced

You probably know the old saying, "If anything can go wrong, it will." This project will certainly be no exception. Refer to photos 4, 5, 6, and 7 if you are having problems. Read over the circuit description and make sure that the proper signals are at the given pins. For example:

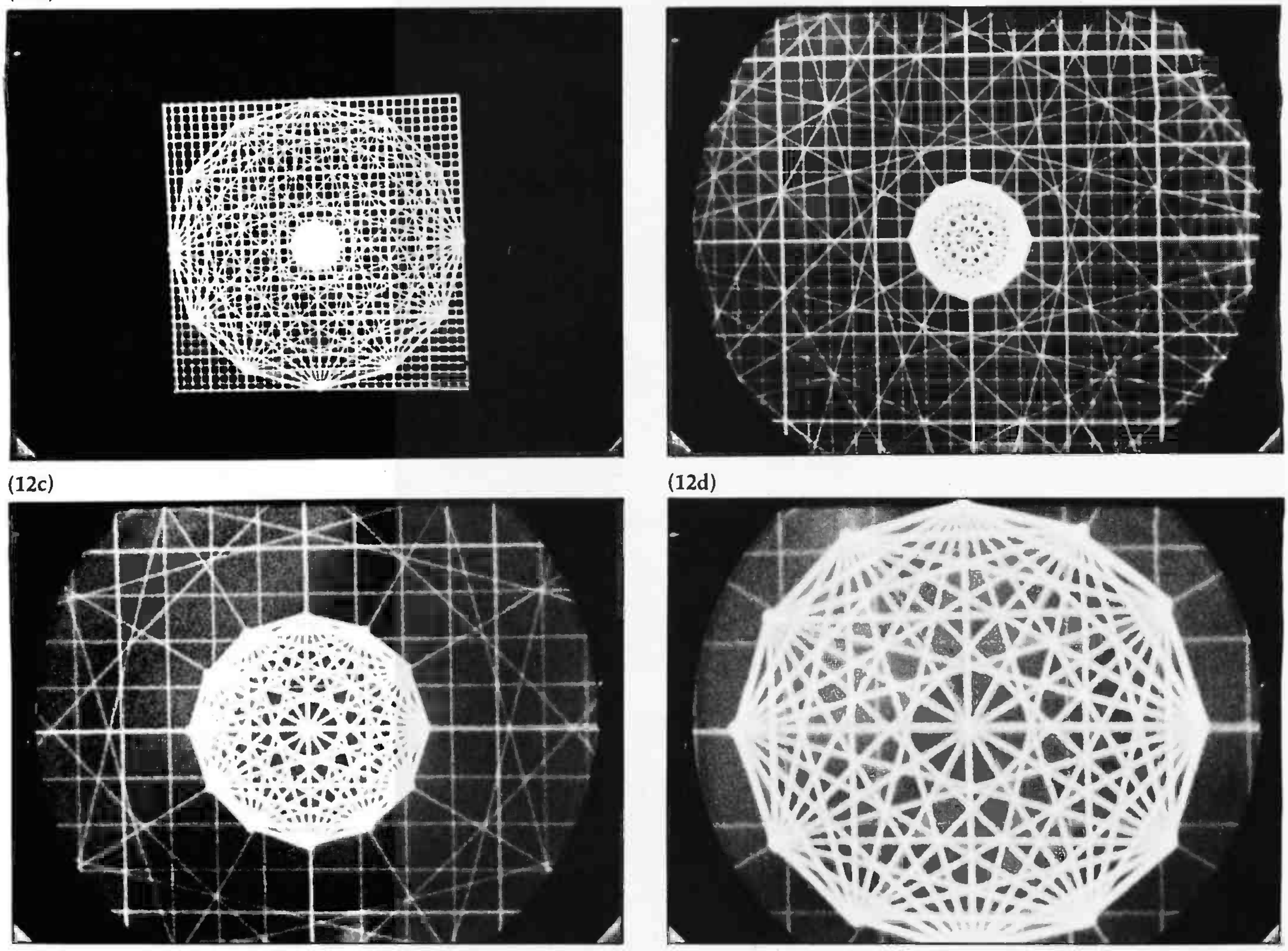


Photo 12: *Using special features of the oscilloscope to alter images. Here, an image is shown normally (photo 12a) and with fourfold, sixteenfold, and hundredfold magnification (photos 12b, 12c, and 12d, respectively).*

- If you are able to get a test pattern but it will not respond to commands, check to see that the data word is being strobed into the PIO when your processor does an I/O operation.
- If you suspect that the Z80 is running the wrong code, see if the NMI request pin is being pulsed as shown in photo 4.
- If the memory sections are not hooked up properly, you will not be getting the four short pulses on pin 15 of IC18, as is shown in photo 5.
- If the NMI pin of the Z80 does not remain high during and shortly after reset, the processor will almost certainly begin executing at the wrong address. Since R7 pulls the NMI line high during reset, make sure it is installed.

A Few Examples

Although the commands are fairly simple to understand, I have developed some examples that are both instructive and entertaining. Listing 2 is a TRS-80 Level II BASIC program called LCIRCLE that was used to draw the images in photo 2. The programs in listing 3 were used to create the corresponding images in photo 11 (e.g., listing 3b produced photo 11b, listing 3c produced photo 11c, and so on). The program STICKS, in listing 4, is the one that drew photo 3. The two parts of photo 1 are freehand "doodles" done with a program called SKETCH (not listed in this article).

Photos 12a through 12d show an interesting feature of the vector-graphics display. By simply increasing the gain on the oscilloscope, you can magnify the frame. The first photo is at the normal setting; the second is magnified by 4; the third is magnified by 16; and the last is magnified by 100 times. Notice that the little circle that was inside the larger circle is blown up so that it is larger than the original circle. All this magnification was accomplished simply by varying the gain on the oscilloscope.

If you want to try animating a complicated scene, rather than trying to redraw each frame: first, put the same background in two different memory pages; then, by displaying one page while updating the next, you can swap the displayed pages back and forth to achieve the appearance of rapid motion. Your best teacher, though, will be experience.

Conclusion

This board is an exciting peripheral device for any computer. The first time you see these displays produced by your computer, you will not believe how sharp and detailed they are. Many creative uses for this display will be possible. I welcome suggestions or comments, but please enclose a SASE if you want a reply. Happy drawing! ■

Software Received

Apple

Accounting Plus II, a complete general-purpose accounting system. This system includes general ledger, accounts payable and receivable, inventory control, sales-order entry, purchase-order entry, payroll, point-of-sale accounting, and system utility programs. For the Apple II and II Plus; floppy disk, $1250. Systems Plus Inc., 1120 San Antonio Rd., Palo Alto, CA 94303.

Alibi, a who-dun-it detective game. You become the detective as you try to discover which of the five suspects is the murderer. The game has six levels of playing difficulty. For the Apple II; floppy disk, $14.95. Hayden Book Co., 50 Essex St., Rochelle Park, NJ 07662.

Basic Guitar 1, a system that teaches beginning guitarists chords and songs. This two-disk set uses sound and graphics to explain how to tune a guitar, read chord diagrams, and learn and practice chords. It plays songs and displays chords on the screen. For the Apple II and II Plus; floppy disk, $49.95. Digital Concept Systems Inc., Suite 201, 4826 Bucknell, San Antonio, TX 78249.

Bumble Games, a set of six number games for children ages 4 to 10. It introduces charts, graphs, and maps. For the Apple II; floppy disk, $60. The Learning Co., 4370 Alpin Rd., Portola Valley, CA 94025.

Bumble Plot, a package of five games that uses positive and negative numbers to help children understand charts, graphs, and how to use computer graphics. For children ages 8 to 13. For the Apple II; floppy disk, $60. The Learning Co. (see above address).

Children's Carrousel, a set of nine games for children between the ages of 2 and 6. Subjects covered include letter recognition, number counting, and color matching. For the Apple II Plus; floppy disk, $19.95. Dynacomp Inc., 1427 Monroe Ave., Rochester, NY 14618.

Crisis Mountain, you must defuse nuclear bombs before they explode and cause a volcano to erupt. This arcade-type game uses high-resolution graphics and game paddles for lively action. For the Apple II and II Plus; floppy disk, $34.95. Synergistic Software, Suite 201, 830 North Riverside Dr., Renton, WA 98055.

Digital Filter Design, a menu-oriented and prompt-driven program for interactive design and analysis of digital filters. For the Apple II and II Plus; floppy disk, $350. Parametrics Inc., 1129 West Oak, Fort Collins, CO 80521.

The Executive Secretary, a professional word-processing system that implements all standard word-processing functions. This system includes an integrated card-file feature and a menu-driven electronic-mail feature when it is used with a Hayes Micromodem. For the Apple II; floppy disk, $250. SOF/SYS Inc., 4306 Upton Ave. S, Minneapolis, MN 55410.

The Executive Speller, a spelling-correction system. The dictionary file can hold up to 25,000 words, and you can add your own dictionary entries. For the Apple II; floppy disk, $75. SOF/SYS Inc. (see address above).

Game Animation Package, a graphics-utility program that allows you to create multicolored shapes and tables of high-resolution screen displays for your own games. For the Apple II and II Plus; floppy disk, $49.95. Synergistic Software (see address above).

Gertrude's Puzzles, a puzzle game that uses different shapes and colors to help children develop reasoning skills. For children ages 7 and up. For the Apple II; floppy disk, $75. The Learning Co. (see above address).

Gertrude's Secrets, a program that teaches shape and color relationships to children while they play games. For children ages 4 to 9. For the Apple II; floppy disk, $75. The Learning Co. (see above address).

Global Program Line Editor, a sophisticated BASIC program editor with global edit, search, and replace. Programming aids can be configured for the most convenient use. For the Apple II and II Plus; floppy disk, $64.95. Synergistic Software (see address above).

Gold Rush, an arcade-type game. You've staked your claim, but now you must protect it against claim jumpers, attacking Indians, and wild animals. If you succeed, wealth and success are yours. For the Apple II and II Plus; floppy disk, $34.95. Sentient Software, POB 4929, Aspen, CO 81612.

Job Cost II, an expense- and materials-accounting system. This program allows you to keep track of up to 350 items, with 35 major categories and 10 subcategories, all user-definable. For the Apple II Plus; floppy disk, $39. Garbo Software, 211 West Fiesta #25, Carlsbad, NM 88220.

Juggles' Rainbow, a set of six programs for children who want to use a computer before they can read. For children ages 3 to 6. For the Apple II; floppy disk, $45. The Learning Co. (see above address).

Linear System Analysis, a software tool for the design of frequency and timing circuits. For the Apple II and II Plus; floppy disk, $350. Parametrics Inc. (see address above).

Magic Spells, a program to help chlidren develop spelling skills. For children ages 4 and up. For the Apple II Plus; floppy disk, $45. Apple Computer Inc., 20525 Mariani Ave., Cupertino, CA 95014.

Moptown, a program that helps children learn logic and language concepts. For children ages 4 and up. For the Apple II Plus; floppy disk, $50. Apple Computer Inc. (see address above).

The Personal Secretary, a word-processing system. This package includes a lowercase ROM chip and a shift-key adapter. For the Apple II; floppy disk, $99.95. SOF/SYS (see address above).

The Programmer, a program generator. When you enter specifications for a particular application, this program will write the Applesoft BASIC coding for you. The user manual is written in a tutorial style. For the Apple II; floppy disk, $199. Advanced Operating Systems, Suite 792, 450 St. John Rd., Michigan City, IN 46360.

Quadrant 6112, an arcade-type game. For the Apple II and II Plus; floppy disk, $34.95. Sensible Software Inc., Department G, 6619 Perham Dr., West Bloomfield, MI 48033.

Rocky's Boots, a player builds animated logic machines to score points and gain an understanding of logic skills. For children ages 7 and up. For the Apple II; floppy disk, $75. The Learning Co. (see above address).

Tharolian Tunnels, an arcade-type game that depicts an underworld universe war. For the Apple II and III; floppy disk, $29.95. The Software Farm, 3901 South Elkhart St., Aurora, CO 80014.

U-Boat Command, a strategic action war game. You command a German U-boat attempting to sink Allied ships while avoiding a similar fate. For the Apple II and II Plus; floppy disk, $29.95. Synergistic Software (see address above).

Atari

Cactus League Baseball, a two-player baseball game where one player controls the pitching, hitting, and fielding of the New York Yankees and the other player controls the Milwaukee Brewers. For the Atari 400 and 800; floppy disk, $19.95. Dynacomp Inc., 1427 Monroe Ave., Rochester, NY 14618.

Cyborg, an arcade-type game. To survive the gaming grids, you must battle and destroy the finest fighting machines ever developed. Half human and half machine, your cyborgs must fight a wide variety of killer robots. For the Atari 400 and 800; floppy disk and cassette, $29.95. Med Systems Software, POB 3558, Chapel Hill, NC 27514.

Nautilus, an arcade-type game. This one- or two-player game pits a nuclear submarine against an antisubmarine destroyer. A split screen allows both players to simultaneously play the game. For the Atari 400 and 800; cassette, $29.95. Synapse Software, 820 Coventry Rd., Kensington, CA 94707.

Rollerball, a futuristic combat game for two players. Strategy and brute force are the main tactics. For the Atari 400 and 800; floppy disk and cassette, $21.95 and $17.95, respectively. Dynacomp Inc. (see address above).

Teacher's Aid, a math drill program. It has subtraction, division, addition, and multiplication exercises and five levels of difficulty. For the Atari 400 and 800; floppy disk and cassette, $17.95 and $13.95, respectively. Dynacomp Inc. (see address above).

CP/M

Citation, a database-management program designed to allow quick access to constantly used information. Data fields may be up to 680 characters long with up to five keywords per entry. For CP/M-based systems; 5¼- and 8-inch floppy-disk formats, $250. Eagle Enterprises, 2375 Bush St., San Francisco, CA 94115.

CPUTIL System, a set of programs that allows users with large disk-storage needs to more efficiently manage their files. For CP/M-based systems; floppy disk, $49.95. Earth Science Associates, 10218 Cantertrot, Humble, TX 77338.

Directory-Sort Utility Version 3.7, a directory utility program for CP/M. It allows you to modify a directory for display in any format you choose and displays information on the disk memory available and organization of files. For CP/M; floppy disk, $31.95 (Aus., plus $10 postage). Software Source Ltd., POB 364, Edgecliff, New South Wales 2027, Australia.

FMS-80, a general-purpose data-management system composed of an integrated set of programs that can be configured for a custom database. For CP/M-based systems; floppy disk, $995. Systems Plus Inc., 1120 San Antonio Rd., Palo Alto, CA 94303.

Help.Com, a computer-aided instruction program useful for storing and retrieving information about CP/M applications programs. You can create your own on-line instructions for your particular application. For CP/M-based systems; floppy disk, $95. Designs Systems Inc., POB 12243, St. Louis, MO 63157.

The Introl-C Compiler, a compiler for the C language that produces fast object-code programming. For CP/M-based systems; floppy disk, $425. Introl Corp., 647 West Virginia St., Milwaukee, WI 53204.

Palantir Word Processing, a sophisticated word-processing system. This second-generation software performs all standard word-processing functions, including footers, headers, underlining, boldface, and overstrikes. For CP/M-based systems; floppy disk, $425. Designer Software, Suite 718, 3400 Montrose Blvd., Houston, TX 77006.

QSort, a coupon-management program. This program will store and sort information on up to 1600 store coupons. It can prepare a list of appropriate coupons compatible with your shopping list. For CP/M-based systems; floppy disk, $39.95. BV Engineering, POB 3351, Riverside, CA 92519.

Stiff Upper LISP, an implementation of the LISP Programming language. Designed for compactness, this version retains many of the features that allow experimentation in artificial intelligence. For CP/M; floppy disk, $165. Lifeboat Associates, 1651 Third Ave., New York, NY 10028.

The Wedge, an electronic spreadsheet program. This package includes installation, operation, and applications manuals. For CP/M-based systems; floppy disk, $295. Systems Plus Inc. (see address above).

IBM Personal Computer

Math Drills, an educational math-drill package. Requires an 80-column monitor. For the IBM Personal Computer; floppy disk, $25. Starware, Suite 800, 1701 K St. NW, Washington, DC 20006.

Quikcalc Real Estate Investor, a real-estate/financial-analysis package. This package includes a template for use with Visicalc or Supercalc. For the IBM Personal Computer; floppy disk, $129.95. Simple Soft Inc., Suite 101, 480 Eagle Dr., Elk Grove, IL 60007.

Stocks and Bonds, a stock-market simulation game. Up to six players can compete to see who can accumulate the greatest wealth in the 10 simulated years of play. For the IBM Personal Computer; floppy disk, $25. Avalon-Hill Game Co., 4517 Harford Rd., Baltimore, MD 21214.

The Thinker, an electronic spreadsheet program. For the IBM Personal Computer; floppy disk, $49. Texasoft, 1028 North Madison Ave., Dallas, TX 75208.

Trilogy, three games of the middle earth. Loosely based on the Tolkien novels, these games present you with challenges in your quest to become a wizard. For the IBM Personal Computer; floppy disk, $35. Texasoft (see address above).

SYM-1

Medifile, a family-accounting program for medical and dental expenses. For the SYM-1; cassette, $30. Lewis Davis, POB 1207, Chico, CA 95927.

Monifile, a financial-records program for family-budget control. For the SYM-1; cassette, $45. Lewis Davis (see above address).

Texas Instruments

Aeronaut, a simulation of hot-air ballooning. The balloon responds to your control according to the laws of physics. For the TI-99/4A; cassette, $21.95. Simulsoft, POB 3494, Scottsdale, AZ 85257.

The Dungeon, an adventure-type game where you try to find your way out of a maze with as much gold as possible. For the TI-99/4A; cassette, $6. Frank Elsesser, 1307 Douglas Dr., Sterling, IL 61081.

TRS-80

AUK's Computer Filing System, a simple menu-driven database-management system that allows you to save, recall, update, and printout information. For the TRS-80 Models I and III; floppy disk, $69.95. AUK's, 4605 Bollenbacher Ave., Sacramento, CA 95838.

BASIC Aid, an enhancement to BASIC and Extended BASIC. This utility features automatic line numbering and single-key entry of most BASIC commands. For the TRS-80 Color Computer; ROM pack, $35.95. Eigen Systems, POB 10234, Austin, TX 78766.

Galax Attax, an arcade-type action game where aliens swoop down on ships dropping bombs. For the TRS-80 Color Computer; cassette, $21.95. Spectral Associates, 141 Harvard Ave., Tacoma, WA 98466..

Offenders, an arcade-type game. For the TRS-80 Color Computer; floppy disk and cassette, $34.95 and $29.95, respectively. American Small Business Computers, 118 South Mill St., Pryor, OK 74361.

QSort, a coupon-management program that keeps track of 1200 store coupons (see full description under CP/M). For TRS-80 Models I and III; floppy disk, $39.95. BV Engineering, POB 3351, Riverside, CA 92519.

3-D Ghost Mania, an arcade-type game where you are given the perspective of a pacman in a maze. For the TRS-80 Models I and III; floppy disk and cassette, $29.95. Computer Price Index Inc., POB 35, West Jordan, UT 84084.

War Boats, a battleship-type naval strategy game. For the TRS-80 Models I and III; cassette, $4.99. Computer Heroes, 1961 Dunn Rd., East Liverpool, OH 43920.

ZBASIC 2.2, an interactive BASIC compiler that compiles BASIC coding into machine-language. It supports random-access files, PRINT USING statements, and high-precision mathematics routines. For the TRS-80 Models I and III; floppy disk and cassette, $89.95 and $79, respectively. Simutek Computer Products Inc., 4897 East Speedway Blvd., Tucson, AZ 85712.

ZX80/81

Las Vegas Games Package, blackjack and slot-machine game programs. For the Sinclair ZX81; BASIC listing, $1. Florida Creations, POB 16422, Jacksonville, FL 32216.

Starcruiser, a Star Trek-type game. This game takes place in a cube of space 100 units on a side. The object is to destroy three enemy ships while maneuvering your ship through the cube. For the ZX81; cassette, $7.95. Barry Hoggard, POB 161, Paragould, AR 72450.

Other

The Puzzle of the Tacoma Narrows Bridge Collapse, an interactive videodisc program used to teach physics students the principles of wave motions. For the Pioneer PR-7820 and VP-1000 videodisc players; $125. John Wiley & Sons Inc., 605 Third Ave., New York, NY 10158.

Type Right, a typing tutor program for 40- or 80-column computers. For the Commodore PET 4016, floppy disk and cassette, $29.95; and the CBM 8032, floppy disk, $39.95. Barron Enterprises, 714 Willow Glen Rd., Santa Barbara, CA 93105.■

This is a list of software packages that have been received by BYTE Publications during the past month. The list is correct to the best of our knowledge, but it is not meant to be a full description of the product or the forms in which the product is available. In particular, some packages may be sold for several machines or in both cassette and floppy-disk format; the product listed here is the version received by BYTE Publications.

This is an all-inclusive list that makes no comment on the quality or usefulness of the software listed. We regret that we cannot review every software package we receive. Instead, this list is meant to be a monthly acknowledgment of these packages and the companies that sent them. All software received is considered to be on loan to BYTE and is returned to the manufacturer after a set period of time. Companies sending software packages should be sure to include the list price of the packages and (where appropriate) the alternate forms in which they are available.

Ask BYTE

Conducted by Steve Ciarcia

Battery Power for Apples

Dear Steve,

I live in a rural area without AC power. I would like to run my Apple II Plus computer and disk drive from a 12-volt marine battery. Do you have a schematic for a power supply that would allow this?

Paul Walkins
Bastrop, TX

Power supplies for computers using 4116-type dynamic RAMs (random-access read/write memories) must be carefully designed to assure proper sequencing of voltages during turn-on and turn-off. A better way is to just use the present power supply in the Apple. I would recommend that you use a 12-volt DC to 120-volt AC inverter (instead of trying to bypass the Apple's power supply). You will find that there are a number of devices on the market that will let you run your Apple II from a rechargeable battery. Radio Shack sells one (part number 22-130) for $99.95. It can handle 300 watts of power, which is more than enough for the Apple II and a monitor. . . . **Steve**

PC Info Source

Dear Steve,

What do you know about the TRS-80 Pocket Computer or the Sharp PC-1211? I'd like to use one to control lights around my house.

Jeffrey Woodhead
Davis, CA

The Pocket Computer Newsletter (35 Old State Rd., Oxford, CT 06483) has up-to-the-minute information on pocket computers such as the Radio Shack TRS-80 PC and the Sharp PC-1211. It contains operating tips, programs, and product and equipment reviews. It should give you the information that you need.

For a general description of the pocket computers, see "The Panasonic and Quasar Hand-Held Computers" by Williams and Meyer (January 1981 BYTE, page 34) and "Introducing the TRS-80 Pocket Computer" (Microcomputing, February 1981, page 162). . . . **Steve**

Computer Burnout

Dear Steve,

I'm curious about the possible wearing out of a computer. I have heard that it may be better to leave the computer on all the time than to turn it off, because the shock of applying power can wear out semiconductors.

Edward M. Roberts
Glen Head, NY

The enemies of solid-state electronic circuits are heat and transients. Leaving a computer on for an extended period will cause no harm if it is properly ventilated because components reach a steady-state operating temperature. If components are not hot to the touch, the heat dissipation is probably adequate and no damage should result.

On the other hand, if the power lines to which the computer is connected are subject to large transients (e.g., with switching inductive loads), there is a greater risk of component damage if the computer is in operation. In a properly designed power supply, the transients generated by on or off switching are not harmful to operation.

In summary, there is really no middle road for computer durability. Use the computer as required and do not worry about component wear-out. . . . **Steve**

Lifelines and Lifeboats for CP/M Fans

Dear Steve,

I have heard about a CP/M user's group in New York City. Do you have any details?

Siegfried Seiffert
Monmouth Beach, NJ

To contact the CP/M users group in New York City, write to CP/MUG, attn: Marcia Coltun, 1651 Third Ave., New York, NY 10028. CP/MUG is operated as an adjunct of Lifeboat Associates, an international distributor of commercial software. Lifeboat operates the group with the assistance of CACHE (Chicago Area Computer Hobbyist Exchange). CACHE edits and catalogs public-domain software and compiles each volume (85 disks, so far), while CP/MUG collects, produces, and distributes the software.

If you are interested in learning what specific software is available through these groups, you can purchase a printed CP/MUG library catalog for $6 from Lifeline Publishing Corp., 1651 Third Ave., New York, NY 10028, (212) 722-1700.

Also, Lifeline produces a monthly 20-page newsletter that provides information about Lifeboat and CP/MUG software. Subscriptions are $18 per year. . . . **Steve**

Boggled by Cassette Tapes

Dear Steve,

We've developed some specialized applications programs on yacht design for TRS-80, Apple II, and TI-99/4 computers. They work best with a disk, but we've found that many potential customers don't have disk drives. Therefore, we've included cassette I/O routines and attempted to distribute the programs on cassette.

We are now experiencing the legendary lack of reliability of cassette data storage, as well as a lack of portability. On a 14K-byte program, it has taken us 5 to 10 tries to get a copy that our computer will read back, and then the odds are less than half that the customer will be able to read it. We've tried five different cassette recorders (including two CTR-80As, which Radio Shack sells for this purpose) and several brands of cassettes, head demagnetizers, cleaners, etc., etc. Honestly, if cassette storage is as bad to everyone else as it has been to us, I don't see why manufacturers bother documenting it in the manuals.

Do you have any suggestions? Are there higher-quality recorders available, or any modifications that might be made to a standard cassette recorder? Is there any chance of improving the signal between the recorder and computer? How does anybody make tapes for program distribution? I've had no trouble reading in programs that I bought on cassette.

John S. Letcher Jr.
Letcher Offshore Design
Southwest Harbor, ME

The high-frequency response of many cassette recorders leaves a lot to be desired. You will have much more success with cassette data storage if you use a high-quality ($100-range) recorder with a tone control. Panasonic and Sony make such models, and some even feature a speed adjustment.

Cassette tapes differ markedly (you get what you pay for). Tapes with dropouts are perfectly satisfactory for audio use because it's difficult for the ear to pick up a gap of several milliseconds on a recording. For the computer, that dropout means the loss of several bytes of data. Generally, the high-quality audio tapes will work. I have had consistently good luck with Maxell UD-60 tapes where others were somewhat sporadic. Once you find a tape that works, stick with it.

Don't use tapes longer than 60 minutes (i.e., 30 minutes per side). The longer tapes are thinner and are more subject to stretching, bleed-through, and breakage. Before recording, wind the tape from one end to the other and back to ensure that it is uniformly wound and will have equal tension on it.

A disk can't be beat for speed and accuracy, but if you follow my recommendations, you may even like using cassette tapes. . . . **Steve**

Low-Cost EPROM Eraser

Dear Steve,

Several years ago, some magazine published a design for a device that erased EPROMs (erasable programmable read-only memories); it used a lamp from an electric clothes dryer. I was able to obtain only one bulb before they became obsolete, and it was defective. Do you know of any source for an inexpensive EPROM eraser?

Also, do you know any company that can provide a usable DOS (disk operating system) for computers based on the 6502 microprocessor? I've got a growing KIM-based S-100 system to which I'm adding an 8-inch drive, so I'm beginning to think about operating systems. I can write a make-do DOS, but if CP/M were available (or Unix or . . .), I'd probably be better off.

Myron Calhoun
Manhattan, KS

A very effective EPROM eraser can be made with a GE (General Electric) G4T4/1 germicidal lamp and a GE 89G435 ballast. The total cost for the eraser is under $25 at current prices, and both components are available from any electrical supply house.

A unit using these components was described in the March 1978 issue of Microcomputing *(see "Faster Erase Times," by Mike L. Simon, page 90).*

Percom Data Company makes an impressive DOS for the KIM. It has patches for Microsoft BASIC, TEC65 text editor, and the Microade Assembler. It supports up to four 5¼-inch disk drives, has the operating system in ROM (read-only memory), and includes full source listings for all patches. It currently costs $600. Further information can be obtained from Percom Data Co., 211 North Kirby St., Garland, TX 75042, (214) 272-3421. . . . **Steve**

PET ROMs Switchable

Dear Steve,

I would like my Commodore PET computer to display Greek characters instead of English characters. Can I switch the ROM (read-only memory) character generator with one programmed for Greek characters? Where could I find such a character generator? Is there a way to make my Epson MX-80 printer print Greek characters?

Frederick N. Harris
American Embassy
APO, NY

Within the last year, I've seen two programmable character generators for the PET advertised. One is made by Integrated Computer Technologies and is available from Micro Mini Computer World, 74 Robinwood Ave., Columbus, OH 43213. It's called the ICT Programmable Character Generator. It allows you to reprogram any of the PET's 256 standard screen characters and would certainly allow the use of Greek characters. The other unit is manufactured by Systems Formulate Corp., 39 Town and Country Village, Palo Alto, CA 94301. It will allow up to 64 programmable characters.

Another device, known as a Soft ROM, consists of a circuit board that plugs into the PET's character-generator ROM socket to provide 4K bytes of programmable memory; an alternate character set may then be loaded into this. This card is available from Canadian Micro Distributors Ltd., 365 Main St., Milton, Ontario L9T 1P7, Canada. It sells for $129.

In November 1980, a company known as Kobetek Systems Limited (R.R. #1 Wolfville, Nova Scotia, B0P 1X0, Canada, (902) 542-9100) advertised a foreign-language ROM for the PET from West River Electronics. You may see if they still carry it, but I have not seen any advertisements recently.

The Epson MX-80 has an option known as Graftrax. It is a set of three ROMs that plug into the main circuit board inside the printer to give it high-resolution graphics capability. With this package, you should be able to print any character set that you can put on the screen. The Graftrax option lists for $100 and is available from any large computer store. . . . **Steve**■

In "Ask BYTE," Steve Ciarcia answers questions on any area of microcomputing. The most representative questions received each month will be answered and published. Do you have a nagging problem? Send your inquiry to:

Ask BYTE
c/o Steve Ciarcia
POB 582
Glastonbury CT 06033

If you are a subscriber to The Source, chat with Steve (TEC317) directly. Due to the high volume of inquiries, personal replies cannot be given. Be sure to include "Ask BYTE" in the address.

Event Queue

November 1982

November-December
Computer Communications Technology Seminars, various sites throughout the U. S. Among the seminars offered are the "James Martin 5-Day Fourth Generation Methodologies," "Managing the Database Environment," and "Database: A Builder's Guide." For complete information, contact the Technology Transfer Institute, 741 10th St., Santa Monica, CA 90402, (213) 394-8305.

November-December
Courses from Don White Consultants, various sites throughout the U.S. and Canada. Among the courses being offered are "Grounding and Shielding" and "MIL-STD 462/462B and System-Level Electromagnetic Interference Testing and Procedures." Course fees range from $815 to $945. For complete details, contact Don White Consultants Inc., State Route 625, Gainesville, VA 22065, (703) 347-0030.

November-December
Courses from Fairchild Camera and Instrument Corporation, Santa Clara, CA. Among the courses being offered are "F16000 Family Introduction," "Pascal for Microprocessors," and "F8 and F3870 Microcomputer Systems." For more information, contact Fairchild Camera and Instrument Corp., Education Center, 3420 Central Expressway, Santa Clara, CA 95051, (408) 773-2161.

November-December
IEEE Computer Society Conferences and Meetings, various sites throughout the U.S., Europe, and Asia. Among the events scheduled are "Compsac '82," "Very Large-Scale Integration and Microcomputers: Today and Tomorrow (Tencon '82)," and "The 1982 Real-Time Systems Symposium." For a complete listing of conferences and meetings, contact the Executive Secretary, IEEE Computer Society, POB 639, Silver Spring, MD 20901, (301) 589-3386.

November-December
Information Management and Technology Seminars, various sites throughout the U.S. Among the wide variety of seminars offered by Datamation Institute are "Distributed Systems: Concepts and Management Overview," "Management of Software Engineering: Lowering Costs, Boosting Productivity," and "Data-Processing Concepts for Management and Users." Registration fees range from $595 to $795, depending upon duration and the topic covered. For details, contact Ms. Joan Merrick, Datamation Institute Seminar Coordination Office, Suite 415, 850 Boylston St., Chestnut Hill, MA 02167, (617) 738-5020. For information on in-house presentations, contact Art Gutmann, Datamation Institute for Information Management and Technology, Seminar Coordination Office, Suite 803, 331 Madison Ave., New York, NY 10017, (212) 697-2361.

November-December
Intensive Seminars for Professional Development, Worcester Polytechnic Institute campus and various sites in the New York City and Boston metropolitan areas. Some of the topics to be presented are "Project Management," "Leadership Skills and Management Tools for High-Technology Professionals," and "Microprocessors: Hardware, Software, and Applications." Fees range from $495 to $990. Complete details are available from Ms. Ginny Bazarian, Office of Continuing Education, Higgins House, Worcester Polytechnic Institute, Worcester, MA 01609, (617) 793-5517. For information on in-house seminars, call Robert J. Hall at (617) 793-5574.

November-December
Seminars of Interest to Women Professionals, various sites around Boston, MA. This series of one- and two-day seminars is presented by Boston University Metropolitan College. Among the topics on the agenda are "Managing Word Processing to Increase Productivity and Profitability," "A Manager's Introduction to Computers and BASIC," and "Data Processing Fundamentals for Accounting and Financial Managers." The seminar fees are $325 and $495, depending on duration. For registration information, contact Ms. Joan Merrick, University Seminar Center, Suite 415, 850 Boylston St., Chestnut Hill, MA 02167, (617) 738-5020.

November-January 1983
Courses from Q.E.D. Information Sciences, various sites throughout the U.S. Among the courses offered are "Database Concepts and Systems," "Human Factors in Office Automation," "Screen Design," and "Designing Systems Controls." Complete course outlines are available from Q.E.D. Information Sciences Inc., Q.E.D. Plaza, POB 181, Wellesley, MA 02181, (617) 237-5656.

November 9-11
The Government-Industry Data Exchange Program-GIDEP, McCormick Inn, Chicago, IL. This annual workshop is open to anyone interested in the exchange of technical information relating to engineering, failure experience, reliability and maintainability, and metrology. For more information, contact the Officer-in-Charge, GIDEP Operations Center, Corona, CA 91720.

November 9-12
Computer Graphics, New York, NY. This course is designed to provide a comprehensive overview of state-of-the-art computer-graphics software and hardware and to present an integrated approach to implementation of graphics applications. Topics to be addressed include technology fundamentals, software and hardware availability and selection criteria, and raster scan, vector, and color techniques. Participants receive a take-home graphics software package. The course fee is $845. Information can be obtained from Ruth Dordick, Integrated Computer Systems, 3304 Pico Blvd., POB 5339, Santa Monica, CA 90405, (800) 421-8166; in California, call (213) 450-2060.

November 9-12
Distributed Processing, Mini- and Microcomputer Implementations, Boston, MA. This course will cover distributed processing concepts and techniques suitable for microprocessor applications. Other topics include design requirements of distributed systems, how to partition system tasks and hardware, and how to implement data links and protocols. The fee is $845. Contact Ruth Dordick, Integrated Computer Systems, 3304 Pico Blvd., POB 5339, Santa Monica, CA 90405, (800) 421-8166; in California, call (213) 450-2060.

November 10
Living in a Computerized World: Challenges to Privacy, Education, and Society, Student Union, Brooklyn College, New York, NY. This conference is a joint presenta-

tion of the New York State Legislative Commission on Science and Technology and the Humanities Institute of Brooklyn College. Contact the Legislative Commission on Science and Technology, State of New York, 14th Floor, Agency 4 Building, Assembly POB 167, Albany, NY 12248, (518) 455-5081.

November 10-12
Accounting and Information Systems Expo '82, MGM Grand Hotel, Reno, NV. This exposition is designed to expand on recent legal, technological, and methodological advances in accounting and computer-related fields. Among the 27 seminars planned are "Computerized Budgeting," "Auditing Computerized Systems," and "Stress Management." Seminar fees range from $125 for one day to $350 for three days. For complete details, contact Shirley Beck, Division of Continuing Education, University of Nevada, Reno, NV 89557, (702) 784-4801.

November 11-12
Microcomputers in Education, Biloxi, MS. This workshop is sponsored by the College of Education at the University of South Alabama in cooperation with the School of Continuing Education. For details and registration forms, contact Ms. Judy Campbell, University of South Alabama, Mobile, AL 36688, (205) 690-6528.

November 11-14
The Fourth Annual Northeast Computer Show and Office Equipment Exposition, Hynes Auditorium, Boston, MA. This show will feature microcomputers, business systems, peripherals, accessories, and supplies. Admission is $5. Contact Northeast Expositions, 822 Boylston St., Chestnut Hill, MA 02167, (617) 739-2000.

November 14-19
Data Processing Training Managers' Workshop, Westin Bay Shore Inn, Vancouver, British Columbia, Canada. This workshop is designed for people with less than 18 months' experience in coordinating data-processing training programs. Participants learn how to establish in-house education programs that will meet managements' objectives and ensure a high return on their organizations' investment in training. The fee is $850. Full details are available from Linda Hubacek, Deltak Inc., 1220 Kensington Rd., Oak Brook, IL 60521, (312) 920-0700.

November 15
Knowledge Engineering in the 1980s, San Francisco, CA. This executive briefing provides an overview of the power and potential of artificial intelligence. It is designed to introduce executives and senior technical personnel to the concepts of knowledge engineering and knowledge systems. Topics to be covered will assist participants in assessing the utility of knowledge engineering, pinpointing areas of impact, and outlining costs and strategies for initiating knowledge-engineering projects. The fee is $750, which includes materials, luncheon, and a reception. For further information, contact Dina Barr, Teknowledge, 151 University Ave., Palo Alto, CA 94301, (415) 327-6600.

November 15-17
Microcomputer Interfacing, Design and Programming Using the Z80/8085/8080, Virginia Polytechnic Institute and State University, Blacksburg, VA. This is a hands-on workshop with the participant designing and testing concepts with the actual hardware. The fee is $395. Contact Dr. Linda Leffel, C.E.C, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061, (703) 961-4848.

November 15-19
Auditing in the Contemporary Computer Environment, New York, NY. This course is sponsored by Coopers & Lybrand. It's designed for internal auditors and financial and data-processing professionals. A comprehensive audit approach for computer-based systems, including how to evaluate controls, will be presented. Topics of interest are how to prepare an audit report and how to design a program of tests using questionnaires, checklists, software tools, and flowcharts. Obtain full details from Marge Umlor, EDP Auditors Foundation, 373 South Schmale Rd., Carol Stream, IL 60187, (312) 682-1200.

November 15-19
The IX Latin American Congress on Banking Automation, ATLAPA Convention Center, Panama City, Republic of Panama. This conference is sponsored by the Latin American Federation of Banks, the Latin American Center for Banking Automation, and the Panama Banking Association. Seminars, conferences, and lectures will be complemented by exhibits of automatic data-processing and telecommunications equipment related to banking operations. For details, contact Asociacion Bancaria de Panama, Apartado 4554—Panama 5, Republic de Panama; Tel: 25-1863.

November 15-19
Unix Workshop, Los Angeles, CA. This introductory course is open to engineers, programmers, managers, and designers. Subject areas include introduction to the Unix editor, file system and directories, and word-processing tools. The fee is $1000. Course outlines are available from Joan Hall, Plum Hall Inc., R.D. 2 Box 235P, Pleasantville, NJ 08232, (609) 927-3770.

November 16
Writing User Manuals That Sell Software, Doubletree Inn, Dallas, TX. This seminar focuses on the user manual as an integral part of a software package. Special attention is given to the manual's role at point-of-sale. Topics on the program include analyzing the manual's part in meeting both user and vendor needs, planning and outlining, and effective writing, packaging, and editing techniques. The fee is $150, which includes a manual on planning and executing a documentation project. Contact Michele Keplinger, Promptdoc Inc., Suite 113, 833 West Colorado Ave., Colorado Springs, CO 80905, (303) 471-9875.

November 16-19
Computer Graphics, San Francisco, CA. For details, see November 9-12.

November 17-19
Local Networks: Designing and Implementing Applications for the 80s, International Hotel, Washington, DC. This conference is intended to provide in-depth evaluations of the advantages and limitations of local networks for different applications, such as how local networks fit into an overall communications strategy. Hardware, software, and services for local networks will be exhibited. Contact U.S. Professional Development Institute, 12611 Davan Dr., Silver Spring, MD 20904, (301) 622-5696.

November 18
Writing User Manuals That Sell Software, Howard Johnson—O'Hare International, Chicago, IL. Refer to November 16 for information.

November 18-21
Applefest, Brooks Hall, San

Francisco, CA. Applefest is a conference convention and exposition featuring Apple computers and Apple-related products such as software, peripherals, accessories, and publications. The admission fee is $5. Contact Northeast Expositions, 822 Boylston St., Chestnut Hill, MA 02167, (617) 739-2000.

November 18-19
The Sixth Western Educational Computing Conference, Kona Kai Club, San Diego, CA. This conference is presented by the California Educational Computing Consortium. It's intended for instructors and administrative personnel at the college and university level. The theme is "Bringing the Information Age to the Campus." Papers will address such topics as student involvement in database design, administrative computing in continuing education, the educational software dilemma, and learning economics with a microcomputer. Contact Professor Frances Grant, Center for Information and Communications Studies, California State University, Chico, CA 95929.

November 19-21
Electronica, Civic Center, Houston, TX. This show will feature a wide variety of personal electronics equipment including computers, electronic games, ham radios, and projection TV. For more information, contact Northeast Expositions, 824 Boylston St., Chestnut Hill, MA 02167, (617) 739-2000.

November 29-December 2
The 1982 Global Telecommunications Conference (Globecom '82), Sheraton Bal Harbour Hotel, Miami, FL. The theme for this IEEE Communications Society-sponsored conference is "Communications—A Synergistic Technology." Topics to be explored include local-area networks, fiber optics, satellite communications, computer/communication security, network performance evaluation, and LSI/VLSI (large-scale integration/very large-scale integration) communications. Panel discussions and about 60 hardware and software exhibits will highlight this conference. Globecom was formerly known as the National Telecommunications Conference (NTC). General conference information is available from Dr. Liang Li, Gould S. E. L., 6901 West Sunrise Blvd., POB 9148, Fort Lauderdale, FL 33310. For registration details, contact Dr. Thomas J. Harrison, Registration Chairman, IBM Department 2K1/203, POB 1328, Boca Raton, FL 33432.

November 29-December 2
COMDEX '82, Convention Center, Las Vegas, NV. This conference and exposition, designed for small-systems vendors and independent sales organizations, is one of the largest annual computer shows. Full details are available from The Interface Group, 160 Speen St., POB 927, Framingham, MA 01701, (800) 225-4620; in Massachusetts, (617) 879-4502.

November 30-December 1
Understanding and Using CAD/CAM, Barbizon Plaza, New York, NY. This seminar will be led by Carl Machover. It is intended to provide an introduction to and the history of computer graphics, the computer-graphics environment, and basic computer-graphics technologies. CAD/CAM (computer-aided design/manufacturing) topics to be addressed include design and analysis, simulation, the size of the market and its expected growth, and management issues. Practical information about hardware, software, systems, and applications will be provided. Workshops and class discussions will follow the concluding session. Full details are available from Carol Sapchin, Frost & Sullivan, 106 Fulton St., New York, NY 10038, (212) 233-1080.

November 30-December 2
Midcon/82, High-Technology Electronics Exhibition and Convention, Dallas Convention Center, Dallas, TX. Contact Electronic Conventions Inc., 999 North Sepulveda Blvd., El Segundo, CA 90245, (800) 421-6816; in California, (213) 772-2965.

November 30-December 2
The 1982 Autofact 4 Conference and Exposition, Civic Center, Philadelphia, PA. This show is sponsored by the Computer and Automated Systems Association of the Society of Manufacturing Engineers (CASA/SME). The focus will be on computer-aided design and manufacturing (CAD/CAM) and the expanding technologies of computer-integrated manufacturing (CIM) and the automated factory. Tutorials and sessions will address analysis and simulation, robotics, assembly, quality assurance, scheduling, material handling, and other related topics. Additional information is available from CASA/SME Public Relations, One SME Dr., POB 930, Dearborn, MI 48128, (313) 271-0777.

November 30-December 3
Computer Graphics, Washington, DC. See November 9-12 for details.

November 30-December 3
Digital Modal Analysis, Marina International Hotel, Marina del Rey, CA. Contact the Continuing Education Institute, Oliver's Carriage House, 5410 Leaf Treader Way, Columbia, MD 21044, (301) 596-0111.

December 1982

December-March 1983
Courses for Developers and Users of Computer Systems, various sites throughout the U. S. Among the courses offered by the AMA (American Management Associations) are "Fundamentals of Data Processing for the Nondata Processing Executive," "BASIC: A Computer Language for Managers," and "Database Concepts and Designs." For complete registration and course information, contact the AMA, 135 West 50th St., New York, NY 10020, (212) 586-8100.

December 1-2
MECC '82, Educational Computing Conference, Minneapolis, MN. The theme for this conference is "Sharing a Decade of Experience." Pre- and post-conference workshops on implementing computing and programming microcomputers are planned. Practical sessions and discussions will cover in-service training techniques, software and hardware evaluations, classroom teaching strategies and activities, and kindergarten through 12th grade curriculum planning. For complete details, contact MECC '82, 2520 Broadway Dr., St. Paul, MN 55113, (612) 376-1131.

December 1-3
Software Information International, Wembley Conference Centre, London, England. Particulars are available from Software/expo, Suite 400, 222 West Adams St., Chicago, IL 60606, (312) 263-3131.

December 2-3
Understanding and Using Computer Business Graphics, Barbizon Plaza, New York, NY. This workshop offers an introduction to and the history of computer graphics, the computer-graphics environ-

ment, and basic computer-graphics technologies. Areas addressed are justifying business graphics, time- and money-saving techniques, business graphics choices, and successful operating techniques. Workshops and class discussions will follow the concluding session. The seminar leader is Carl Machover. Contact Carol Sapchin, Frost & Sullivan, 106 Fulton St., New York, NY 10038, (212) 233-1080.

December 3-5

Electronica, Moscone Hall, San Francisco, CA. See November 19-21 for further details.

December 5-10

Data Processing Training Managers' Workshop, Sheraton Universal Hotel, Los Angeles, CA. For details, see November 14-19.

December 6-7

Farm Computer Seminar, Argos Computers, Fresno, CA. This seminar is sponsored by Argos Computers. It's designed for the farmer considering investing in an on-farm computer system, the operators to be responsible for operating the system, and the controller, accountant, and bookkeeper planning the installation of a farm computer system. The program is intended to provide a general understanding of computers, computerization, and computerized farm management. The program covers hardware, software, database-management systems, how to specify system requirements, charting information flows, and preparing a farm for computerization. Hands-on experience will be provided. The fee is $250. A full seminar description is available from Alan R. Thodey, Argos Computers, Suite 360, 790 West Shaw Ave., Fresno, CA 93704, (209) 221-7211.

December 6-8

Hands-on Pascal Workshop, Los Angeles, CA. This course will provide the opportunity to learn Pascal through hands-on experience on Apple II Pascal systems. Topics to be addressed include coding the language, using structured programming techniques, developing portable and maintainable software, and implementing real-time software for microcomputer and minicomputer applications. The course fee is $695. For information, contact Ruth Dordick, Integrated Computer Systems, 3304 Pico Blvd., POB 5339, Santa Monica, CA 90405, (800) 421-8166; in California, (213) 450-2060.

December 6-9

Computers in Science, Conrad Hilton, Chicago, IL. This conference seeks to provide information on how changing computational technologies will influence future scientific research. Sessions, lectures, and presentations will cover such topics as "Products of the Technological Revolution: Building Blocks of Future Computer Systems," "Computational Systems: Man/Machine Synergism and the Conduct of Scientific Research," and "Scientific Communication and Collaboration: Conducting Research in the New Computational Environment." In addition, preconference tutorials on hardware, software, and communication technology are planned. This conference is sponsored by *Science* magazine in cooperation with Scherago Associates Inc., 1515 Broadway, New York, NY 10036, (212) 730-1050.

December 6-10

Unix Workshop, Boston, MA. Details are listed under November 15-19.

December 7-8

Plenary Technology, New York, NY. Details are available from the Yankee Group, POB 43, Harvard Square, Cambridge, MA 02138, (617) 542-0100.

December 7-8

Computers—Can You Afford Not to Understand?, St. Charles, IL. The fee for this executive seminar is $500. Contact the Registrar, Arthur Andersen & Co., Center for Professional Education, 1405 North Fifth Ave., St. Charles, IL 60174, (800) 323-0815; in Illinois, (800) 942-0851.

December 7-10

Distributed Processing, Mini- and Microcomputer Implementations, Washington, DC. See November 9-12 for details.

December 9-11

The 1982 California Educational Exposition, Anaheim Convention Center, Anaheim, CA. This exposition's theme is "Public Education: Our Purpose—Our Future." Exhibits and an all-day computer-literacy workshop highlight this event. Address inquiries to Alice Lytle, California School Boards Association, 916 23rd St., Sacramento, CA 95816, (916) 443-4691.

December 9-12

Southeast Computer Show and Office Equipment Exposition, Civic Center, Atlanta, GA. For details, contact Computer Expositions Inc., POB 3315, Annapolis, MD 21403, (800) 368-2066; in Maryland, (301) 263-8044.

December 10

The 1982 Computer Networking Symposium, Gaithersburg, MD. "Planning for the Near Term: The Next Three Years" is the theme for this symposium, which is sponsored by the IEEE Computer Society Technical Committee on Computer Communication and the Institute for Computer Sciences and Technology of the National Bureau of Standards. Papers related to the design, selection, and implementation of network systems within the next three years will be delivered. Areas of particular interest include long-haul networks, local-area networks, and satellite systems. Full details are available from Computer Networking Symposium, IEEE Computer Society, POB 639, Silver Spring, MD 20901, (301) 589-3386.

December 12-17

Small Computers in Biomedical Research, Woods Hole, MA. This course is sponsored by the Marine Biological Laboratory. It emphasizes hands-on exercises using several fully equipped microprocessor systems. The concentration is on basic machine operation and assembly language. Other topics include number systems, machine logic and architecture, operating systems, and flowcharting and interrupts. Contact the Marine Biological Laboratory, Woods Hole, MA 02543, (617) 548-3705.

December 13-15

Office Automation for Management Productivity, Shoreham Hotel, Washington, DC. Conference sections will focus on better methods to evaluate productivity, to select equipment or procedures, to integrate equipment or procedures into an organization, and to get people to work effectively in a changing environment. For further details, contact the Information Exchange, Suite 334, 4500 South Four Mile Run Dr., Arlington, VA 22204, (703) 820-5720.

December 13-17

C Programming Workshop, Boston, MA. This workshop is designed for programmers or engineers able to program in another language. Areas to be explored include C operands and operators, C preprocessors, pointers and arrays, and structures and unions. The fee is $1000. A full course outline is available from Joan Hall, Plum Hall Inc., RD 2 Box 235P, Pleasantville, NJ 08232, (609) 927-3770.

December 13-17
Digital Continuous-System Simulation, University of Maryland University College, Adelphi, MD. The fee for this course is $975. For details, contact Marc Rosenberg, UCLA Extension, Continuing Education in Engineering and Mathematics, 6266 Boelter Hall, Los Angeles, CA 90024, (213) 825-1047.

December 14-15
Plenary Technology, Palo Alto, CA. Details are available from the Yankee Group, POB 43, Harvard Square, Cambridge, MA 02138, (617) 542-0100.

December 14-16
A Business Approach to Systems Controls, Chicago, IL. The fee for this seminar is $600. Contact the Registrar, Arthur Andersen & Co., Center for Professional Education, 1405 North Fifth Ave., St. Charles, IL 60174, (800) 323-0815; in Illinois, (800) 942-0851.

December 14-17
Systems Project Management, Chicago, IL. The fee for this seminar is $900. For full details, contact the Registrar, Arthur Andersen & Co., Center for Professional Education, 1405 North Fifth Ave., St. Charles, IL 60174, (800) 323-0815; in Illinois, (800) 942-0851.

January 1983

January 5-7
The Sixteenth Hawaii International Conference on Systems Sciences, Honolulu, HI. This conference will focus on recent developments in the theory and practice of computer software, hardware, and advanced computer systems applications as related to information and systems science. Special emphasis will be placed on medical information processing, decision support systems, and office systems and technology. Further information is available from Emily M. Yano Jorgensen, Office of Management Programs, College of Business Administration, University of Hawaii, 2404 Maile Way C-202, Honolulu, HI 96822, (808) 948-7396.

January 18-20
Southcon/83, High-Technology Electronics Exhibition and Convention, Georgia World Congress Center, Atlanta, GA. Contact Electronic Conventions Inc., 999 North Sepulveda Blvd., El Segundo, CA 90245, (800) 421-6816; in California, (213) 772-2965.

January 20-21
The Twelfth Annual National Measurement Science Conference and Exhibition, Hyatt Rickeys Hotel, Palo Alto, CA. This conference is intended for managers, scientists, engineers, and operating personnel. Its theme is "Accuracy and Automation." Seminar sessions will stress practical applications of new equipment and techniques to solve measurement problems. By format and objective, this conference will promote professional and state-of-the-art approaches and emerging technologies in the fields of measurement science. For registration information, contact Bob Weber, Lockheed Missile & Space Corp., Sunnyvale, CA 94046, (408) 742-2957.

January 31-February 2
Communication Networks '83, the Rivergate, New Orleans, LA. This conference and exposition will encompass the voice, data, and telecommunications industry with sessions and demonstrations. The theme is "Communications Cost Control Via High Technology." Topics on the agenda include electronic mail and office communications, local-area networks and internetting, and modems and multiplexers. Optional in-depth skill seminars will be held. These seminars, led by industry leaders, include lectures, class activities, and a workbook. General registration fees are $395; skill seminars cost $295. Contact Louise Myerow, Conference Management Group, CW Communications Inc., POB 880, Framingham, MA 01701, (800) 225-4698; in Massachusetts, call (617) 879-0700 collect.■

In order to gain optimal coverage of your organization's computer conferences, seminars, workshops, courses, etc, notice should reach our office at least three months in advance of the date of the event. Entries should be sent to: Event Queue, BYTE Publications, POB 372, Hancock NH 03449. Each month we publish the current contents of the queue for the month of the cover date and the two following calendar months. Thus a given event may appear as many as three times in this section if it is sent to us far enough in advance.

Clubs and Newsletters

Down East TRS-80 Group

The Southern Maine TRS-80 Group meets on the first Tuesday of every month at 6:30 p.m. in classroom 2, Maine Medical Center, Bramhill St., in Portland, Maine. Dues are $10 annually or $1 a month. The group's newsletter is called *Byte Babble*. Contact the Southern Maine TRS-80 Group, 15 Mountain View Rd., Cape Elizabeth, ME 04107.

Second call for Clubs and Newsletters Directory

To be included in the fifth edition of the BYTE Clubs and Newsletters Directory, your club or publication must supply the following information:

1. *name of organization or publication*
2. *mailing address*
3. *contact person and telephone number*
4. *name of newsletter or publication*
5. *special interests*

Send your information to Clubs and Newsletters Directory, BYTE/McGraw-Hill, POB 372, Hancock, NH 03449.

Keeping Up with Communications

The Electronic Mail & Message Systems (EMMS) is a twice-monthly newsletter covering technology, user, product, and legislative trends in graphic and record communications. Subscriptions are $210 a year for 24 issues; single copies are available for $10. Overseas subscriptions are $245 a year. Write to EMMS, 30 High St., Norwalk, CT 06851.

IBM Group in Toronto

The recently formed Toronto Area IBM Personal Computer Users Group seeks communication with members of other IBM users groups. Joint activities will be sponsored and a newsletter may be published. To contact the Toronto group, send a brief description of your equipment, a legal-sized envelope, and your group's name, address, and telephone number to the IBM User Group of Toronto, POB 1376, Station B, Downsview, Ontario, M3H 5V6, Canada. In Canada, send a stamped envelope, elsewhere enclose $1 (U.S. funds).

British Form 68' Micro User Group

Software and hardware for the 6800 series of microprocessors is the focus of a newly formed British users group. Meetings are held once a month and a newsletter is planned. Further information can be obtained by sending a self-addressed, stamped envelope to Jim Anderson, 41 Pebworth Rd., Harrow, Middlesex, HA1 3UD, England.

IBM PC Users Connect

IBM Personal Computer owners in Stamford, Connecticut, have organized a club and planned a substantial agenda for future meetings. The club meets on the third Tuesday of each month at 6:30 p.m. at Computerland, 111 High Ridge, Stamford, CT. Dues are $5 annually and include mailing fees. Further details are available from Dave Foulger, 69 River St., New Canaan, CT 06840.

Save Time and Money

Flexible Automation, The Newsletter of Automated Systems, reports recent developments in computer hardware and software as they are introduced. Computer-integrated manufacturing businesses that subscribe will have information relevant to flexible production systems. Subscriptions to the twice-monthly publication are $144 for one year (23 issues) and $250 for two years. Contact *Flexible Automation*, POB 175, Ho-Ho-Kus, NJ 07423.

Suggestions Welcome

Commodore VIC-20 users are invited to send their suggestions for a new club forming in North Carolina to Microcomputers Users Club, POB 17142, Bethabara Station, Winston-Salem, NC 27116.

Atari Australian Style

The Atari Computer Enthusiasts (New South Wales) is an Australian users group for both beginning and advanced users of the Atari 400/800 home computer systems. Meetings are held the first Monday of every month at 6 p.m. at I.P. Sharp Associates, 8th floor of the Carlton Centre, 55 Elizabeth St., Sydney. The group has a small reference library of Atari literature, is developing a software exchange, and publishes a newsletter called *Inside Info*. Membership to A.C.E. (N.S.W.) is $15 plus a $15 annual subscription fee (Australian dollars). Call Garry Francis at (02) 2-0933 ext. 354 or write to Atari Computer Enthusiasts (N.S.W.), 78 Ayres Rd., St. Ives, New South Wales, Australia 2075.

NY Amateurs Meet

The New York Amateur Computer Club holds meetings open to the public on the second Thursday of each month from 7 to 10 p.m. in the Main Building of New York University, 100 Washington Square East, New York City. Because meeting locations change, call (212) 864-4595 for room number. The group publishes a monthly newsletter, holds monthly board meetings, and participates in area computer conventions. It has also published a catalog of more than 100 volumes of public-domain software. For information call Don Wiss at (212) 532-5722 or write POB 106, Church St. Station, New York, NY 10008.

North Star in NYC

Affiliated with the New York Amateur Computer Club is the New York City North Star Users Group. It meets once a month for information exchange and discussions of hardware and software. Contact Dr. Jeremy Shapiro at (212) 496-6050 or 302 West 86th St., New York, NY 10024. ■

BYTELINES

News and Speculation about Personal Computing

Conducted by Sol Libes

Random Rumors: Still no word on when Commodore's new 16-bit microprocessor, the 65000, will be announced, but specifications are starting to leak out. Scuttlebutt has it that the chip will be mounted in a standard 40-pin DIP (dual-inline package) that should allow the manufacturer to hold down its cost. The 65000 will have 24 address bits, allowing it to directly access 16 megawords (32 megabytes) of memory. It will contain sixty-four 8-bit registers and will be designed to provide direct support for high-level languages via descriptors that associate data types with variables. The initial version is expected to have a programmable I/O channel with 22 associated instructions, which will let it service I/O devices without disturbing the main processor. Rumors are circulating that before the microprocessor will be made available to outsiders, the initial production runs will be used for a new computer that Commodore has in the works. . . . It's estimated that IBM sold more than 250,000 Personal Computers during the first year of production, fully half the number of Apple IIs sold in that machine's first 5 years of production. IBM is expected to greatly expand its list of independent retailers of the Personal Computer. . . . According to reports, Motorola is shipping sample 68000 microprocessors rated to run at 16 MHz and the company may distribute a version of Digital Research's CP/M disk operating system for 68000-based machines. . . . Tecmar Inc., Cleveland, Ohio, is said to be working on a 68000 processor card for the IBM Personal Computer. . . . Any day now, Microsoft is expected to release MS-DOS version 2 (known as PC-DOS on the IBM Personal Computer). It may have multitasking capability. Microsoft is also rumored working on a version that will run as a task under multiuser Xenix so that owners of that operating system will be able to run MS-DOS-based software too. Microsoft may soon have a word-processing program, possibly called Multiword, to complement Multiplan. Microsoft is also rumored to be interested in buying *PC Magazine* from Tony Gold (formerly of Lifeboat). We wonder what that will do to *PC*'s credibility. . . . **MH** . . . American Bell, the new AT&T computer subsidiary, is expected to start releasing a host of new computer products starting early next year. You can anticipate a lot of software, terminals, and minicomputers. Although most of the new products will be directed toward the telephone industry, many will find use in general applications (the terminals, for example, use Motorola's 68000 microprocessor, are said to be highly intelligent, have super graphics, cost about $1000 each in quantity, and may be well suited for text-editing and work-station use). AT&T denies it, but rumors persist that a 32-bit microprocessor designed specifically to run Unix System III (the latest officially released version) will be introduced. . . . If Timex is successful in mass-marketing the ZX81, expect Sinclair Research to turn over the new Spectrum color computer to that company, too. . . . Lanx Corporation, San Jose, California, and IMI (International Memories Inc.) are thought to be readying a 100-megabyte 8-inch Winchester-disk drive using vertical recording. . . . Sources say that Shugart Associates is shipping evaluation samples of its new optical mass-storage system to potential customers. Production is slated for late next year. The storage system is said to be of the write-once variety, which means that information written cannot be erased. Because the system has a capacity of 1 gigabyte per optical-disc surface and because the media are removable, the write-once philosophy is easily justified. . . . Look for Panasonic to announce a system compatible with IBM's Personal Computer. . . . IBM is said to be squaring away a souped-up version of the Personal Computer that uses Intel's 8086 microprocessor and has more memory-addressing capability and larger disks. Expect its introduction by year's end. . . . Rumor has it that the well-known Wall Street analyst Benjamin M. Rosen, who publishes the *Rosen Electronics Letter* on the electronics industry, is actively backing a new personal computer venture. Formal announcement of the new company and its product should occur early this month. Stay tuned for more details. . . . **CM**

Commodore Status Report: Commodore Business Machines appears to be trying to compete with everybody by introducing five new machines with list prices ranging from a low of $179 to a high of $2995. The low-cost MAX is essentially a game machine, but it does incorporate some of the features of the VIC-20, PET, and the new Commodore 64. It appears to be intended to compete with the Atari Video Computer System.

In the meantime, the VIC-20 is selling like hotcakes at discount prices as low as $229 (list is $299); however, industry pundits speculate that it will soon be replaced by an upgraded model with a better display, graphics, and sound. The Commodore 64 ($595 list)—with 64K bytes of memory and a good keyboard—may turn out to be the lowest-cost machine capable of running CP/M. An optional plug-in Z80 cartridge should be available for it sometime next year.

With the introduction of the P128 (list $995), Commodore finally appears to be replacing the PET computer. The P128 has 128K bytes of memory and is compatible with PET peripherals. The new B128 ($1695) and BX256 ($2995) computers appear to be replacements for the CBM 8032. Both have 80-character by 24-line video displays and built-in floppy-disk drives. The B128 carries 128K bytes of memory, while the BX256 has 256K and a second processor, an Intel 8088. Both systems accept up to 640K bytes of memory and have detachable keyboards. These machines seem designed to rival the IBM Personal Computer and Apple III.

Commodore's line of machines is larger than that of any other manufacturer in the industry. Previously, Radio Shack had the broadest line with four different machines. Commodore's new machines present a new price-versus-performance standard and should shake up the industry when they become available in quantity early next year.

Apple Rumors: Apple is expected to announce the long-awaited successor to the Apple II, the Apple II-E, early in January. The II-E should have an 80-column video display and more than 64K bytes of memory—features presently available on the Apple II only through add-on peripherals. It may sell at a slightly lower price than the Apple II, and it's expected to use only 11 integrated circuits (less memory) and incorporate many manufacturing economies. It is believed that the II-E will maintain software compatibility with existing Apple II software.

Apple's long-rumored office-of-the-future using the 68000 microprocessor may be announced next year. In a minimum configuration of the system, code-named Lisa, prices should start at about $10,000. Apple Computer might wait until late in 1983 to announce a new low-cost system, presently referred to as Macintosh; its base price is estimated at $1500. Macintosh should have many of the same capabilities found in Lisa. Apple's avowed goal in presenting these new systems is to reduce the time required to learn how to use them to less than an hour and to eliminate the programming bottleneck by providing a large base of off-the-shelf software.

In the meantime, a federal district court has denied Apple's request for a preliminary injunction against Franklin Computer Corporation. Apple accused Franklin and its Ace Computer of patent and copyright infringement. The Ace 1000 is now being shipped and is purported to be hardware- and software-compatible with the Apple II. Also, the Federal Trade Commission has closed its investigation of alleged unfair business practices by Apple without taking any action. The investigation was initiated after Apple dropped mail-order and over-the-phone dealers.

UCSD p-System Gains Acceptance: The UCSD p-System, developed by Softech Microsystems, will soon be the standard operating system on the portable Osborne 1 computer. Osborne chose the p-System because it will let users easily transfer software from other systems, such as the IBM Personal Computer, DEC (Digital Equipment Corporation) VT180, and the Apple II—all of which have different disk formats. Softech has introduced an attachment to these computers, called the Universal Medium, that makes it possible to take a disk from one vendor's machine and read it with another's by converting the disk controller's format specifications. The p-System operating system supports BASIC, FORTRAN-77, and Pascal and offers programs to help you develop software to run under it.

Z80 Sales Strong As Ever: Zilog reports that Z80 microprocessor sales are stronger than ever (probably due to the popularity of the Sinclair ZX81). Recently, Zilog closed two deals to supply other companies with one million processors and three deals for one-half million processors each. In this quantity, Z80 prices are typically around $3 a piece. Zilog claims that it is currently supplying 60% of the Z80 market, that Mostek supplies 20%, and that SGS and Sharp chip in the remaining 10%. Zilog expects to ship about 6 million Z80s this year, up from 4 million last year. This means that about 10 million Z80s will be sold this year.

Dataquest, a market-research outfit, recently reported that 50% of the new microcomputer products introduced at the recent National Computer Conference contained Z80s. Current Zilog Z80s are rated for 6 MHz and 8 MHz operation. Zilog expects to introduce a low-power CMOS (complementary metal-oxide semiconductor) Z80 next year.

Personal Computer Rebate Offered: Following the example of the auto companies, Texas Instruments inaugurated a $100 rebate on its 99/4A computer, which now retails for $299. This is believed to be an attempt to reduce an inventory rumored at between 40,000 and 50,000 units. It also steps up the price war that has developed in the low-cost consumer-oriented segment of the personal computer market. It is likely that Commodore, Atari, and Tandy will respond with a new round of price cuts if Christmas sales begin to falter.

Tandy Broadens Distribution Via Dealers: Bowing to the increased competition in the low-end personal computer arena, Tandy (Radio Shack's parent company) has authorized 60 RCA consumer-product distributors to market the TRS-80 Color Computer (it will be called the TDP System 100 and its enclosure will be white instead of grey) through about 2000 independent dealers. This should put Tandy in a better position to compete against Texas Instruments, Atari, Commodore, and Timex, which have lined up such mass merchandisers as K-Mart and Sears Roebuck. This should provide an incentive for independent software developers to write software for the machine. It's likely that Tandy will distribute some other low-end computer products through this network.

Latest 32-Bit Microprocessor News: The June 1982 issue of *Computer Architecture News* reported on some benchmarks recently run at Berkeley comparing the latest microprocessors with Digital Equipment Corporation's VAX, a popular and powerful minicomputer. The results, expressed in fractions of a VAX, are that Intel's iAPX-432, a 32-bit, 4-MHz, multiple-chip processor, is equal to 0.05 VAX; Intel's 8086, running at 5 MHz, is equal to 0.4 VAX; and Motorola's 68000, at 8 MHz, is equal to 0.6 VAX and, at 16 MHz, it's 1.75 VAX.

Several universities already have systems based on Intel's iAPX-432 running and are developing software. A group at the University of Washington is developing an object-oriented language/operating system designed to run on one to four 432 microprocessors and to be a network component. The project, called Eden, is intended to build a powerful environment for computer-science research.

Intel is rumored to be redesigning the 432 so that it will be faster and easier to make; this probably involves some changes in the processor's architecture. Intel has also launched an intensive effort to design the iAPX-386, a

32-bit microprocessor that will be upward-compatible with the 16-bit 8086 and its successors, the 80816 and 80286. This move is in response to the strategy of Motorola, National, and Zilog, whose forthcoming 32-bit processors will be software-compatible with their 16-bit processors.

Elite Corporation, Wichita Kansas, is believed to be the first company to announce a system based on the new National Semiconductor 16032 microprocessor (a multiple-chip set). A desk-top system using the Motorola VME bus, Elite's computer system will have a $12,400 base price.

AMD (Advanced Micro Devices), currently a second source for many Zilog microprocessors, has announced that it will not second-source Zilog's forthcoming 32-bit Z8000 microprocessor. Rather, it will second-source Intel's new 32-bit iAPX-386.

DEC has introduced a 16-bit microprocessor with 32-bit architecture, called the Micro/J-11. Its software is compatible the firm's PDP-11 minicomputer and contains on-board memory management to address up to 4 megabytes of memory.

Bubble Memory Growing in Popularity: With the introduction of several portable microcomputer systems, the demand for bubble-memory devices has increased dramatically. The result is that Intel is reportedly increasing production capacity for bubble-memory devices. Intel's bubble-memory facility is working around the clock, in three shifts, trying to keep up with the increasing demand. Motorola and Intel have signed a 5-year pact to jointly develop a new generation of bubble devices with a common pinout and a standard architecture. The first device will have a capacity of 1 megabit, and it will be followed by a 4-megabit device.

Motorola will second-source Intel's current line of bubble-memory devices. This will be Intel's first second source and Motorola's third attempt at second-sourcing bubble memories. Motorola had previously entered into agreements with Rockwell International and National Semiconductor, only to have these companies abandon the bubble-memory business. Intel has also been discussing second-sourcing with Hitachi.

EEPROMS and Adaptive Microprocessors: Intel, Seeq, General Instrument, National Semiconductor, and Hitachi are expected to begin shipping 16K-byte EEPROMS (electrically erasable programmable read-only memories) that require only a 5-volt power supply. This may signal the beginning of the end for ultraviolet-erasable EPROMs (most PROMs used today are programmed electrically, but must be exposed to ultraviolet light to be erased). EEPROMs are expected to sell for 8 to 10 times the cost of today's EPROMs, but they should drop to about twice the EPROM's price by 1985. Sometime next year, 32K-bit EEPROMs should become available, and 64K-bit devices should appear in 1985. Seeq has disclosed that it plans to introduce a 256K-bit CMOS (complementary metal-oxide semiconductor) part in 1985 and will then move on to a 1-megabit CMOS device.

Current EEPROM devices are so expensive because the EE (electrically erasable) memory cell is about 4 times as large as the modern EPROM's memory cell. Manufacturing EE devices is considered the most complex semiconductor process today; however, some of the cost is offset by the fact that EEPROMs can be housed in low-cost plastic packages, while EPROMs must be housed in ceramic packages with an expensive quartz window.

Seeq also expects to introduce an EEPROM-backed version of Zilog's Z8 microprocessor, which, in effect, creates an adaptive microprocessor that can learn, remember, and change its microcode. Presently, microprocessors are not capable of doing anything other than what the designer thought of beforehand.

CP/M Versus Unix: Finally, we are beginning to see microcomputers being sold with Unix as the standard operating system. Western Electric does not permit other companies to use the name Unix, even though many have Unix licenses. One example of that is the Xenix operating system, which was developed by Microsoft under a license from Western Electric. Microsoft claims that Xenix is an enhanced version of Unix. Naturally, people are beginning to compare the price and performance against other 8-bit disk operating systems such as Digital Research's CP/M and MP/M, a multiuser version of CP/M.

Several trends are emerging from these comparisons. For example, 16-bit Unix systems have base prices of more than $10,000 and, in typical multiuser configurations, may cost $20,000 or more. On the other hand, multiuser CP/M-based systems (MP/M) usually cost less than half of that. Microsoft is rumored working on a Unix system for the Radio Shack Model 16 (a version of the TRS-80 Model II that has both 16- and 8-bit processors); the operating system will accommodate three users. This is the least expensive Unix/68000 combination in sight.

CP/M, a single-user operating system, was created in 1974. It was designed to run with memory systems as small as 16K bytes, so it was engineered to take up only 6K bytes of memory. It has grown in size, and version 3, due for release shortly (with added features), will be a little larger still, having been designed to run in systems that average 48K bytes or larger. In turn, CP/M-based applications software runs very nicely in small-memory systems (we are at the point today where anything less than the 64K-byte maximum of most 8-bit machines is considered small memory).

Unix systems, however, require several times more memory (16 bits wide). It is not uncommon for Unix operating systems to occupy more than 50K words (100K bytes) of memory. Hence, Unix systems characteristically require a minimum of 128K words, and most Unix suppliers recommend a minimum of 256K, which accounts for a good deal of the increased cost.

The operating speed of the multiuser Unix-like systems now available leaves something to be desired in terms of response time. The problem appears to be a combination of the large amount of operating-system code being executed and the fact that most of the work is handled by one processor. Suppliers are trying to cope with this by introducing a second processor, typically a Z80, to manage all I/O operations. Math processors and memory-management devices are used to off-load these tasks from the main processor. Both Motorola and Intel will soon have versions of their 16-bit processors with virtual-memory-management facilities to improve multiuser performance. These approaches, coupled with additional fine tuning of the software, are expected to improve the performance of 16-bit Unix systems. In the meantime, 8-bit multiuser systems have also been improved.

The great popularity of CP/M is directly attributable to the huge amount of applications software available for it (much in the public domain). Another factor is a disk-format standard (8-inch single-density) that lets CP/M users exchange software without hassles and allows commercial suppliers to easily distribute CP/M-based software. Although a large body of Unix-based applications software had been developed at universities, little of this has yet been transported to 16-bit Unix systems. Additionally, the lack of a disk-format standard and differences between various Unix operating systems not only makes exchanging software difficult but vendors have trouble selling software for these systems. The system purchaser must, therefore, rely on a supplier for his or her software needs. At this time and for the near future, the result is that an applications-software void for these systems exists. I expect that it will take a long time to fill that void.

The Unix user interface leaves a great deal to be desired, according to some views. It has difficulties with consistency and command syntax and it lacks prompts and helpful error messages. To a great extent, this is also true of CP/M. Both systems were originally intended to serve system and software developers in scientific and engineering communities. The expectation now is that Unix systems will be used in business and commercial applications. Some Unix-system suppliers are attempting to cope with the problem by adding menu screens. They also plan to overcome Unix's lack of security by adding record- and file-locking schemes. This, however, will result in a lack of consistency among different Unix implementations.

Multiuser, Multiprocessor Systems Flourishing: On several occasions, I have expressed concern over the slow operation of multiuser (timesharing) microcomputer systems. This sluggishness is a by-product of the traditional way of using a single processor to handle multiple users. With each additional user, the processor must work harder, and it quickly reaches what some call the "Von Neumann bottleneck": the computer processes instructions serially at a finite speed, so as different users' work is switched in and out of memory, the system appears to slow down.

The alternate approach, which is rapidly gaining popularity, is to use multiple processors on a common bus so that each user has his or her own processor and memory. Each user shares resources via the bus and has access to facilities such as the disk system and printer. In effect, this creates a network of processors within one computer system. Each user is effectively independent of the bus except when he or she wishes to communicate with other users or peripheral devices by means of the bus. Such systems are already in operation on Z80-based computers using the S-100 bus (also known by its IEEE-696 standard specification) using CP/M, CP/NET, and TurboDOS and on a new system from Colonial Data Services. In operation, they have already proved to have a better performance record than most multiuser computers with single 16-bit processors.

Where Is The Japanese Microcomputer Invasion? The Japanese have long been expected to become a major force in the American personal computer marketplace. This has yet to develop, and many marketing experts are wondering why. About 70 companies are already manufacturing personal and small-business computers in Japan but, as yet, less than 20 are exporting products to the U. S.

Those companies that have introduced systems into the U. S. market have done so in a very low-keyed and cautious manner. Some have shown systems at trade shows but have not yet begun selling them. A number of industry analysts speculate that the Japanese are testing the American market and experimenting with different forms of hardware and software. Although the hardware is being designed and manufactured in Japan, the software, in most cases, is of American origin. This is particularly true in respect to operating systems, languages, and business programs. The Japanese are, however, proving quite original in creating computer games.

The Japanese may not make major inroads into the American personal computer market for another year or two (or possibly three?). Some market analysts are predicting that in 5 years the Japanese will control half of the American personal computer market. This prediction is based on the assumption that such companies as Sony, NEC, Sanyo, Hitachi, and Matsushita Electric (maker of Technics and Panasonic equipment) will capitalize on their tremendous marketing capabilities.

Asian Copying Situation Worsens: Apple Computer is actively combating the production of illegal copies of the Apple II in the Far East by filing court suits against companies in New Zealand, Taiwan, and Hong Kong. So far, these suits do not appear to have had any effect, because the copied computers are becoming increasingly available in Far Eastern countries. In Indonesia and Singapore, reportedly swarming with bogus Apples, prices are said to be as low as $500.

Counterfeit Apples can be purchased assembled, in kit form, and even as bare printed-circuit boards, without integrated circuits. The boards are identical to the genuine Apple II board, with the exception that the ROM (read-only memory) sockets have been reconfigured to accept standard 2716-type EPROMs (erasable programmable ROMs). Peripherals such as the 80-column video cards, Microsoft's Softcard (with the Z80 microprocessor), language cards, and so on are being copied too. Tandy has also filed suit against a number of Hong Kong firms for copying TRS-80 firmware. The situation with software is reportedly worse: virtually any game can be bought for $0.50 above the cost of a blank floppy disk and popular business-applications software is being sold at tremendous discounts.

TV And Movies Turning To Computer Graphics: Television stations and movie studios have discovered that computer-generated images expand creative horizons and, in many cases, reduce production costs. TV studios are using more and more computer graphics to animate commercials, create channel logos, and to zoom program titles into place or put them through wondrous transformations.

Movie studios are using computers to create backgrounds for scenes, as well as for special effects. Instead of building full-size props or miniature models, computers now generate three-dimensional images, and the live action is then superimposed on the backdrop images photographically. The images are produced on color video screens having upwards of 2 million pixels (picture elements) and then captured on film. Movement is animated on a theater screen by flashing a sequence of thousands of images, with each being slightly different from the preceding one. Previously, each of the images had to be individually made by an artist, but now the computer quickly and easily constructs each frame at substantially less cost.

Hotline For The Disabled: SIGCAPH (Special Interest Group on Computers and the Physically Handicapped), a subgroup of the ACM (Association for Computing Machinery), has set up a hotline for people seeking information on computer and high-technology aids for the blind, deaf, or motor impaired. The number is (503) 357-4354.

Computer To Pinch Car Thieves: Great Britain's Home Office, Scientific Research and Development Branch, has developed a system in which a TV camera is linked to a computer that contains the latest data on stolen cars. As a car passes by the camera, the computer reads its license plate, determines if the car is stolen, and alerts the police to a stolen vehicle within seconds. A prototype has already been demonstrated, and the Home Office expects the system to be in operation soon.

Customs Service Impounds Chess Computer: Intent on stopping the flow of sensitive technology to the Soviet Union, the U. S. Customs Service recently seized and impounded Belle, the world-champion chess computer. Ken Thompson, the Bell Laboratories scientist who built Belle, was taking it to Moscow for a chess exhibition at the time. The Commerce Department said that Belle, winner of the 1980 World Computer-Chess Championship tournament, might be of military use to Moscow.

When asked to comment, Thompson said, "the thing plays chess . . . that's all." He added that the only way it could be used militarily would be "to drop it out of an airplane. You might kill somebody that way."

A Commerce Department spokesman said Thompson would be subject to a penalty for violation of the Export Control Act. The penalty ranges from a cash fine to losing the computer altogether.

Thompson, noting that all the parts used in Belle are easily purchased in this country, added, "I just don't see the point of all this."

Random News Bits: Centronics, which originally slated the introduction of its Quietwriter printer for the spring of 1981, has begun showing the unit to potential customers, but still hasn't given any word on delivery. The Quietwriter uses a stylus to print in much the same manner that a human uses a pen to write on paper. . . . Atari recently introduced ERIC (Electronic Retail Information Center), really a "computer salesperson" consisting of an Atari 800 tied to a videodisc player. It asks prospective customers to answer a few questions, then it selects one of 13 different sales presentations on the disk. . . . Zilog has begun providing samples of the Z8003 and Z8004, enhanced versions of the Z8001 and Z8002. When used with the Z8015 paged MMU (memory-management unit), the new microprocessors will give the processors paged virtual-memory capability. . . . Computerland Corporation and Kanematsu-Gosho Limited, Tokyo, have entered into an agreement to open Computerland stores in Japan. Ten stores are expected to be opened next year, with an eventual total of 250 planned. Currently, there are a little more than 800 computer stores in Japan, most of which are geared toward the hobbyist. . . . Consumers Union, publisher of *Consumer Reports*, is reportedly working on a study of personal computers. . . . IBM is selling a 68000-based system via its recently acquired Danbury, Connecticut, subsidiary, IBM Instruments. The computer uses the Versabus and comes with a multitasking operating system. Price is $5700. . . . Did you know that there are almost 600 database systems accessible to computer users by telephone and that the number of systems is growing at a very healthy rate? The *Directory of Online Data-bases*, from Cuadra Associates, Santa Monica, California, lists them all.

Quotation Of The Month: "Eight Things Your Computer Won't Do: 1) A computer won't save you money. 2) A computer won't make your organization run right. 3) A computer won't solve every problem. 4) A computer won't run itself. 5) A computer won't always be right. 6) A computer won't protect itself. 7) A computer won't meet all its own needs. 8) A computer won't become obsolete." Joe Makower, "Plugging Into The New Computers," *Eastern Review*, June 1982, published by East/West Networks.

MAIL: I receive a large number of letters each month as a result of this column. If you write to me and wish a response, please include a self-addressed, stamped envelope.

Sol Libes
POB 1192
Mountainside, NJ 07092

Books Received

Amateur Radio: Theory and Practice, Robert L. Shrader. New York: Gregg/McGraw-Hill, 1982; 340 pages, 18.5 by 23.5 cm, softcover, ISBN 0-07-057146-5, $14.95.

Basic BASIC-English Dictionary for the Apple, PET, and TRS-80, Larry Noonan. Beaverton, OR: Dilithium Press, 1982; 147 pages, 14 by 26.3 cm, softcover, ISBN 0-918398-54-1, $10.95.

The BASIC Conversions Handbook for Apple, TRS-80, and PET Users, David A. Brain, Philip R. Oviate, Paul J. A. Paquin, and Chandler D. Stone Jr. Rochelle Park, NJ: Hayden Book Co., 1981; 80 pages, 14.6 by 22.6 cm, softcover, ISBN 0-8104-5534-X, $7.95.

BASIC for Beginners, William E. Conley. Princeton, NJ: Petrocelli Books, 1982; 162 pages, 13.8 by 20.8 cm, softcover, ISBN 0-89433-141-8, $9.95.

Building Effective Decision Support, Ralph H. Sprague Jr. and Eric D. Carlson. Englewood Cliffs, NJ: Prentice-Hall, 1982; 329 pages, 15.5 by 23.5 cm, hardcover, ISBN 0-13-086215-0, $24.95.

Color Graphics for Intecolor 3651 and Compucolor II Computers, David B. Suits. Hilton, NY: Joseph J. Charles Publishing (POB 750), 1981; 152 pages, 21.5 by 27.5 cm, softcover, ISBN 0-9607080-1-4, $15.

Computer Awareness Book, 2nd edition, Donald D. Spencer. Ormond Beach, FL: Camelot Publishing Co., 1982; 32 pages, 21.5 by 28 cm, softcover, ISBN 0-89218-051-X, $2.90.

Computer Science, David Woodhouse, Greg Johnstone, and Ann McDougall. Milton, Queensland, Australia: Jacaranda Wiley Ltd. (65 Park Rd.), 1982; 612 pages, 18.3 by 24.6 cm, softcover, ISBN 0-471-33389-1, $14.94 (Aus.).

The Custom TRS-80 & Other Mysteries, Dennis Bathory Kitsz. Upland, CA: IJG Computer Services (1260 West Foothill Blvd.), 1982; 335 pages, 21 by 27.5 cm, softcover, ISBN 0-936200-02-2, $29.95.

Design and Analysis of Computer Communication Networks, Vijay Ahuja. New York: McGraw-Hill, 1982; 306 pages, 16.5 by 24.5 cm, hardcover, ISBN 0-07-000697-0, $29.95.

Electronics for the Modern Scientist, Paul B. Brown, Gunter N. Franz, and Howard Moraff. New York: Elservier North-Holland Co., 1982; 496 pages, 18 by 26 cm, hardcover, ISBN 0-444-00660-5, $29.95.

File and Data Base Techniques, James Bradley. New York: Holt, Rinehart & Winston, 1982; 562 pages, 18.1 by 24.2 cm, hardcover, ISBN 0-03-058673-9, $27.95.

A First Course in Computer Programming Using Pascal, Arthur Keller. New York: McGraw-Hill, 1982; 306 pages, 21.5 by 27.9 cm, softcover, ISBN 0-07-033508-7, $14.95.

Games for the Atari, S. Roberts. Pomona, CA: Elcomp Publishing Inc. (53 Redrock Lane), 1982; 115 pages, 13.5 by 20.9 cm, softcover, ISBN 3-911682-84-3, $7.95.

Handbook of Cubik Math, Alexander H. Frey Jr. and David Singmaster. Hillside, NJ: Enslow Publishers (POB 777), 1982; 193 pages, 15.2 by 23 cm, softcover, ISBN 0-

a message to our subscribers

From time to time we make the BYTE subscriber list available to other companies who wish to send our subscribers promotional material about their products. We take great care to screen these companies, choosing only those who are reputable, and whose products, services or information we feel would be of interest to you. Direct mail is an efficient medium for presenting the latest personal computer goods and services to our subscribers.

Many BYTE subscribers appreciate this controlled use of our mailing list, and look forward to finding information of interest to them in the mail. Used are our subscribers' names and addresses only (no other information we may have is ever given).

While we believe the distribution of this information is of benefit to our subscribers, we firmly respect the wishes of any subscriber who does not want to receive such promotional literature. Should you wish to restrict the use of your name, simply send your request to the following address.
BYTE Publications Inc
Attn: Circulation Department
70 Main St
Peterborough NH
03458

89490-058-7, $9.95.

How to Solve Statistical Problems with Your Pocket Calculator, Vicki F. Sharp. Blue Ridge Summit, PA: Tab Books, 1982; 257 pages, 12.6 by 20.7 cm, softcover, ISBN 0-8306-1303-X, $8.95.

IBM's Personal Computer, Chris DeVoney and Richard Summe. Indianapolis, IN: Que Corp. (6515 East 82nd St.), 1982; 320 pages, 18.9 by 23.5 cm, ISBN 0-88022-100-3, $14.95.

Industrial Electronics: A Text-Lab Manual, 3rd edition, Paul B. Zbar. New York: Gregg/McGraw-Hill, 1981; 278 pages, 21 by 28 cm, softcover, ISBN 0-07-072793-7, $12.95.

Information and Communication Technology for the Community, 2nd edition, Steve Johnson. Portland, OR: Rain Community Resources (2270 Northwest Irving St.), 1982; 33 pages, 21.5 by 27.2 cm, softcover, ISBN-none, $6.

Interfacing to S-100/IEEE 696 Microcomputers, Sol Libes and Mark Garetz. Berkeley, CA: Osborne/McGraw-Hill, 1981; 321 pages, 16 by 23.5 cm, softcover, ISBN 0-931988-37-3, $15.

Introduction to Computers, 2nd edition, Alton R. Kindred. Englewood Cliffs, NJ: Prentice-Hall, 1982; 542 pages, 17.5 by 23.5 cm, softcover, ISBN 0-13-480079-6, $18.95.

An Introduction to Microcomputers, Volumne 0: The Beginner's Book, 3rd edition, Adam Osborne and David Bunnell. Berkeley, CA: Osborne/McGraw-Hill, 1982; 233 pages, 16.7 by 23.3 cm, softcover, ISBN 0-931988-64-0, $12.50.

Introduction to Simulation: Programming Techniques and Methods of Analysis, James A. Payne. New York: McGraw-Hill, 1982; 324 pages, 16.4 by 24.2 cm, hardcover, ISBN 0-07-048945-9, $27.95.

Managing the System Life Cycle, A Software Development Methodology Overview, Edward Yourdon. New York: Yourdon Press, 1982; 144 pages, 17.7 by 25.3 cm, softcover, ISBN 0-917072-26-X, $27.

The Master Handbook of IC Circuits, Thomas R. Powers. Blue Ridge Summit, PA: Tab Books, 1982; 532 pages, 12.6 by 20.7 cm, softcover, ISBN 0-8306-1370-6, $14.95.

Microcomputer Math, William Barden Jr. Indianapolis, IN: Howard W. Sams & Co., 1982; 128 pages, 13.5 by 21.5 cm, softcover, ISBN 0-672-21927-1, $11.95.

Microprocessor Interfacing, Joseph J. Carr. Blue Ridge Summit, PA: Tab Books, 1982; 246 pages, 12.6 by 20.7 cm, softcover, ISBN 0-8306-1396-X, $7.95.

Pascal Programming, A Spiral Approach, Walter S. Brainerd, Charles H. Goldberg, and Jonathan L. Gross. San Francisco, CA: Boyd & Fraser Publishing, 1982; 584 pages, 20.2 by 25.2 cm, softcover, ISBN 0-87835-122-1, $17.95.

Personal Computing, 2nd edition, Daniel R. McGlynn, New York: John Wiley & Sons, 1982; 335 pages, 17 by 25.3 cm, softcover, ISBN 0-471-86164-2, $14.95.

The Pocket Guide of Computer Terminology, Donald D. Spencer. Ormond Beach, FL: Camelot Publishing Co., 1982; 16 pages, 10.7 by 28 cm, softcover, ISBN 0-89218-066-8, softcover, $1.25.

Programming the PET/CBM, The Reference Encyclopedia for Commodore PET & CBM Users, Raeto Collin West. Greensboro, NC: Compute! Books, 1982; 504 pages, 18.7 by 25.8 cm, softcover, ISBN 0-942386-04-3, $24.95.

Projects in Machine Intelligence for Your Home Computer, David L. Heiserman. Blue Ridge Summit, PA: Tab Books, 1982; 337 pages, 12.6 by 20.7 cm, softcover, ISBN 0-8306-1391-9, $9.95.

6502 Assembly Language Subroutines, Lance A. Leventhal and Winthrop Saville. Berkeley, CA: Osborne/McGraw-Hill, 1982; 550 pages, 18.5 by 23.5 cm, softcover, ISBN 0-931988-59-4, $15.95.

Structured FORTRAN 77 Programming, Seymour V. Pollack. San Francisco, CA: Boyd & Fraser Publishing, 1982; 496 pages, 21.6 by 27.7 cm, softcover, ISBN 0-87835-095-0, $17.95.

Swift's 1982 Educational Software Directory, Apple II Edition. Austin, TX: Sterling Swift Publishing Co., 1982; 358 pages, 14 by 21.5 cm, spiral binder, ISBN 0-88408-150-8, $14.95.

The Theory and Practice of Reliable System Design, Daniel P. Siewiorek and Robert S. Swarz. Bedford, MA: Digital Press, 1982; 772 pages, 19 by 24 cm, ISBN 0-932376-13-4, $55.

Understanding Computer Systems, Harold W. Lawson Jr. Rockville, MD: Computer Science Press, 1982; 164 pages, 17.2 by 25.4 cm, softcover, ISBN 0-914894-31-5, $9.95.

Using Personal Computers in the Church, Kenneth Bedell. Valley Forge, PA: Judson Press, 1982; 109 pages, 13.8 by 21.4 cm, softcover, ISBN 0-8170-0948-5, $6.95.

Visicalc for the TRS-80 Model II and Model 16 Computers, E. J. Desautels. Dubuque, IA: Wm. C. Brown Co., 1982; 144 pages, 22 by 27.9 cm, spiral binder, ISBN 0-697-09955-5, $16.95.

Visicalc: Home and Office Companion, David M. Castlewitz, Lawrence J. Chisausky, and Patricia Kronberg. Berkeley, CA: Osborne/McGraw-Hill, 1982; 181 pages, 21.2 by 27.5 cm, softcover, ISBN 0-931988-50-0, $15.99.

What to Do When You Get Your Hands on a Microcomputer, Charles P. Holtzman. Blue Ridge Summit, PA: Tab Books, 1982; 188 pages, 17.6 by 25.3 cm, softcover, ISBN 0-8306-1397-8, $10.95.

The Wonders of Magic Squares, Jim Moran. New York: Vintage Books, 1982; 227 pages, 21.5 by 27.5 cm, softcover, ISBN 0-394-74798-4, $5.95.

Working Robots, Fred D'Ignazio. New York: Elsevier/Nelson, 1982; 149 pages, 15.5 by 23.5 cm, hardcover, ISBN 0-525-66740-7, $11.50.

Writings of the Revolution, Edward Yourdon, ed. New York: Yourdon Press, 1982; 460 pages, 21 by 27.5 cm, softcover, ISBN 0-917072-25-1, $30. ■

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.

Powerful... because it's Relational

The new RL-1 Database® from ABW Corporation gives you the power of a sophisticated relational database management system for your IBM Personal Computer*, Cromemco*, or CP/M* computer.

Why a Data Base Management System?

Whether your business is accounting, engineering, or production your main use of a computer is to maintain and process information. A Data Base Management System allows that information to be maintained independent of a particular application. Different programs can easily process the same data without modification or data re-entry.

Why Relational?

The relational model presents data in simple, easy to use tables. The simplicity and power of this tabular form allows the user to answer complicated questions by learning only three operations: Selection, Projection, and Join.

The RL-1 System Includes:

Relational Data Base
A complete implementation of a relational data base.

Query Language
An interactive high level query language, similar to SQL. This query language uses simple English phrases for the operations selection, projection, and join. Thus, even the novice user can easily ask sophisticated questions.

Relational Editor
A screen oriented editor to create, delete, and update your data files.

Program Interface
Allows you to access the data base through high level language programs.

File Transfer Programs
Utility programs to assist the user in transferring to/from existing programs and other machines.

These five packages allow you to create and maintain a sophisticated data base system for many diverse applications.

Application Packs

To assist the user several application packages will soon be available for use with the RL-1 system.

Report Generator
Automatically formats data from multiple files for report generation.

Input Processor
Allows user to input data via custom designed "forms" for easy operator entry.

General Ledger
Includes General Journal, Posting to Accounts, Trial Balance, Balance Sheet, and Income Statement.

Accounts Receivable
Generates invoices and statements. Handles aging of accounts receivable.

Accounts Payable
Handles checks, check register, vouchers, and vendor files.

Payroll
Processes 940, 941, and W-2 forms. Maintains employee files and payroll register.

Inventory and Production Control
Maintains inventory status and current price lists. Generates reorder report, bill of materials, etc.

Executive Planner
Assists in the generation of business plans and projections. Allows for optimization of key parameters.

Graphics Processor
Allows data to be displayed graphically. Compatible drivers for the IBM Personal Computer, Cromemco SDI, Tektronix* 4010, Houston Instruments DMP* plotters, and many others.

RL-1 is available for IBM DOS, Cromix, CDOS, and CP/M system for only $495.† Application Packs at additional costs.

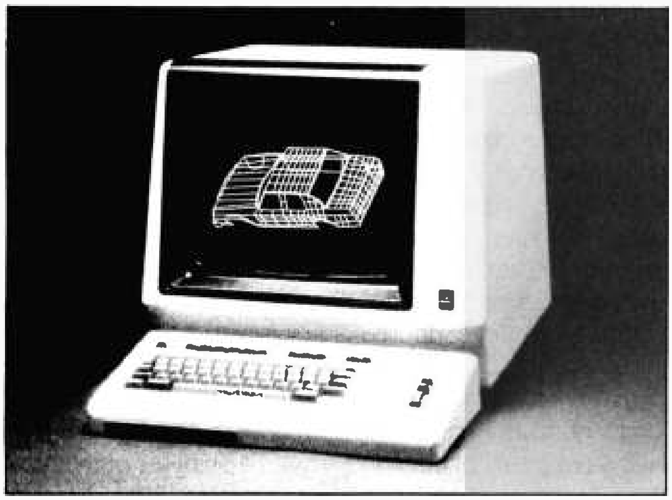
RL-1®
RELATIONAL DATA BASE

For further information contact:
ABW Corporation
P.O. Box M1047
Ann Arbor, MI 48106
(313) 971-9364

ABW CORPORATION

Circle 8 on inquiry card.

Graphics



Graphics Terminals

The NJC-M1401 series of graphics terminals from Nippon Computer Company can mix graphics with text. Standard features include RS-232C- and Centronics-compatible 8-bit parallel ports, 274K bytes of memory, a 14-inch raster-scan display, 1032- by 780-dot picture resolution, and compatibility with the Tektronix Plot 10. Plotting commands supplied include point, straight line, circle, ellipse, elliptical arc, grid, oblong, polygon, and symbol. Standard control commands include virtual window, fact, rotor, and mode. Full specifications are available from Nippon Computer Co. Ltd., Naito Building, Nihonbashi Hamacho 2-25-1, Chuo-ku, Tokyo, Japan 103.

Circle 600 on inquiry card.

Graphics Presentation Tool

Plotstar is a graphics presentation tool from Covington Computer Sales Ltd. Designed for CP/M-based systems and the IBM Personal Computer, Plotstar lets you prepare graphs for use in business and scientific presentations. It has the ability to mix graphics with word processing for report preparation and it uses existing accounting and statistical information to prepare graphs.

Plotstar costs $975. For the name and address of your nearest Plotstar dealer, contact Covington Computer Sales Ltd., 269 Pleasant Park Rd., Ottawa, Ontario K1H 5M7, Canada, (514) 337-0844.

Circle 601 on inquiry card.

Two Graphics Products Marketed by Peachtree

The PGL (Peachtree Graphics Language) interactive graphics programming language and the Business Graphics System are being marketed by Peachtree Software. PGL lets you create high-precision text, graphs, and bar charts in both color and black-and-white. It includes two- and three-dimensional graphics transformations and features multiple exploded pie-chart segments, zooming, panning, strip-chart scrolling, multiple independent graphs, rotation, and annotation. Many popular digitizers, light pens, cursor keys, and joysticks are supported. Its price is $600.

The Business Graphics System is a menu-driven graphics-applications program for CP/M-based microcomputers. It can be used to develop presentation graphics such as transparencies, slides, business charts, and graphs. A presentation designed by the Business Graphics System can contain any combination of bar and pie charts, line and area graphs, and word charts using as many as seven character fonts. It's supplied with an interface to the company's Peachcalc electronic spreadsheet and to the Peachtext word processor. The suggested retail price is $400. Contact Peachtree Software Inc., 3445 Peachtree Rd. NE, Atlanta, GA 30326, (404) 239-3000.

Circle 602 on inquiry card.

Easy-to-Use Business Graphics

The Redding Group designed its fully interactive Graftalk graphics package for business users. Graftalk can make bar charts, pie charts, and line and symbol charts on most CP/M-based microcomputers equipped with graphics devices and color or black-and-white monitors. Graftalk features English-language commands and an install procedure to configure the program to your microcomputer and graphics devices: screens, printers, or plotters. Graph characteristics are adjustable through simple commands, and Graftalk lets you design graphics using more sophisticated commands, ranging from moves and draws to windows and viewports. Graftalk lets you execute commands in three ways: typed in for execution, collected in the built-in editor's workspace and executed in a sequence, or collected and run as a file from a disk. For most business graphics, knowledge of Graftalk's more complex commands is not required.

Graftalk requires that data be entered in the form of a table of numbers. Data tables can be entered while you are using Graftalk or tables can be stored on disk. The price is $450. Full details are available from the Redding Group Inc., 609 Main St., Ridgefield, CT 06877.

Circle 603 on inquiry card.

Graphics Generator

The RG-GG7 is a two-board Multibus-compatible graphics generator from Raster Graphics. It has a 512 (horizontal) by 480 (vertical) display format, and it provides you with dual refresh memories, refresh-memory readback, light-pen interface, vertical scrolling, and a 4K-byte dual-port RAM (random-access read/write memory) for instruction storage. Other standard features include text and graphics, rectangular fill, selective erase, circles, variable-size characters, bold characters, point-to-point draw for coordinate list, and RS-170 composite video and TTL (transistor-transistor logic) output signals. RG-GG7 can be configured for red/green/blue or for black-and-white use.

The RG-GG7 costs $1295. Further details are available from Raster Graphics, POB 23334, Tigard, OR 97223, (503) 620-2241.

Circle 604 on inquiry card.

Full-Color Video Film Recorder

Polaroid's Videoprinter Model 8 is an 8 by 10 color-film recorder that transforms video signals into full-color instant photographs. The microprocessor-controlled display produces continuous-tone Polaroid 8- by 10-inch overhead transparencies and prints of computer or video images. The system has automatic settings for brightness, contrast, and color balance, all of which are manually adjustable. The Videoprinter measures 24 by 16 by 25 inches and weighs 50 pounds.

The Model 8 Videoprinter has a suggested retail price of approximately $6000. For further details, contact Polaroid Industrial Marketing, 575 Technology Square, Cambridge, MA 02139, (800) 225-1618; in Massachusetts, call collect (617) 547-1577.

Circle 605 on inquiry card.

RGB Board for Apple

A video board that provides the Apple II with composite synchronization signals for any RGB (red/green/blue) monitor is available from Video Marketing. The board can be used with the 80-character Videx card, so you can display both color graphics and 80-column text on the same monitor. The board plugs into Apple slot 7 and permits text-page displays in one of eight colors. Measuring 4¼ by 2¾ inches, the board's output signals are +TTL (transistor-transistor logic), and its composite signals are −TTL.

The board comes with gold edge contacts and 5 feet of five-conductor ribbon cable for signal output. It costs $179 and is available from Video Marketing Inc., POB 339, Warrington, PA 18976, (215) 343-3000.

Circle 606 on inquiry card.

Cursor-Control Option

The Cross Hair Cursor option from Selanar Corporation is fully compatible with the company's graphics enhancements for alphanumeric terminals. This multifunction control pad consists of a pressure-sensitive keypad with eight directional keys, six mode-selection keys, and two user-definable function-control keys. Keys supplied include term and graph clear, print, term mode, jump, and fast. The Cross Hair Cursor can operate in the Tektronix Emulation mode. It measures 4 by 6 inches.

The Cross Hair Cursor is provided with a 36-inch cable that connects it to the Selanar Graphics board through the terminal. The suggested list price is $250. For complete details on graphics boards and the Cross Hair Cursor, contact Selanar Corp., 437-A Aldo Ave., Santa Clara, CA 95050, (408) 727-2811.

Circle 607 on inquiry card.

Graphics Package Has Got a Secret

Avant-Garde Creations' Hi-Res Secrets Graphics Applications System, by Don Fudge, is designed to show you what's needed to create marketable graphics programs. Based on the Apple Hi-Res Secrets package, Graphics Applications extends that package by leading you step by step through procedures that explain how faster and better high-resolution BASIC and assembly-language graphics programs can be designed. Procedures provided include business graphs, electronic and architectural design, arcade and adventure game creation, three-dimensional shapes, scene creation, shape drawing, and shape and scene saving.

The Hi-Res Secrets Graphics Applications System is composed of three unprotected disks and a manual. An Apple II Plus with 48K bytes of memory is required. The price is $75. Available from Avant-Garde Creations, POB 30160, Eugene, OR 97403, (503) 345-3043.

Circle 608 on inquiry card.

Graphics Processing System

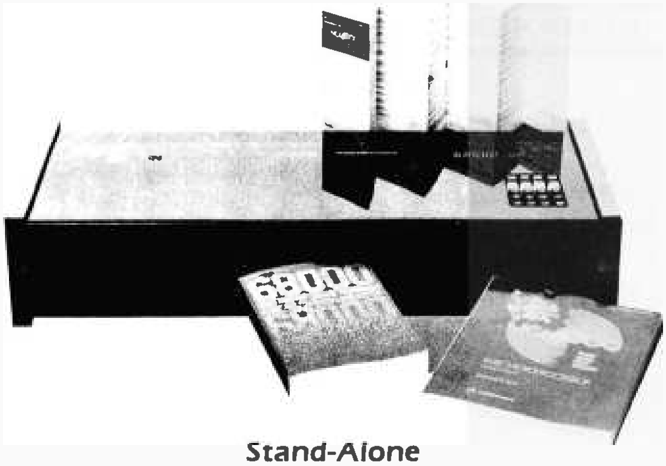
GPS (Graphics Processing System) from Stoneware lets you create, edit, and manipulate images on your Apple II. GPS, which requires any Apple-compatible joystick or paddle, lets you create images with six primary colors. You can draw with and mix any colors. GPS features the ability to work on any scale, 4 and 16 times zoom capabilities, two-dimensional rotation, image enlargement or reduction, and the ability to change proportions horizontally and vertically. Standard text fonts are uppercase.

The Professional GPS is compatible with the Apple

Graphics Tablet, the Symtec Light Pen, and Houston Instrument's Hi-Plot DMP 3, 4, 6, and 7. The Professional GPS has a suggested retail price of $179; the standard version costs $69. GPS is manufactured by Stoneware Inc., 50 Belvedere St., San Rafael, CA 94901, (415) 454-6500.

Circle 609 on inquiry card.

SYSTEMS



Stand-Alone 68000 Trainer

Computer System Associates has introduced a self-contained, MC68000-based training and prototyping system called the Micro 68000. It comes with a 6-amp switching power supply, 20-key keyboard, 28-digit hexadecimal display, 80-bit binary display, and keyboard-monitor program. Micro 68000 permits direct entry of machine-language instructions.

Encased in a wood and clear plastic cabinet, Micro 68000 is available factory-direct for $1495. It's supplied with 68000 Assembly Language Programming by Gerry Kane, Doug Hawkins, and Lance Leventhal (Osborne/McGraw-Hill) and Prentice-Hall's 16-Bit Microprocessor User's Manual. Contact Computer System Associates Inc., 7562 Trade St., San Diego, CA 92121, (714) 566-3911.

Circle 610 on inquiry card.

Multipurpose OEM Boards

National Semiconductor is marketing two versions of a complete, multipurpose, single-board computer designed for OEM (original equipment manufacturer) applications or process-control and custom-testing systems. Designated the BLC-80/24 and the BLC-80/28, both versions support up to 32K bytes of ROM (read-only memory) and are upward-compatible with National's BLC-80/204. Standard features include an 8085A-2 central processor, jumper-selectable 4.8- or 2.4-MHz clock rates, and 48 programmable I/O lines with a single programmable RS-232C serial port. The PL/M-80 programming language is available as an option.

In production quantities, the BLC-80/24 is $945, which includes 4K bytes of RAM (random-access read/write memory). For $1095, the BLC-80/28 provides 8K bytes of RAM. Contact National Semiconductor, 2900 Semiconductor Dr., Santa Clara, CA 95051, (408) 721-5000.

Circle 611 on inquiry card.

Single-Board 68000 Computer

Educational Microcomputer Systems' M-68000 single-board computer kit is based on Motorola's 16-bit 68000 microprocessor. The system operates at 10 MHz and is equipped with 20K bytes of on-board static RAM (random-access read/write memory), 16K bytes of on-board EPROM (erasable programmable read-only memory) space, and five 16-bit counter/timers. Standard features include seven levels of prioritized interrupts, two memory-expansion buses, two RS-232C serial communications ports, a 16-bit bidirectional parallel port, on-board real-time clock, and an on-board hardware protection circuit. The M-68000 is software-compatible with Motorola's MEX68KDM board.

Prices for the M-68000 board begin at $99.95 (bare board). For complete pricing and technical specifications, contact Educational Microcomputer Systems, POB 16115, Irvine, CA 92713, (714) 553-0133.

Circle 612 on inquiry card.

Portable Computer Has Bubble Memory

Teleram's 3000 portable computer features 128K bytes of internal bubble memory. Under CP/M operations, the nonvolatile memory is configured as a drive A. The 3000 has a 4-line by 80-character LCD (liquid-crystal display) window that scrolls up and down a 24-line by 80-character display memory. Other display attributes include a 5 by 7 matrix, 160 displayable characters, and a choice of viewing angles. The 3000's keyboard has 83 keys, 16 of which are user-definable, arranged in a standard typewriter format and a 12-key numeric and cursor keypad. Standard features include a 2.5-MHz Z80L central processor, a serial RS-232C port, 64K bytes of RAM (random-access read/write memory), and 4K bytes of

What's New?

ROM (read-only memory) with bank-switched diagnostics and housekeeping. Power is supplied by batteries that recharge during 9- to 15-volt DC or 110- to 230-volt AC operations.

Options include an expanded 256K-byte memory and an expansion chassis made up of a card cage, up to four 5¼-inch floppy-disk drives, and a display screen. Prices begin at $2995. For additional details, write to Teleram Communications Corp., 2 Corporate Park Dr., White Plains, NY 10604.

Circle 613 on inquiry card.

Winchester Disk Standard with E'Lite

Barrington International Corporation's E'Lite microcomputer has a built-in Irwin 510 5¼-inch Winchester-disk drive for 10 megabytes of formatted data storage. Carrying 64K bytes of RAM (random-access read/write memory), E'Lite uses a 6-MHz Z80B microprocessor and is supplied with built-in controllers for a printer, display monitor, floppy-disk drive, and communications. Standard features include an integral 3-inch cartridge tape backup that, according to Barrington, can copy 10 megabytes of data in 8 minutes and a 2K-byte cache memory. Supplied software is made up of the CP/M operating system, Micropro's Wordstar word processor, an electronic spreadsheet, and the Condor Series 20 database management system, a full relational system.

E'Lite has a suggested retail price of $7995. Dealer inquiries are invited. For more information, contact Barrington International Corp., Suite 4, 738 Airport Blvd., Ann Arbor, MI 48104, (313) 769-7611.

Circle 614 on inquiry card.

6-MHz Super Cadet

The Super Cadet from Integrated Business Computers uses Zilog's 6-MHz Z80B microprocessor. It has a 150-nanosecond RAM (random-access read/write memory) and uses 64K-byte integrated circuits for a total of 256K bytes of memory. Standard features include double-sided double-density floppy-disk drives with voice-coil actuation rather than stepper motors, and switch-selectable MP/M-to-Oasis-to-FAMOS operating systems. The single-board Super Cadet can be expanded to include 10 I/O ports (nine for users, one for a printer), large SMD disk drives, and reel-to-reel or cartridge-tape units.

The basic 64K-byte Super Cadet is available in either a desktop or a rack-mounted unit for $5595. Write or call Integrated Business Computers, 21592 Marilla St., Chatsworth, CA 91311, (213) 882-9007.

Circle 615 on inquiry card.

PERIPHERALS

Bisynchronous Communications for the Apple

IE Systems is marketing a serial synchronous I/O board that lets a CP/M-based Apple II or III communicate with remote computers using bisynchronous protocols. When combined with the bisynchronous software products from Micro-Integration Inc., an Apple can emulate an RJE (remote job entry) terminal using either 3780, 3741, 2780, and 2770 protocols or a 3271/77, 3274/78, 3275, and 3276 bisynchronous device.

The serial I/O board with one bisynchronous software product costs $1195. Dealer discounts are available. For full information on the asynchronous, bisynchronous, and synchronous data-link control software for 8- and 16-bit microcomputers, contact IE Systems Inc., 98 Main St., POB 359, Newmarket, NH 03857, (603) 659-5891.

Circle 616 on inquiry card.

Keyboards Designed for Disabled

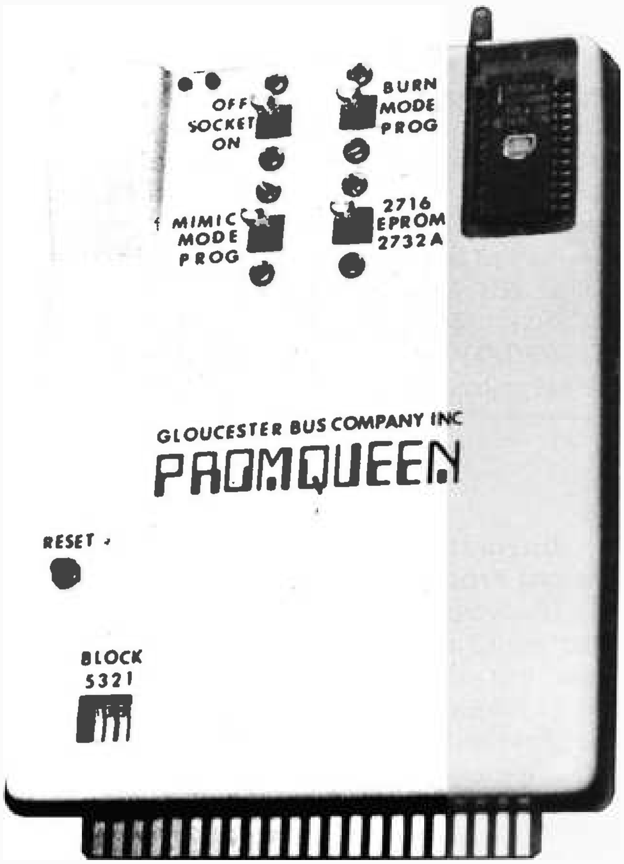
EKEG Electronics Company markets remote and expanded Apple II keyboard attachments for physically disabled individuals. The remote keyboard features an adjustable bracket that lets you mount the board in any position appropriate for the user and joystick and push-button controls. The unit is designed to be easily accessible by means of a mouthstick or headstick and features latching switches on the shift, control, and repeat keys.

The expanded keyboard is designed to accommodate individuals with a variety of disabilities, such as motor or limb dysfunctions, visual impairments, and learning disabilities. The board does not require an external power supply, nor does it interfere with the Apple keyboard's standard operation.

Both keyboards are designed to ignore unintentional movements associated with involuntary tremors. The suggested price for either keyboard is $675. Other expanded keyboards are available for the Sinclair ZX81, the Commodore PET, the Casio Organ, and Texas Instruments' Speak & Spell, Speak & Read, and Speak & Math. Full details are available from EKEG Electronics Co. Ltd., POB 46199, Station G, Vancouver, British Columbia, V6R 4G5, Canada, (604) 685-7817.

Circle 617 on inquiry card.

What's New?



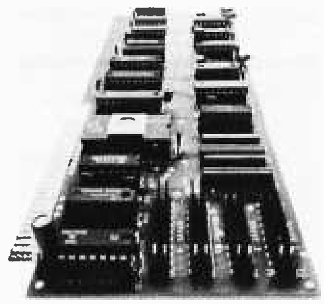
To the VIC Belongs the PROMQueen

The PROMQueen Cartridge from the Gloucester Computer Bus Company provides EPROM programming, operating, and emulating capabilities for the Commodore VIC-20 computer. PROMQueen supports 2716, 2732A, and 2732 EPROMs (erasable programmable read-only memories). A Mimic switch permits an external computer to access programs written in PROMQueen's 4K bytes of RAM (random-access read/write memory). A DIP (dual-in-line package) switch is used to determine which of the VIC's four expansion blocks is occupied by PROMQueen so that PROMQueen's RAM can be used to expand the VIC's user BASIC memory. The DIP switch allows PROMQueen to be used with other cartridges, such as the Commodore VIC-MON 6502 assembler and editor, without address conflicts. A ZIF (zero insertion force) socket that can be run directly on the VIC is included.

The PROMQueen Cartridge costs $199, which includes a tutorial-type user's manual and a general-purpose machine-language loader, editor, and debugging program. Contact Gloucester Computer Bus Co. Inc., 6 Brooks Rd., Gloucester, MA 01930, (617) 283-7719.

Circle 618 on inquiry card.

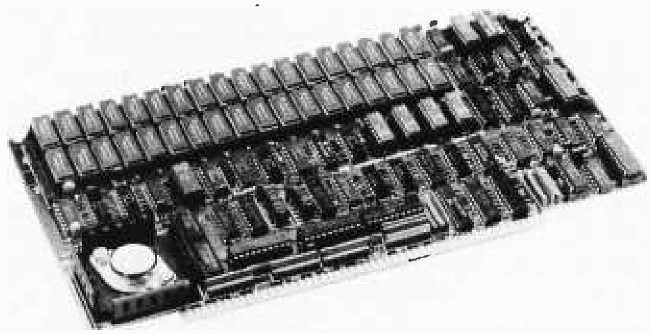
Controller Card Has Four-Drive Capability



Rana Systems' Elite Controller Card has a four-drive capability and can be used with any combination of Elite Minifloppy or Apple II disk drives. Elite automatically boots 13- and 16-sector disks and is compatible with DOS 3.3, Pascal 1.1, and CP/M 2.20B. Standard features include LED (light-emitting diode) indicators for operating modes and diagnostic aids, power-reduction capabilities, and an interface-buffering design.

Elite comes with a manual and a disk enhancer. The price is $135. Full details are available from Rana Systems, 20620 South Leapwood Ave., Carson, CA 90746, (213) 538-2353.

Circle 619 on inquiry card.



Multiuser Memory Board

Macrotech International's 256K-byte dynamic memory board is designed for 8- and 16-bit S-100-based computer systems. The board supports 24-bit addressing and features a mapping option for use with systems equipped with 16-bit addressing capabilities. A memory-mapping scheme lets you translate each 4K block of the 16-bit (64K) logic address to any 4K block of the 256K-byte on-board memory. The board operates at 6 MHz with Z80/8085-type processors and at 8 MHz with most 16-bit processors without wait states.

A complete installation guide for MP/M II BIOS and CP/M 2.2 virtual-disk applications is included in the manual. The board, called the Model SS256, costs $1379; a faster version is available on request. Contact Macrotech International, 22133 Cohasset St., Canoga Park, CA 91303, (213) 887-5737.

Circle 620 on inquiry card.

What's New?

SOFTWARE

Programmer Uses Shorthand

Advanced Operating Systems' Programmer provides a "programming shorthand" by taking your ideas and writing the necessary BASIC program lines. It presents your options in a menu format, lets you copy any program on disk, and has the ability to generate graphics and music programs.

Programmer is currently available for the Apple II Plus with 64K-byte Applesoft BASIC, Apple CP/M systems, and 64K-byte IBM Personal Computers with two disks drives, a monochrome display or printer card, and PC DOS. Complete with documentation, the Programmer costs $199. The documentation alone is available on request for $30. Contact Advanced Operating Systems, 450 St. John Rd., Michigan City, IN 46360, (800) 348-8558; in Indiana, (219) 879-4693.

Circle 621 on inquiry card.

Filer: Apple Disk Utility

The Filer is an Apple disk-utility system for 35-, 40-, and 70-track drives. Produced by Central Point Software, the Filer package contains a disk-drive speed check, disk-drive test, a 35-second fast-copy program, and a file manager. Options include catalog with space on disk, delete, lock and unlock files, change booting program (name and file type), and copy files, disk, and DOS (disk operating system).

The Filer has a suggested retail price of $19.95. It's available at computer stores or factory-direct from Central Point Software Inc., POB 19730–#203, Portland, OR 97219, (503) 244-5782.

Circle 622 on inquiry card.

IBM Software Line

Lifeboat Associates has announced that its 8086 Software Library programs can now run on the IBM Personal Computer with PC-DOS and on other 8086/8088 computers that run MS-DOS, such as Seattle, Godbout, and Tecmar. Emulator/86 is among the programs in the library. It lets you run CP/M-86 software under PC-DOS faster than with CP/M-86. Another member of the library is the Pmate text editor. It features single-keystroke editing, expression evaluation, horizontal scrolling, and macro command definitions.

Also available is the Lattice C Compiler. A full implementaion of the C language, Lattice C is Unix version 7 compatible. It produces relocatable machine code in Intel's 8086 object-module format for use with the linker supplied with DOS. For system utilities, Lifeboat offers the UT86 system, which gives you formatted and sorted directories, interactive copy routines, and formatted printouts. For complete details, contact Lifeboat Associates, 1651 Third Ave., New York, NY 10028, (212) 860-0300.

Circle 623 on inquiry card.

Integrated Word Processor

The Finalword is an integrated word-processing system that runs with CP/M, CP/M86, or PC-DOS. Produced by the Mark of the Unicorn, and requiring a 56K-byte computer, Finalword is configured to support most printers and terminals. It features automatic word-wrap and insert mode, global search and replace, justification, multiple-line spacing, move and delete blocks of text, and cursor positioning according to words, sentences, lines, and paragraphs. With Finalword, index entries and footnotes are placed in appropriate text areas. When you output a document under Finalword, an index is created with appropriate page numbers and entries. Other features include multiple buffers and windows that allow you to split the screen and display two separate files simultaneously, directory access while editing, simultaneous editing and printing, crash recovery, state save, and true proportional spacing. In addition, eight menus, callable at any time, are provided.

The Finalword costs $300. For full details, contact Mark of the Unicorn, POB 423, Arlington, MA 02174, (617) 489-1387.

Circle 624 on inquiry card.

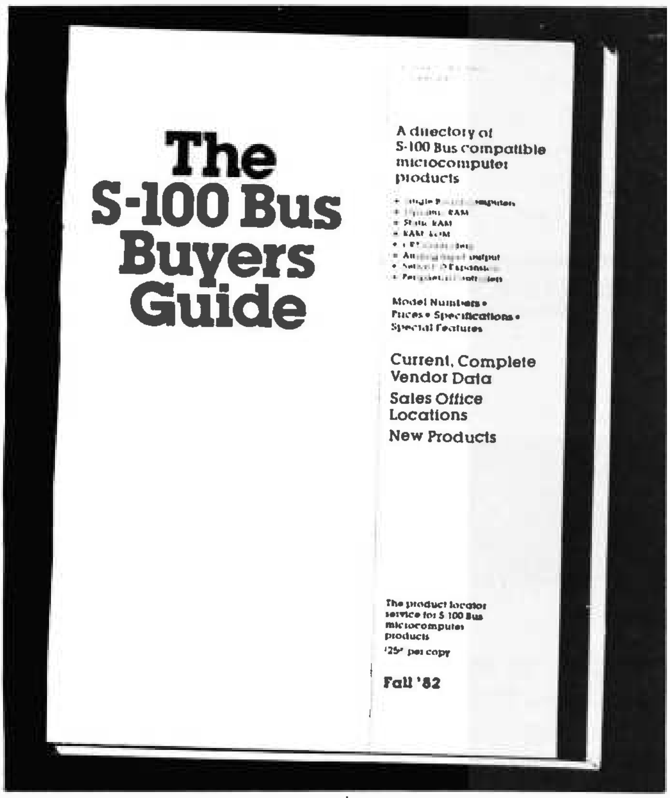
PUBLICATIONS

Accounting Plus Training Manual

The Accounting Plus Training Manual is a self-teaching guide covering the accounting principles necessary to run a business using a microcomputer and Systems Plus's Accounting Plus system, an integrated eight-module CP/M- and MP/M-compatible system. After explaining accounting terminology and detailing the audit trail from the ledger to individual department records, this manual gives you hands-on experience with the software's business, accounting, and management-reporting functions. From there, you'll learn the entire operation of Accounting Plus, including its general ledger, payables, receivables, sales order entry, payroll, and point-of-sale capabilities.

The Accounting Plus Training Manual is available through your local Systems Plus retailer. Contact Systems Plus Inc., 1120 San Antonio Rd., Palo Alto, CA 94303, (415) 969-7047.

Circle 625 on inquiry card.



S-100 Bus Buyers Guide

Ironoak Company's S-100 Bus Buyers Guide lists more than 450 S-100 bus-compatible board-level products, including single-board computers, peripheral controllers, and video boards. Product descriptions provide design and performance specifications, prices, delivery/availability, date first manufactured, and manufacturers' local sales offices. More than 65 companies are represented.

The S-100 Bus Buyers Guide is produced semiannually. Single copies cost $25. Additional copies shipped to the same address are $9.95 each; add $10 per copy for orders outside the U. S. Available directly from Ironoak Co., 3239 Caminito Ameca, La Jolla, CA 92037, (714) 450-0191.

Circle 626 on inquiry card.

Free Brochure on Flexydisks

A 6-page product bulletin on Flexydisks is available free of charge from BASF Systems Corporation. The brochure explains how Flexydisks are made and offers tips on proper disk care and handling. Also included is a product listing. BASF Flexydisks are available in both 5¼- and 8-inch formats. Write to BASF Systems Corp., Computer Media Marketing, Crosby Dr., Bedford, MA 01730.

Circle 627 on inquiry card.

Local Networks and Teletext Explored

Local Network Handbook and Teletext and Videotex in the United States are two recent publications from the Data Communications Special Project Center. A collection of articles first published in Data Communications magazine, Local Network Handbook explores all aspects of local networking. Professionals will find this book a comprehensive reference tool that provides an overview of network technology ranging from historical to specific applications. This book was edited by George Davis, editor-in-chief of Data Communications.

Teletext and Videotex in the United States is an all-encompassing guide to the technological revolution that may someday alter the manner in which Americans shop, work, and communicate. Commissioned by the National Science Foundation, this book's team of authors from the Institute for the Future have created chapters on technology, applications, marketing opportunities, and sociological implications. It is written with the hands-on professional and mature enthusiast in mind.

Local Network Handbook costs $25. Available in hardcover, Teletext and Videotex in the United States is priced at $30. Order from Data Communications Special Project Center, McGraw-Hill Publications Co., 1221 Avenue of the Americas, New York, NY 10020, (212) 997-2015.

Circle 628 on inquiry card.

Brochure Describes Graphics Software

Precision Visuals has a free 8-page brochure illustrating its device-independent approach to graphics software. Your Complete System for Building Better Graphics describes the company's DI-3000 FORTRAN-callable graphics subroutines, its Grafmaker data-presentation subroutines, a three-dimensional display package called Contouring, and the Metafile translator, a "time-independent" picture editor. For your copy of this full-color brochure, contact Dave Glander, Precision Visuals, 250 Arapahoe, Boulder, CO 80302, (303) 449-0806.

Circle 629 on inquiry card.

Graphics and Image Processing Algorithms

Theo Pavlidis's Algorithms for Graphics and Image Processing is available from the Computer Science Press. This book explores most aspects of pictorial information processing by computer, including computer graphics, computer image processing, and pictorial pattern recognition. Although its emphasis is on mathematical tools, the book also covers image synthesis, analysis, and encoding. Detailed listings of many algorithms are provided.

Algorithms for Graphics and Image Processing costs $24.95. Contact the Computer Science Press Inc., 11 Taft Court, Rockville, MD 20850, (301) 251-9050.

Circle 630 on inquiry card.

Logo Book Doubles As Self-Study Guide

A text and a self-study guide suited for use with the Logo programming language, Turtle Geometry: The Computer as a Medium for Exploring Mathematics has been released by the MIT Press. The authors, Harold Abelson and Andrea diSessa, are members of the Logo Group at the Massachusetts Institute of Technology's Artificial Intelligence Laboratory, where Logo was developed. Some of the topics explored are random motion, branching processes, space-filling designs, vector operations in two and three dimensions, topology of curves, maze-solving algorithms, and spherical and "cubical" geometry. Three hundred illustrations enhance this 477-page book, which costs $22.50 and is available from the MIT Press, 28 Carleton St., Cambridge, MA 02142, (617) 253-2884.

Circle 631 on inquiry card.

Bulletin Describes Sonic Digitizer

Science Accessories Corporation is offering a free 2-page technical bulletin describing the capabilities of its Grafbar Model GP-7 sonic digitizer. The bulletin contains technical specifications, descriptions of the GP-7's menu features and output formats, and discusses available styli, cursors, and sensors. The GP-7 permits left- or right-hand digitizing on any work surface.

For your copy, request technical bulletin GP-7-3-82 from Science Accessories Corp., 970 Kings Highway W, Southport, CT 06490.

Circle 632 on inquiry card.

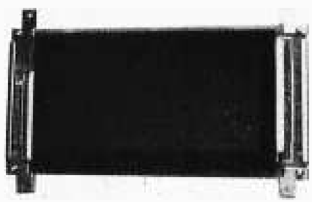
VIC-20 User Guide

The VIC-20 User Guide, by John Heilborn with Ran Talbott, addresses experienced and beginning programmers alike. Produced by Osborne/McGraw-Hill, this 250-page paperback book provides operating instructions for the Commodore VIC and its associated peripherals, such as disk drives, printers, and modems. It has tutorials in VIC-20 BASIC and detailed coverage of BASIC statements and functions, including advanced color graphics. Appendices offer further information on trigonometric functions and assembly codes and machine-level subroutines. Also provided is a memory map specifying many PEEK and POKE locations.

The VIC-20 User Guide costs $16.95. Contact Osborne/McGraw-Hill, 630 Bancroft Way, Berkeley, CA 94710, (415) 548-2805.

Circle 633 on inquiry card.

MISCELLANEOUS



Fujitsu to Market Plasma Display

The Component Division of Fujitsu America is marketing a 480-character plasma-display panel called the FPC 4012 NRUL. It uses monolithic integrated circuits for its drive circuits and CMOS (complementary metal-oxide semiconductor) LSI (large-scale integration) devices for control logic. The unit features high-contrast orange characters on a black background and a CRT- (cathode-ray tube) compatible interface that connects to various system buses through a CRT controller. Power consumption is 13 watts.

The FPC 4012 NRUL costs $597 in OEM (original equipment manufacturer) quantities. Contact George Neeno, Fujitsu America Inc., Component Division, 918 Sherwood Dr., Lake Bluff, IL 60044, (312) 295-2610.

Circle 634 on inquiry card.

Fast Floating Point for Atari

The Fastchip floating-point mathematics ROM (read-only memory) from Newell Industries is said to provide up to three and one-half times the speed of the original Atari BASIC floating-point routines. Fastchip is pin-compatible with the ROM it replaces and requires no modifications, cuts, or wires.

Fastchip costs $41.95, including shipping and handling. It comes with a 90-day warranty. Overseas orders are $2 higher. For additional information, contact Newell Industries, 3340 Nottingham Lane, Plano, TX 75074, (214) 423-1781.

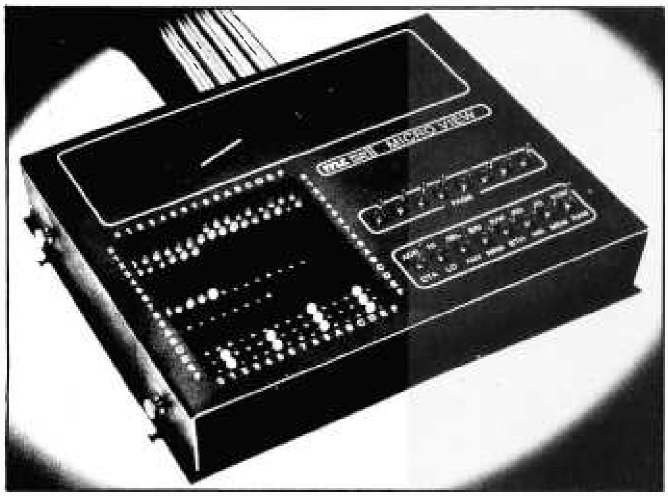
Circle 635 on inquiry card.

Stack Rack

The Stack Rack from Remtron lets you tuck more than 600 sheets of paper underneath your Epson MX-80 printer. Stack Rack features a bail guide that prevents the paper from snagging and a paper stop that halts the paper from sliding out the rear during operation or transportation. The unit is constructed of clear acrylic and is equipped with skid-resistant padded feet.

Stack Rack costs $14.95, plus $2 shipping and handling. Order from Remtron, POB 2280, Santa Clara, CA 95055.

Circle 636 on inquiry card.



Overview of Processor Activity

Micro View's 256 LEDs (light-emitting diodes) keep you informed of microprocessor activity. Manufactured by Micro Logic Corporation, Micro View has 16 switch-selectable modes that let you choose address or data, read and write, I/O or memory, detailed or overview modes, and one, several, or all pages in memory. Its display also provides you with information on program flow, memory references, port activity, and hardware and software interaction. The program stack is depicted as a moving bar graph.

A variety of personality packs are available for Micro View, including packs for 1802, 6502, 6800, 6808, 8039, F8, Z80, Apple, STD Bus, TRS-80, and a user-definable model. Micro View costs $995, complete with accessories and your choice of personality pack. Prices for additional personality modules begin at $95. Contact Micro Logic Corp., 100 Second St., POB 174, Hackensack, NJ 07602, (201) 342-6518.

Circle 637 on inquiry card.

Monitor Stand for Osborne

Montop locks on top of the Osborne 1 and holds any monitor firmly in place. Produced by SGW Enterprises, Montop can help reduce eye and neck strain by placing the screen at a more comfortable viewing angle. On Osbornes with the new vented case, Montop lifts the monitor up off the vent. No hardware is required.

Made of clear plexiglass, Montop has a $21.95 suggested retail price. Large and small plexiglass printer stands and Osborne desk covers are also available. Contact SGW Enterprises, POB 1015, Del Mar, CA 92014, (714) 755-8324.

Circle 638 on inquiry card.

Line Status Indicator

The Tech's Helper is an RS-232C-compatible line status indicator from Electro-Service Company. It shows the high, low, and data status of the seven most commonly used pins of a serial (i.e., DB25) connector. Indicators for numbers 2, 3, 4, 5, 6, 8, and 20 are provided as well as a shield to number 1 and the common to pin number 7. The device is tested to data rates up to 9600 bps (bits per second) and is supplied with male and female connectors.

The Tech's Helper costs less than $50; dealer inquiries are invited. Order Model 827L from Electro-Service Co., POB 92, Redmond, WA 98052, (206) 881-0709.

Circle 639 on inquiry card.

Where Do New Products Items Come From?

The information printed in the new products pages of BYTE is obtained from "new product" or "press release" copy sent by the promoters of new products. If in our judgment the information might be of interest to the personal computing experimenters and homebrewers who read BYTE, we print it in some form. We openly solicit releases and photos from manufacturers and suppliers to this marketplace. The information is printed more or less as a first-in first-out queue, subject to occasional priority modifications. While we would not knowingly print untrue or inaccurate data, or data from unreliable companies, our capacity to evaluate the products and companies appearing in the "What's New?" feature is necessarily limited. We therefore cannot be responsible for product quality or company performance.

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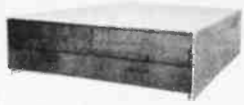
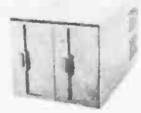

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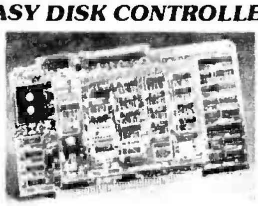

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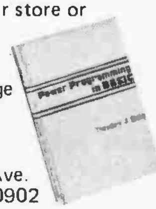

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★ WEST ★ 15381 Chemical Lane, Huntington Beach, CA 92649

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For 2 - 8" or 5" Shugart 801R or 851R, Qume DT-8 with DC Cables for 8"
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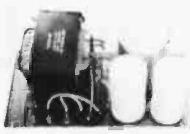

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+16VDC @ 6 Amps
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PC Board Design
Dimensions: 5" x 6" x 11"

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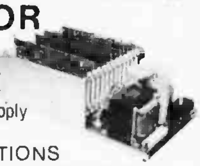
S-100 MOD KIT
by XOR



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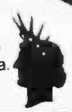

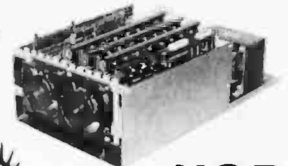

XOR S-100 MOD

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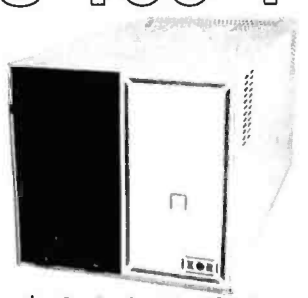
S-100-4



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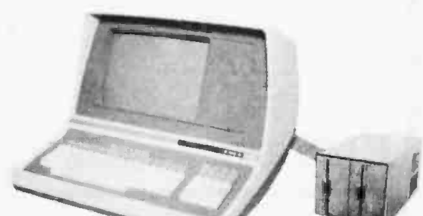

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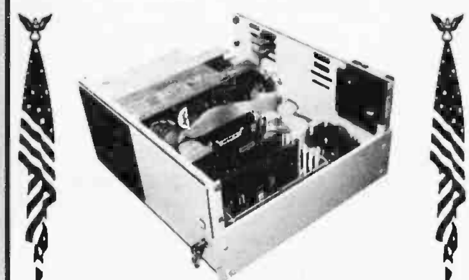

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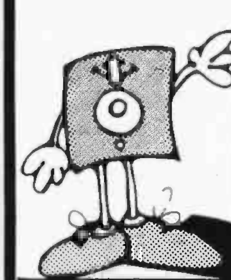

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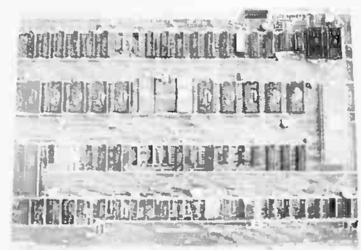

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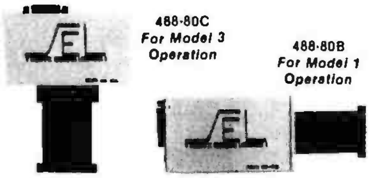

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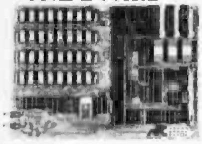

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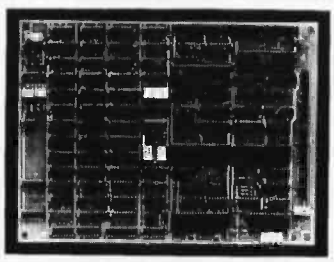

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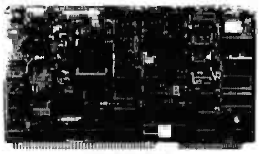

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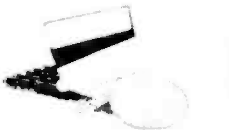

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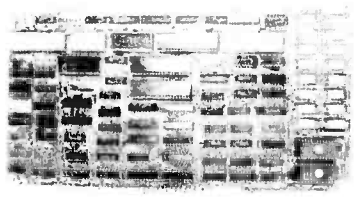

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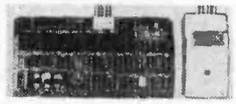

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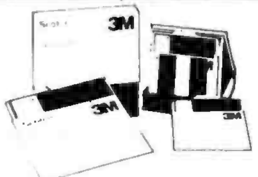

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74C927	6 95

INTERFACE	
8095	65
8096	65
8097	65
8098	65
8T09	1 25
8T10	1 75
8T13	1 40
8T20	4 95
8T23	1 75
8T24	1 75
8T25	3 20
8T26	1 69
8T28	1 95
8T97	99
8T98	99

MOS MEMORY RAM	
2101-1	1 95
2102-1	85
2102AL-4	1 25
2102AN-2L	1 65
2104A-4	4 95
2107B-4	3 75
2111-1	2 99
2112-2	2 99
2114	2 24
2114L 300ns	2 00
2114L 450ns	1 95
4116 200ns	2 25
8-4116 200ns	12 40
8-4116 150ns	18 50
MM5280	3 00
MM5321	9 95
MM5330	5 94
P5101L	8 95
4200A	11 50
9368	3 50
410D	10 00
416	2 50
TMM2016	5 95
HM6116-4	6 95
HM6116LP3	8 95
4164 200ns	7 25
MK 4816	24 50

CLOCKS	
MM5311	4 95
MM5312	3 90
MM5314	3 90
MM5369	1 95
MM5841	14 45
MM5865	7 95
CT7010	8 95
CT7015	8 95
MM5375AA/N	3 90
MM5375AG/N	4 90
7205	16 50
7207	7 50
7208	15 95
7209	4 95
MSM5832	8 95

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6530	9 50
6532	11 25
6551	11 85
6800	5 70
6820	4 95
6850	3 50
8080A	3 95
8085A	7 50
Z80A	6 00
Z80B	16 95
Z80 PIO	6 50
Z80A PIO	5 95
Z80 CTC	5 95
Z80A CTC	8.65
Z80 DART	15 25
Z80A DART	18 75
Z80 DMA	17 50
Z80A DMA	27 50
Z80 SIO	18 50
Z80A SIO	21 95
Z80 SIO 1	15 00
Z80A SIO 1	23 90
Z80 SIO 2	23 95
Z80A SIO 2	28 95
Z80B CTC	15 50
Z80B PIO	15 50
8212	1 85
8214	3 75
8216	1 80
8224	2 50
8228	4 95
8251	4 75
8253	8 95
8255	4 75
8257	8 75
8259	6 90
1802CE plas	13 95
1802E plas	17 95
1861P	5 95

UART FIFO	
AY5-1013	3 95
AY5-1014A 1612	6 95
3341	6 95

PROM	
1702A	4 50
2532	7 95
2708	3 75
2716TI	8 50
2716 5 Volt	4 95
8 2716 5 Volt	29 60
2732	6 95
2758	7 49
8741A	39 95
8748	29 95
8755	31.95
N82S23	2 95
N82S123	3 95
N82S126	5 75
N82S129	4 75
N82S131	4 95
N82S136	8 75
N82S137	8.75
DM8577	2 90
2716-1	8 95

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44 pin edge	2.75
86 pin edge	4 00
100 pin edge	3 95
100 pin edge w.w	4 95

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8	13	22	30
14	14	24	30
16	16	28	40
18	20	36	58
20	29	40	49

WIRE WRAP LEVEL 3

PIN		PIN	
14	55	24	93
16	57	28	1 00
18	67	40	1.59

CRYSTALS	
1 MHz	4.50
2 MHz	3 95
4 MHz	3 95
5 MHz	3 95
10 MHz	3 95
18 MHz	3 90
20 MHz	3 90
32 MHz	3 90
32768 Hz	4 00
1.8432 MHz	4 50
3 5795 MHz	1.20
2.0100 MHz	1 95
2 097152 MHz	3.95
2.4576 MHz	3.95
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5.0688 MHz	3 95
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AY5-3600PRO	11.95
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D Connectors RS232	
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DB25S	3 50
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5-position	.90
6-position	90
7-position	95
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24V CT 100 ma	3 95		
24V CT 600 ma	4 95	9 VDC 500 ma	3 75

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VENTURE is a 16" by 20" main board with separate ASCII and HEX keyboards. It runs fast, almost 4 MHz, and has the capability of putting 1.5 megabyte of RAM and ROM on the board along with a variety of inexpensive options.

A 16-channel analog-to-digital converter allows use of joysticks, control functions, instrumentation, temperature sensing, etc. T1 sound generator, software controlled music, Votrax voice synthesizer and real time clock calendar add to its versatility.

VENTURE connects directly to a monitor or to your TV set through an RF modulator. And now for the heart of VENTURE ... its video display. VENTURE has a high resolution programmable video display with up to 16,384 user-defined characters, alphanumeric symbols, special graphics or objects, such as space ships, etc. Each character is 8 pixels wide by 15 pixels high, with 2 grayscale maps; it has 64 levels of grayscale plus video invert/compliment and hidden screen update for a "snow" free display. The display is 512 x 512 pixel mapped with 2 planes of video RAM per display. VENTURE video is in short ... astounding!

VENTURE has complete software support with full BASIC, 3 ROM monitors, disassembler/assembler/editor. It will run real-time video games, all RCA chip 8 programs and all current Quest 1802 software. VENTURE DOS will accommodate up to four 5¼" double density floppies. A complete 1802 programming book is available. All versions of VENTURE are shipped with a set of manuals written to be understood by the inexperienced as well as experienced user.

A standard 60-pin bus with 5 slots, parallel ports and 2 serial ports with full handshaking (75 to 9600 BAUD) allow expansion into floppy disks, color, EPROM programmer, printer, model of your choice. Later expansion will add a light pen, a universal user programmable music sound board, General Purpose Instrument Bus, and a high resolution color/grayscale pixel mapped video board.

On-Board Options
16 channel A to D; 5 slot 60 pin bus, 2 serial ports, parallel ports, 4 video options incl. color, 48K RAM, Votrax voice synthesizer, sound generator, EPROM, full BASIC disassembler, editor, assembler, metal cabinet, additional power supply, ASCII keyboard real time clock calendar.

Expansion Options
Floppy disk, EPROM programmer, light pen, universal user programmable music, sound board high resolution color/grayscale pixel mapped video board. General Purpose Instrument Bus, 8088 co-processor board.

Minimum VENTURE System $195.00
Kit includes CPU and control with 4K of RAM, 1K of scratchpad, 2K monitor, 1861 video graphics, cassette interface and separate HEX keyboard with LED displays for address and output. Power supply is included along with 2 game cassettes. The main board is 16" x 20" and includes space for all of the previously discussed on-board options. Full on-board expansion can be completed for under $1000.00. Call for further details, option prices, etc.

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The Super Elf comes complete with power supply and detailed 127 page instruction manual which includes over 40 pages of software, including a series of lessons to help get you started and a music program and graphics target game. Many schools and universities are using the Super Elf as a course of study. OEM's use it for training and R&D. A monthly newsletter, Questdata is devoted exclusively to software for the Super Elf and there are many software books available at low cost.

The Super Elf computer system is now available as a series of bare boards as well as full kits and assembled.

Bare Boards: Super Elf $35.00. Super Expansion $35.00. Power Supply $10.00. S-100 Color $35.00. Dynamic RAM $40.00. Manuals $10.00. Super Basic $45.00.
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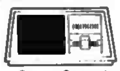

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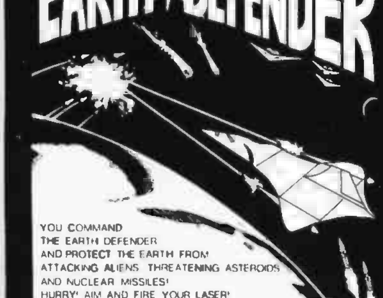

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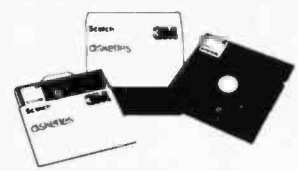

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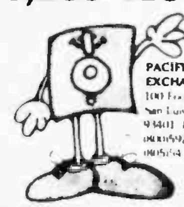

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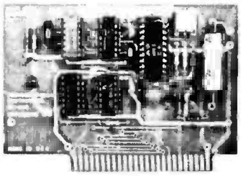

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Documentation includes basic user programs, a phoneme chart and listing of coded words to help you get started. Documentation for the Apple II* Speech Synthesizer includes a disk with text to speech program.

81-088 Apple II Speech Synthesizer	$129.95
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Prices include the SC-01 Chip	
SC-01 sold separately for	$ 39.95

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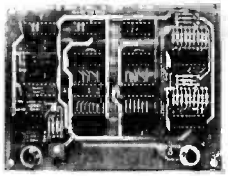

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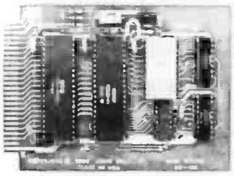
6502 MICROCOMPUTER

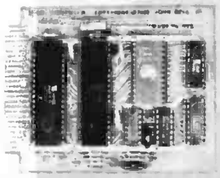


6502 MPU, 6522 VIA, 2716 EPROM, 2114 RAM single board computer. Single 5 volt power supply at 400 Ma. Two independent 8 bit I/O ports with handshake lines. RC controlled 1 MHz clock.

Complete documentation. I/O lines use 50 pin edge connector. Data and address lines are not accessible. Mod. for 2532 is included. EPROM is not included. 1K RAM, 2K EPROM, 2 I/O ports.

80-153	Assm. $110.95

Z-80 MICROCOMPUTER

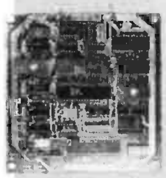


Z-80 MPU, Z-80 PIO, 2716 EPROM, 2114 RAM single board computer. Single 5 volt power supply at 300 Ma. Two independent 8 bit I/O ports with handshake lines. RC controlled 2MHz clock.

Complete documentation. I/O lines use 50 pin edge connector. Data and address lines are not accessible. Mod. for 2532 is included. EPROM is not included. 1K RAM, 2K EPROM, 2 I/O ports.

80-280	Assm. $129.95

CRT CONTROLLER



This intelligent CRT Controller uses an 8085A CPU and an 8275 Integrated CRT Controller. It features:

- 25 lines (80 char./line)
- 5x7 dot matrix
- Upper & lower case
- Two 2716's (controller & char. generator)
- Serial interface RS232 & TTL
- Baud rates of 110, 150, 300, 600, 1200, 2400, 4800 and 9600
- Keyboard scanning system
- Unencoded keyboard required
- Uses +5V & ± 12V Power Supplies
- Does not have graphic capabilities.

Documentation includes program listing and composite video circuit.

Bare Board only (with doc)	$39.95
2716 Char. Gen. A7	$19.95
2716 Program A12	$19.95
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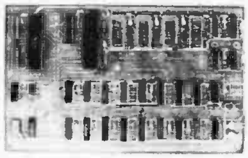
MINI VIDEO 40 X 24



This board can be used to add a video display to your AIM or other computer. It can also, with the addition of a parallel keyboard, 5V power supply and video monitor, be used as a home computer. It will run Tom Pittman's Tiny Basic. The 2716 character gen. will produce 256 8x8 characters, ASCII upper and lower case and graphic characters. The 44 pin expansion connector can be used to add up to 6K of memory or extra I/O ports. Power requirements: 5 volts 600 MA 3 watts.

Documentation includes schematic, parts list, connector pin outs, and source listing for video display and Monitor. Control character response:

- H back space
- I up one line
- J line feed
- L clear screen and home
- M carriage return
- U forward space non destructive

The curser is flashing underline type.

82-140A assm. W/O EPROMS	$149.95
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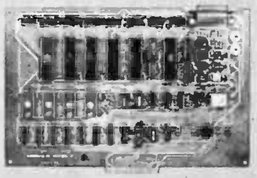
JBE I MICROCOMPUTER



JBE's 7.75 x 11.75 6502 base Microcomputer has the capacity for 16K of EPROM, 4K of RAM, 8 Parallel Ports and 1 Serial Port. Monitor and Tiny Basic are also available.

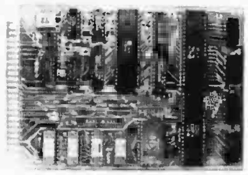
Both versions include sockets for 2716s or 2532s, 8 16 pin sockets for I/O interfacing and a DB25 connector for RS232.

All address and data lines are brought off the board to the 50 pin edge connector. (Similar to the Apple II bus.)

This board also features power on reset and cassette interface.

81-030C Fully Populated	$399.95
81-030M Partially Populated	$299.95
2716 EPROM (with Tiny Basic)	$ 19.95

81-260 "SLIM"



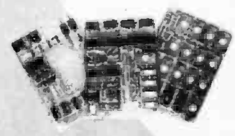
Single board large scale integration Microcomputer. This 4.5 x 6.5 board uses the 6502 Microcomputer, two 6522 VIA's four 2114 RAM's, 2516, 2716 or 2532 EPROM. The fully buffered 22/44 pin bus is similar to the KIM®, SYM®, and AIM® expansion connector. The four 8 bit I/O ports connect through 16 pin dip sockets. This board was designed for control and is ideal for Personal and OEM use.

- 6502 MPU
- Two 6522 VIA's
- Four 2114 RAM's (2K bytes)
- One EPROM 2516 or 2532
- Crystal clock 1 MHz
- Requires 5V 1AMP power
- 4.5 x 6.5 card
- Power on reset
- Fully buffered-expandable
- Solder mask-both sides

Use your Apple II Computer, JBE 6522 Parallel Interface card and EPROM Programmer as a development system for SLIM.

81-260A	Assm. $199.95

PHERIPHERALS FOR SLIM



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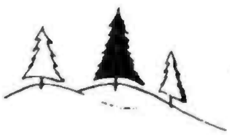

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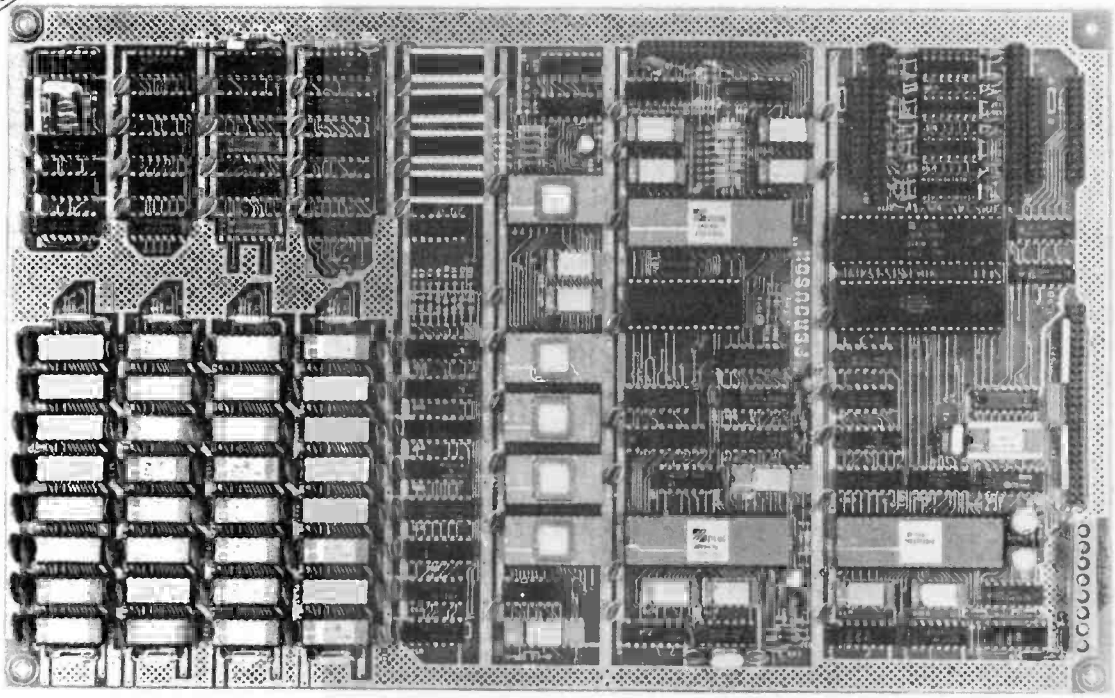

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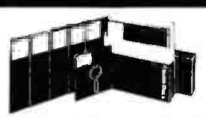

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INTERFACER 1 - CompuPro
2 serial I/O ports 50-19.2K baud.

IOI-1810A	A & T	$218.95
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4116-2	200ns	1.25
4116-3	250ns	1.15
2118	5V 150ns	Call
MK 4816	5V 300ns	Call
4164-200	5V 200ns	Call
4164-150	5V 150ns	Call

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2102-1	450ns	.7
2102L-2	250ns LP	1.5
2111	450ns	2.4
2112	450ns	2.6
2114	450ns	1.7
2114 L-3	300ns LP	1.8
2114 L-2	200ns LP	1.9
2147	55ns	8.9
TMS 4044-4	450ns	3.2
TMS 4044-3	300ns	3.5
TMS 4044-2	200ns	3.9
MK 4118	250ns	9.7
TMM 2016	200ns	5.4
TMM2016	150ns	6.4
TMM 2016	100ns	7.4
HM6116-4	200ns	Ca
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74S08	.38	74S139	.88	74S257	1.39
74S09	.38	74S140	.54	74S258	1.39
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7404	.22	7489	4.90	74174	.89
7405	.22	7490	.35	74175	.89
7406	.22	7491	.39	74176	.89
7407	.24	7492	.49	74177	.75
7408	.24	7493	.49	75178	1.10
7409	.19	7494	.65	74180	.75
7410	.19	7495	.55	74181	2.20
7411	.25	7496	.69	74182	.75
7412	.30	7497	2.69	74184	1.99
7413	.35	74100	.99	74185	1.99
7414	.55	74107	.29	74186	18.00
7416	.25	74109	.45	74190	1.10
7417	.25	74110	.45	74191	1.10
7420	.20	74111	.55	74192	.79
7421	.35	74116	1.49	74193	.79
7422	.29	74120	1.19	74194	.85
7423	.29	74121	.29	74195	.85
7425	.29	72122	.45	74196	.79
7426	.29	74123	.55	74197	.75
7427	.29	74125	.45	74198	1.32
7428	.45	74126	.45	74199	1.32
7430	.20	74128	.55	74221	1.32
7432	.29	73132	.45	74246	1.32
7433	.45	74136	.49	74247	1.25
7437	.29	74141	.65	74248	1.79
7438	.29	74142	2.90	74249	1.90
7440	.19	74143	2.90	74251	.79
7442	.45	74144	2.90	74259	2.20
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7448	.65	74152	.65	74290	.95
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7453	.22	74155	.75	74351	2.20
7454	.22	74156	.65	74365	.65
7460	.22	74157	.55	74366	.65
7470	.35	74159	1.65	74367	.65
7472	.29	74160	.85	74368	.65
7473	.32	74161	.69	74376	2.10
7474	.32	74162	.85	74390	1.69
7475	.45	74163	.85	74393	1.30
7476	.32	74164	.85	74425	3.10
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4001	.30	4093	.90	74C90	1.75
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4016	.45	4518	1.20	74C164	2.00
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4018	.90	4520	1.20	74C173	2.00
4019	.45	4522	1.20	74C174	2.25
4020	.90	4526	1.20	74C175	2.25
4021	.90	4527	1.90	74C192	2.25
4022	1.10	4528	1.20	74C193	2.25
4023	.35	4531	.90	74C195	2.25
4024	.75	4532	1.90	74C200	5.75
4025	.35	4538	1.90	74C221	2.25
4026	1.60	4539	1.90	74C373	2.75
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4076	.90	74C74	.85	14409	12.90
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T = TO-220
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LM567	.99	75451	.35
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74LS05	.24	74LS136	.49	74LS266	.49
74LS08	.24	74LS137	.95	74LS273	1.60
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74LS22	.24	74LS155	.89	74LS324	1.75
74LS26	.30	74LS156	.89	74LS352	1.49
74LS27	.24	74LS157	.75	74LS353	1.49
74LS28	.30	74LS158	.75	74LS363	1.49
74LS30	.24	74LS160	.95	74LS364	1.95
74LS32	.36	74LS161	.95	74LS365	.89
74LS33	.55	74LS162	.95	74LS366	.89
74LS37	.55	74LS163	.95	74LS367	.69
74LS38	.35	74LS164	.95	74LS368	.69
74LS40	.30	74LS165	.95	74LS373	.99
74LS42	.49	74LS166	1.95	74LS374	1.69
74LS47	.75	74LS168	1.69	74LS377	1.40
74LS48	.75	74LS169	1.69	74LS378	1.15
74LS49	.75	74LS170	1.69	74LS379	1.35
74LS51	.30	74LS173	.75	74LS385	1.89
74LS54	.35	74LS174	.89	74LS386	.59
74LS55	.35	74LS175	.89	74LS390	1.79
74LS63	1.20	74LS181	1.99	74LS393	1.79
74LS73	.39	74LS189	9.50	74LS395	1.59
74LS74	.44	74LS190	.89	74LS399	1.59
74LS75	.49	74LS191	.89	74LS424	2.89
74LS76	.39	74LS192	.89	74LS447	.75
74LS78	.49	74LS193	.89	74LS490	1.89
74LS83	.75	74LS194	.89	74LS668	1.65
74LS85	.95	74LS195	.89	74LS669	1.85
74LS86	.39	74LS196	.79	74LS670	2.10
74LS90	.65	74LS197	.79	74LS674	9.50
74LS91	.79	74LS221	1.10	74LS682	2.99
74LS92	.65	74LS240	.95	74LS683	2.39
74LS93	.59	74LS241	.95	74LS684	2.39
74LS95	.79	74LS242	1.79	74LS685	2.39
74LS96	.79	74LS243	1.79	74LS688	2.39
74LS107	.39	74LS244	.95	74LS689	2.39
74LS109	.39	74LS245	1.89		
74LS112	.39	74LS247	.79	81LS95	1.65
74LS113	.39	74LS248	1.20	81LS96	1.65
74LS114	.49	74LS249	.89	81LS97	1.65
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OPERATIONS AVAILABLE:

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- EMULATES PROMS OR EPROMS
- RS232C COMPUTER INTERFACE FOR EDITING AND PROGRAM LOADING
- LOADING DATA INTO RAM BY KEYBOARD
- CHANGING DATA INTO RAM BY KEYBOARD
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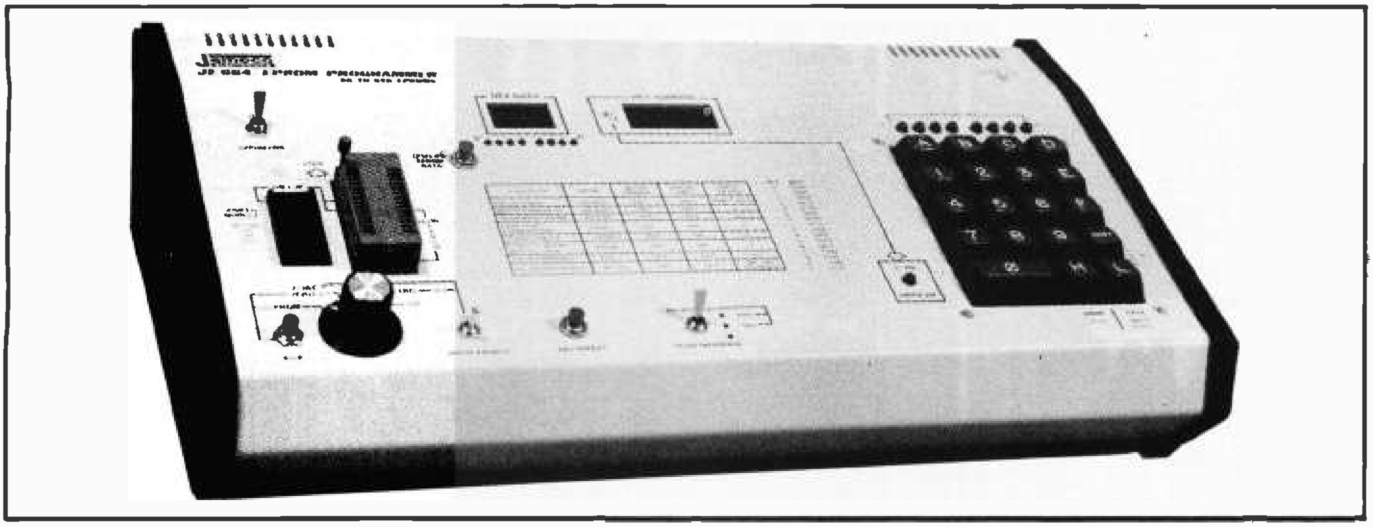

The JE664 EPROM Programmer emulates and programs various 8-BIT-WORD EPROMS from 8K to 64K-BIT memory capacity. Data can be entered into the JE664's internal 8K x 8 BIT RAM in three ways: (1) from a ROM or EPROM; (2) from an external computer via the optional JE665 RS232C BUS; (3) from its panel keyboard. The JE664's RAMS may be accessed for emulation purposes from the panel's test socket to an external microprocessor. In programming and emulation, the JE664 allows for examination, change and validation of program content. The JE664's RAMS can be programmed quickly to all "1"s (or any value), allowing unused addresses in the EPROM to be programmed later without necessity of "UV" erasing. The JE664 displays DATA and ADDRESS in convenient hexadecimal (alphanumeric) format. A "DISPLAY EPROM DATA" button changes the DATA readout from RAM word to EPROM word and is displayed in both hexadecimal and binary code. The front panel features a convenient operating guide. The JE664 Programmer includes one JM16A Jumper Module (as listed below).

POWER INPUT: 115VAC, 60Hz, less than 10W power consumption.

SIZE: 15-5/8"L x 8-3/4"D x 3-1/2"H.

ENCLOSURE: Color-coordinated, light tan panels with molded end pieces in mocha brown.

WEIGHT: 5-3/4 lbs.

MODEL NO. — PRICE

JE664-A .... EPROM PROGRAMMER—ASSEMBLED & TESTED (INCLUDES JM16A MODULE) **$995.00**

OPTION

JE665 RS232C INTERFACE OPTION — The JE665 RS232C Interface Option implements computer access to the JE664's RAM. A sample of software written in BASIC is provided for the TRS-80® Model I, Level II Computer. Baud Rate: 9600; Word Length: 8 Bits — Odd Parity; Stop Bits: 2. This option may be readily adapted to other computers.

JE664-ARS .... EPROM PROGRAMMER W/JE665 OPTION ASSEMBLED & TESTED (INCLUDING JM16A MODULE). **$1195.00**

EPROM JUMPER MODULES

The JE664's JUMPER MODULE (Personality Module) is a plug-in Module that pre-sets the JE664 for the proper programming pulses to the EPROM and configures the EPROM socket connections for that particular EPROM.

JE664 EPROM JUMP. MOD. #	EPROM	EPROM MANUFACTURER	PRICE	JE664 EPROM JUMP. MOD. #	EPROM	EPROM MANUFACTURER	PRICE
JM08A	2708	AMD, MOTOROLA, NAT'L, INTEL, TI	$14.95	JM32B	2732	AMD, FUJITSU, NEC, HITACHI, INTEL	$14.95
JM16A	2716 TMS2516(TI)	INTEL, MOTOROLA, NAT'L, NEC, TI	$14.95	JM64A	MCM68764 MCM68L764	MOTOROLA	$14.95
JM16B	TMS2716 (3 Voltages)	MOTOROLA, TI	$14.95	JM64B	2764	INTEL	$14.95
JM32A	TMS2532	MOTOROLA, TI	$14.95	JM64C	TMS2564	TI	$14.95

CHECK FOR AVAILABILITY OF JUMPER MODULES FOR EPROMS NOT LISTED ABOVE.
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SN7409N	14	.25
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SN7412N	14	.35
SN7413N	14	.35
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SN7420N	14	.19
SN7421N	14	.35
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SN7423N	16	.59
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SN7483N	16	.59
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SN7486N	14	.35
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SN7491N	14	.59
SN7492N	14	.39
SN7493N	14	.39
SN7494N	14	.69
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SN7496N	16	.49
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SN74100N	24	1.49
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74LS04	14	.29
74LS05	14	.29
74LS08	14	.29
74LS09	14	.29
74LS10	14	.29
74LS11	14	.35
74LS12	14	.35
74LS13	14	.39
74LS14	14	.59
74LS15	14	.35
74LS20	14	.29
74LS21	14	.29
74LS22	14	.29
74LS26	14	.29
74LS27	14	.29
74LS28	14	.35
74LS30	14	.29
74LS32	14	.35
74LS33	14	.55
74LS37	14	.35
74LS38	14	.35
74LS40	14	.29
74LS42	16	.55
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74LS51	14	.25
74LS54	14	.29
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74LS73	14	.39
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74LS90	14	.55

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74LS109	16	.39
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74LS113	14	.39
74LS114	14	.39
74LS122	14	.49
74LS123	16	.79
74LS125	14	.49
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74LS136	14	.39
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74LS139	16	.59
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74LS192	16	.79
74LS193	16	.79
74LS194	16	.69
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74LS221	16	.89
74LS240	20	1.09
74LS241	20	1.09
74LS242	14	1.09
74LS243	14	1.09
74LS244	20	1.09
74LS245	20	1.49
74LS247	16	1.09
74LS248	16	1.09
74LS251	16	.59
74LS253	16	.59
74LS257	16	.59
74LS258	16	.59
74LS260	14	.59
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74S05	14	.45
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74S09	14	.39
74S10	14	.35
74S11	14	.35
74S15	14	.35
74S20	14	.35
74S22	14	.35
74S30	14	.35
74S32	14	.45
74S38	14	.89
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74S51	14	.35
74S64	14	.39
74S65	14	.39
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MC68488P	40	General Purpose Inf. Adapter	8.95
MC68652P2	40	Multi. Protocol Comm. Controller	24.95
MC68661PB	28	Enhanced Prog. Comm. Inf.	8.95

8080A SERIES

Part No.	**Pins	Function	Price
INS8080A	40	CPU	3.95
TMS5501	40	Synchronous Data Interface (SIRC)	14.95
INS8154	40	128 Byte RAM 16-Bit I/O	13.95
INS82C06	20	Octal D Flip Flop Tri-State (74C374)	2.49
DP8212	24	8-bit Input/Output (74S412)	2.25
DP8214	24	Priority Interrupt Control	3.95
DP8216	16	Bi-Directional Bus Driver	2.25
DP8224	16	Clock Generator/Driver	2.25
DP8226	16	Bus Driver	2.25
DP8228	28	System Cont./Bus Driver (74S428)	3.49
DP8238	28	System Controller (74S438)	4.49
INS8243	24	I/O Expander for 48 Series	5.95
INS8245	18	16-Key Keyboard Encoder (74C922)	4.49
INS8246	20	20-Key Keyboard Encoder (74C923)	4.95
INS8247	28	Display Controller (74C911)	8.95
INS8248	28	Display Controller (74C912)	8.95
INS8250N	40	Asyn. Comm. Element (INS8250)	10.95
DP8251	28	Prog. Comm. I/O (USART)	4.49
DP8253	24	Prog. Interval Timer	6.95
DP8255	40	Prog. Peripheral I/O (PPI)	4.49
DP8257	40	Prog. DMA Control	7.95
DP8259	28	Prog. Interrupt Control	6.95
DP8275	40	Prog. CRT Controller	29.95
DP8279	40	Prog. Keyboard/Display Interface	6.95
DP8303	20	8-Bit Tri-State Bi-Directional Trans.	3.95
DP8304	20	8-bit Bi-Directional Receiver	2.49
DP8307	20	8-bit Bi-Directional Receiver	2.49
DP8308	20	8-bit Bi-Directional Receiver	2.49
DP8310	20	Octal Latched Peripheral Driver	4.95
DP8311	20	Octal Latched Peripheral Driver	4.95

MICROPROCESSOR MANUALS & DATA BOOKS

M-Z80	User Manual	7.50
M-CDP1802	User Manual	7.50
M-2650	User Manual	5.00
10400	1982 Intel Data Book (1405 pg.)	14.95
30001	1981 Nat. CMOS Book (628 pg.)	6.95
30002	1980 Nat. Interface Book (540 pg.)	6.95
30003	1982 Nat. Linear Book (1952 pg.)	11.95
30005	1981 Nat. TTL Book (624 pg.)	9.95
30008	1980 Nat. Memory Data Book (464 pg.)	6.95
30011	1980 Nat. Linear Applications (736 pg.)	15.95
30013	1983 Zilog Data Book (641 pg.)	7.95
205610	1981 Intel Peripheral Design (828 pg.)	9.95

DYNAMIC RAMS

Part No.	**Pins				Price
1103	18	1024x1	(300ns)		.99
4027	16	4096x1	(250ns)		2.49
4116N-2	16	16,384x1	(150ns)		1.89 - 8/14.95
4116N-3	16	16,384x1	(200ns)		1.69 - 8/12.95
4116N-4	16	16,384x1	(250ns)		1.49 - 8/10.95
4164N-150	16	65,536x1	(150ns)		7.95 - 8/59.95
4164N-200	16	65,536x1	(200ns)		7.49 - 8/54.95
MM5261	18	1024x1	(300ns)		.49 - 8/1.95
MM5262	22	2048x1	(365ns)		.49 - 8/1.95
MM5270	18	4096x1	(250ns)	MK4096	4.95
MM5280	22	4096x1	(200ns)	2107	3.95
MM5290-2	16	16,384x1	(150ns)		1.89 - 8/14.95
MM5290-3	16	16,384x1	(200ns)		1.69 - 8/12.95
MM5290-4	16	16,384x1	(250ns)		1.49 - 8/10.95
MM5298-3	16	8192x1	(200ns)		1.69

STATIC RAMS

Part No.	**Pins				Price
1101	16	256x1	(650ns)		1.49
2101	22	256x4	(450ns)	8101	2.49
2102	16	1024x1	(350ns)		.89
21L02	16	1024x1	(450ns)	L.P.	1.49
2111	18	256x4	(450ns)	8111	2.95
2112	16	256x4	(450ns)	MOS	2.95
2114	18	1024x4	(450ns)		1.95 - 8/13.95
2114L	18	1024x4	(450ns)	L.P.	2.25 - 8/15.95
2114-2	18	1024x4	(200ns)		2.25 - 8/15.95
2114L-2	18	1024x4	(200ns)	L.P.	2.49 - 8/17.95
2141-3	18	4096x1	(150ns)		3.95
2147	18	4096x1	(70ns)		4.95
2148	18	1024x4	(70ns)		8.95
TMS4044	18	4096x1	(450ns)		3.95
TMS4045	18	1024x4	(450ns)		3.95
5101	22	256x4	(450ns)	CMOS	4.95
MM5257	18	4096x1	(450ns)	4044	4.95
HM6116P-3	24	2048x8	(150ns)	CMOS	7.95
HM6116-4	24	2048x8	(200ns)	CMOS	6.95
HM6116LP-4	24	2048x8	(200ns)	L.P. CMOS	7.95
7489	16	16x4	(50ns)	3101	2.25
74C920	22	256x4	(250ns)	CMOS (6551)	3.95
74C921	18	256x4	(250ns)	CMOS	3.95
74C929	16	1024x1	(250ns)	CMOS (6501)	3.95
74C930	18	1024x1	(250ns)	CMOS (6518)	3.95
74S189	16	16x4	(35ns)	93405	1.95
74S200	16	256x1	(80ns)	93410	3.95
74S206	16	256x1	(60ns)	93411	3.95
74S289	16	16x4	(35ns)	3101	2.25
82S10	16	1024x1	(50ns)	O.C. (93415)	3.95
82S25	16	16x4	(50ns)	O.C. (74S289)	2.25

EPROMS

Part No.	**Pins				Price
1702A	24	256x8	(1us)		4.95
2708	24	1024x8	(450ns)		3.95
2708-5	24	1024x8	(550ns)	SM00246	2.95
TMS2516	24	2048x8	(450ns)	2716	6.95
TMS2532	24	4096x8	(450ns)	NMC2532	9.95
TMS2564	28	8192x8	(450ns)		19.95
TMS2716	24	2048x8	(450ns)	3 voltage	7.95
2716	24	2048x8	(450ns)		4.95
2716-1	24	2048x8	(350ns)		6.95
2732	24	4096x8	(450ns)		9.95
2758D	24	1024x8	(450ns)	single +5V	2.95
MM2764	28	8192x8	(450ns)		16.95
MM2764-3	28	8192x8	(300ns)		19.95

PROMS

Part No.	**Pins			Price
74S188	16	32x8	PROM O.C. (6330-1)	1.49
74S287	16	256x4	PROM T.S. (6301-1)	1.95
74S288	16	32x8	PROM T.S. (6331-1)	1.95
74S387	16	256x4	PROM O.C. (6300-1)	1.95
74S471	20	256x8	PROM T.S. (6309-1)	5.95
74S472	20	512x8	PROM T.S. (6349-1)	4.95
74S473	20	512x8	PROM O.C. (6348)	4.95
74S474	24	512x8	PROM T.S. (DM87S296N)	4.95
74S475	24	512x8	PROM O.C. (6340)	4.95
74S478	24	1024x8	PROM T.S. (TBP28S86)	8.95
74S570	16	512x4	PROM O.C. (6305)	2.95
74S571	16	512x4	PROM T.S. (6306)	2.95
74S572	18	1024x4	PROM O.C. (6352)	4.95
74S573	18	1024x4	PROM T.S. (82S137)	4.95
82S23	16	32x8	PROM O.C. (27S18)	2.95
82S115	24	512x8	PROM T.S. (27S15)	9.95
82S123	16	32x8	PROM T.S. (27S19)	2.95
82S126	16	256x4	PROM O.C. (27S20)	3.95
82S129	16	256x4	PROM T.S. (27S21)	3.95
82S130	16	512x4	PROM O.C. (27S12)	5.95
82S185	18	2048x4	PROM T.S. (TBP24S81)	9.95
DM87S180N	24	1024x8	PROM O.C. (82S180)	9.95
DM87S181N	24	1024x8	PROM T.S. (82S181)	9.95
DM87S184N	18	2048x4	PROM O.C. (82S184)	9.95
DM87S185N	18	2048x4	PROM T.S. (82S185)	9.95
DM87S190N	24	2048x4	PROM O.C. (82S190)	19.95
DM87S191N	24	2048x8	PROM T.S. (82S191)	19.95

DATA ACQUISITION

Part No.	**Pins	Function	Price
DC10		Mostek DC/DC Convert. +5V to -9V	2.95
MC3470P	18	Floppy Disk Read AMP System	4.95
MC1408L7	16	7-bit D/A Converter (DAC0807LCN)	2.49
MC1408L8	16	8-bit D/A Converter (DAC0808LCN)	2.95
ADC0804	20	8-bit A/D Converter (1 LSB)	3.49
DAC0806	16	8-bit D/A Converter (0.78% Lin.)	1.95
ADC0809	28	8-bit A/D Converter (8-Ch. Multi.)	4.49
AY-5-1013A	40	30K BAUD UART (TR1602)	4.95

INTERSIL

*Evaluation Kits

Part No.	**Pins	Function		Price
7045IPI	28	CMOS Precision Timer		14.95
7045EV/Kit*	28	Stopwatch Chip, XTL		19.95
7106CPL	40	3½ Digit A/D (LCD Drive)		9.95
7106EV/Kit*	40	IC, Circuit Board, Display		34.95
7107CPL	40	3½ Digit A/D (LED Drive)		11.95
7107EV/Kit*	40	IC, Circuit Board, Display		29.95
7116CPL	40	3½ Digit A/D LCD Dis. HLD		16.95
7117CPL	40	3½ Digit A/D LED Dis. HLD		15.95
7201IUS		Low Battery Volt Indicator		2.25
7205IPG	24	CMOS LED Stopwatch/Timer		12.95
7205EV/Kit*	24	Stopwatch Chip, XTL		14.95
7206CJPE	16	Tone Generator		4.95
7206CEV/Kit*	16	Tone Generator Chip, KTL		7.95
7207AIPD	14	Oscillator Controller		5.95
7207AEV/Kit*	14	Freq. Counter Chip, XTL		7.95
7208IPI	28	Seven Decade Counter		15.95
7209IPA	8	Clock Generator		3.95
7215IPG	24	4 Func. CMOS Stopwatch CKT		13.95
7215EV/Kit*	24	4 Func. Stopwatch Chip, XTL		14.95
7216AIJI	28	8 Digit Univ. Counter C.A.		29.95
7216CIJI	28	8 Digit Freq. Counter C.A.		24.95
7216DIPI	28	8 Digit Freq. Counter C.C.		19.95
7217IJI	28	4 Digit LED Up/Down Counter C.A.		10.95
7217AIPI	28	4 Digit LED Up/Down Counter C.C.		11.95
7224IPL	40	LCD 4½ Digit Up Counter DRI		10.95
7226AIJL	40	8 Digit Univ. Counter		29.95
7226AEV/Kit*	40	5 Function Counter Chip, XTL		74.95
7240IJE	16	CMOS Bin Prog. Timer/Counter		4.95
7242IJA	8	CMOS Divide-by-256 RC Timer		2.25
7250IJE	16	CMOS BCD Prog. Timer/Counter		6.00
7260IJE	16	CMOS BCD Prog. Timer/Counter		5.25
7555IPA	8	CMOS 555 Timer		1.45
7556IPD	14	CMOS 556 Timer		2.20
7611BCPA	8	CMOS Op Amp Comparator	5MV	2.25
7612BCPA	8	CMOS Op Amp Ext. Cmvr.	5MV	2.95
7621BCPA	8	CMOS Dual Op Amp Comp.	5MV	3.95
7631CCPE	16	CMOS Tri Op Amp Comp.	10MV	5.35
7641CCPD	14	CMOS Quad Op Amp Comp.	10MV	7.50
7642CCPD	14	CMOS Quad Op Amp Comp.	10MV	7.50
7660CPA	8	Voltage Converter		2.95
8038CCPD	14	Waveform Generator		3.95
8048CCPE	16	Monolithic Logarithmic Amp		16.95
8069CCQ		50ppm Band—GAP Volt Ref. Diode		2.50
8211CPA	8	Volt Ref/Indicator		2.95
8212CPA	24	Volt Ref/Indicator		2.95
30009		1983 Intersil Data Book (1358 pages)		$9.95

74C—C/MOS

74C00	14	.35
74C02	14	.35
74C04	14	.29
74C08	14	.35
74C10	14	.35
74C14	14	.59
74C20	14	.35
74C30	14	.35
74C32	14	.39
74C42	16	1.39
74C48	16	1.95
74C73	14	.79
74C74	14	.69
74C85	16	1.95
74C86	14	.39
74C89	16	5.95
74C90	14	1.19
74C93	14	1.19

74C95	14	1.39
74C107	14	.89
74C151	16	2.49
74C154	24	3.49
74C157	16	2.25
74C160	16	1.19
74C161	16	1.19
74C162	16	1.19
74C163	16	1.19
74C164	14	1.49
74C173	16	.79
74C174	16	1.19
74C175	16	1.19
74C192	16	1.49
74C193	16	1.69
74C195	16	1.39

74C221	16	1.95
74C240	20	1.95
74C244	20	1.95
74C373	20	2.49
74C374	20	2.49
74C901	14	.59
74C903	14	.59
74C906	14	.59
74C911	28	8.95
74C912	28	8.95
74C915	18	1.19
74C917	28	8.95
74C922	18	4.49
74C923	20	4.95
74C925	16	5.95
74C926	18	5.95
80C95	16	.39
80C97	16	.39

NEW PRODUCT! 74HC High Speed CMOS

74HC00	14	.75
74HC02	14	.75
*74HCU04	14	.75
74HC08	14	.75
74HC10	14	.75
74HC20	14	.75
74HC27	14	.75
74HC74	14	.99
74HC75	16	.99
74HC86	14	.99
74HC109	16	1.39

74HC138	16	1.49
74HC139	16	1.49
74HC147	16	1.19
74HC151	16	1.19
74HC157	16	1.19
74HC160	16	1.79
74HC161	16	1.79
74HC164	14	1.79
74HC174	16	1.39
74HC175	16	1.39
74HC242	14	2.79

74HC243	14	2.79
74HC251	16	1.19
74HC266	14	.99
74HC280	14	4.95
74HC373	20	3.95
74HC374	20	3.95
74HC533	20	3.95
74HC534	20	3.95
74HC4075	14	.75
74HC4538	16	2.95
74HC4543	16	4.95

*74HCU04 is unbuffered. All others are buffered. Send $.30 for Data Sheet.

NEW Programmable Array Logic (PALS)

Part No.	**Pins	Function	Price
PAL10H8	20	Octal 10-Input AND-OR Gate Array (High Output)	$5.95
PAL12H6	20	Hex 12-Input AND-OR Gate Array (High Output)	5.95
PAL14H4	20	Quad 14-Input AND-OR Gate Array (High Output)	5.95
PAL10L8	20	Octal 10-Input AND-OR-Invert Gate Array (Low Output)	5.95
PAL12L6	20	Hex 12-Input AND-OR-Invert Gate Array (Low Output)	5.95
PAL14L4	20	Quad 14-Input AND-OR-Invert Gate Array (Low Output)	5.95
PAL16L8	20	Octal 16-Input AND-OR-Invert Gate Array (Low Output)	9.95
PAL16R8	20	Octal 16-Input Register AND-OR Gate Array	9.95
PAL16R6	20	Hex 16-Input Register AND-OR Gate Array	9.95
PAL16R4	20	Quad 16-Input Register AND-OR Gate Array	9.95
30012		1982 National PAL Data Book (176 pages)	$5.95

LINEAR

TL071CP	8	.79
TL072CP	8	1.39
TL074CN	14	1.95
TL081CP	8	.59
TL082CP	8	1.19
TL084CN	14	1.95
LM301CN	8	.35
LM302H		1.95
LM304H		1.95
LM305H		.99
LM307CN	8	.45
LM308CN	8	.69
LM309K		1.25
LM310CN	8	1.75
LM311CN	8	.69
LM312H		2.49
LM317T		1.19
LM317K		3.95
LM318CN	8	1.95
LM319N	14	1.95
LM320K-5		1.35
LM320K-12		1.35
LM320K-15		1.35
LM320T-5		.89
LM320T-12		.89
LM320T-15		.89
LM323K		5.95
LM324N	14	.59
LM337T		1.95
LM338K		6.95
LM339N	14	.69
LM340K-5		1.35
LM340K-12		1.35

LM340K-15		1.35
LM340T-5		.79
LM340T-12		.79
LM340T-15		.79
LM348N	14	.99
LM350K		4.95
LF355N	8	1.10
LF356N	8	1.10
LM370N	14	4.49
LM373N	14	3.95
LM377N	14	1.95
LM380N	14	.89
LM381N	14	1.79
LM382N	14	1.39
LM384N	14	1.79
LM386N-3	8	.89
TL494CN	16	2.95
TL496CP	8	1.19
NE510A	14	4.95
NE529A	14	2.95
NE531V	8	2.95
NE536H		8.95
NE540H		4.95
NE544N	14	2.95
NE550A	14	1.95
NE555V	8	.35
LM556N	14	.69
NE564N	16	2.95
LM565N	14	1.19
LM566CN	8	1.49
LM567V	8	.89

NE570N	16	3.95
LM703CN	8	1.19
LM709N	14	.49
LM710N	14	.69
LM711N	14	.79
LM723N	14	.55
LM733N	14	1.00
LM739N	14	1.95
LM741CN	8	.35
LM747N	14	.69
LM748N	8	.59
LM1310N	14	1.49
LM1458CN	8	.59
LM1488N	14	.69
LM1489N	14	.69
LM1496N	14	1.95
LM1800N	16	1.49
LM1889N	18	1.95
LM1896N	14	2.95
LM2002T		1.49
LM3189N	16	1.59
LM3900N	14	.59
LM3905CN	8	1.19
LM3909N	8	.99
LM3914N	18	3.49
LM3915N	18	3.49
LM3916N	18	3.49
RC4136N	14	1.25
RC4151NB	8	1.95
ICL8038B	14	3.95
LM13080N	8	1.19
LM13600N	16	1.19

MORE AVAILABLE

CONNECTORS

DB25 — D Subminiature (meets RS232)

Part No.	Description	Price
DE9P	9 Pin Plug	$1.79
DE9S	9 Pin Socket	1.95
DA15P	15 Pin Plug	1.95
DA15S	15 Pin Socket	2.95
DB25P	25 Pin Plug (Meets RS232)	2.49
DB25S	25 Pin Socket (Meets RS232)	3.25
DB25P-831	25 Pin Right Angle Plug	4.95
DB25S-831	25 Pin Right Angle Socket	5.25
DC37P	37 Pin Plug	4.75
DC37S	37 Pin Socket	5.95
DD50P	50 Pin Plug	5.95
DD50S	50 Pin Socket	6.95

Accessories

Part No.	Description	Price
DE-9H	Hood for DE-9 Series Connectors	$1.19
DA-15H	Hood for DA-15 Series Connectors	1.19
DB25H	Hood for DB25 Series Connectors	1.25
DC37H	Hood for DC37 Series Connectors	1.29
DD50H	Hood for DD50 Series Connectors	1.49
D20418-2	2 screws for mtg. connectors to a panel	.79

Solder Eyelet/Wire Wrap Edge Card

Part No.	Cnts.	Sp.	Description	Price
15/30SE	15/30	.156	Solder Eyelet	$1.79
18/36SE	18/36	.156	Solder Eyelet	1.95
22/44SE	22/44	.156	Solder Eyelet	2.49
22/44PC	22/44	.156	PC type (no mtg. ears)	.99
50/100SE	50/100	.125	Solder Eyelet	9.95
22/44WW	22/44	.156	Wire Wrap - Level 3	4.95
67031-5	22/44	.156	WW (Pins .0625x.03x.75)	3.95
R-681-1	50/100	.125	Wire Wrap - Level 3	7.95
R-681-2	50/100	.125	Wire Wrap - Level 1	6.95

RF Coaxial Connectors

Part No.	Description	Price
PL259	UHF Plug	$.89
SO239	UHF Panel Receptacle	.69
PL258	UHF Straight Adapter	.69
UG175/U	UHF Reducing Adapter	.49
UG88/U	BNC Plug	1.49
UG89/U	BNC Jack	1.59
UG306/U	BNC Angle Adapter	2.49
UG260/U	BNC Plug	1.49
UG1094/U	BNC Bulkhead Receptacle	.89

IC SOCKETS

For Socket Required, See Column After The IC Part No.

LOW PROFILE (TIN) SOCKETS

	1-9	10-99	100-999
8 pin LP	.16	.14	.13
14 pin LP	.17	.15	.14
16 pin LP	.19	.17	.16
18 pin LP	.26	.24	.23
20 pin LP	.30	.27	.25
22 pin LP	.31	.28	.26
24 pin LP	.33	.30	.28
28 pin LP	.40	.37	.35
36 pin LP	.48	.45	.42
40 pin LP	.49	.46	.43

— Soldertail Standard Tin & Gold Also Available —

WIRE WRAP (GOLD) SOCKETS LEVEL #3

	1-9	10-99	100-999
8 pin WW	.49	.45	.42
10 pin WW	.65	.62	.59
14 pin WW	.65	.62	.59
16 pin WW	.69	.65	.61
18 pin WW	.89	.85	.79
20 pin WW	1.09	1.05	.99
22 pin WW	1.25	1.19	1.15
24 pin WW	1.29	1.23	1.18
28 pin WW	1.59	1.50	1.45
36 pin WW	1.85	1.75	1.69
40 pin WW	1.99	1.89	1.79

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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

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

Circle 236 on inquiry card.

4164 64K DYNAMIC 200 NS $6.25

TMM2016 2KX8 STATIC 200 NS $4.15

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STATIC RAMS

2101	256 x 4 (450ns)	1.95
5101	256 x 4 (450ns) (cmos)	3.95
2102-1	1024 x 1 (450ns)	.89
2102L-4	1024 x 1 (450ns) (LP)	1.29
2102L-2	1024 x 1 (250ns) (LP)	1.69
2111	256 x 4 (450ns)	2.99
2112	256 x 4 (450ns)	2.99
2114	1024 x 4 (450ns)	8/14.95
2114L-4	1024 x 4 (450ns) (LP)	8/15.25
2114L-3	1024 x 4 (300ns) (LP)	8/15.45
2114L-2	1024 x 4 (200ns) (LP)	8/15.95
2147	4096 x 1 (55ns)	4.95
TMS4044-4	4096 x 1 (450ns)	3.49
TMS4044-3	4096 x 1 (300ns)	3.99
TMS4044-2	4096 x 1 (200ns)	4.49
MK4118	1024 x 8 (250ns)	9.95
TMM2016-200	2048 x 8 (200ns)	4.15
TMM2016-150	2048 x 8 (150ns)	4.95
TMM2016-100	2048 x 8 (100ns)	6.15
HM6116-4	2048 x 8 (200ns) (cmos)	4.95
HM6116-3	2048 x 8 (150ns) (cmos)	5.95
HM6116-2	2048 x 8 (120ns) (cmos)	8.95
HM6116LP-4	2048 x 8 (200ns) (cmos)(LP)	6.95
HM6116LP-3	2048 x 8 (150ns) (cmos)(LP)	8.95
HM6116LP-2	2048 x 8 (120ns) (cmos)(LP)	10.95
Z-6132	4096 x 8 (300ns) (Qstat)	34.95

LP = Low Power Qstat = Quasi-Static

DYNAMIC RAMS

TMS4027	4096 x 1 (250ns)	1.99
MK4108	8192 x 1 (200ns)	1.95
MM5298	8192 x 1 (250ns)	1.85
4116-300	16384 x 1 (300ns)	8/11.75
4116-250	16384 x 1 (250ns)	8/11.95
4116-200	16384 x 1 (200ns)	8/13.95
4116-150	16384 x 1 (150ns)	8/15.95
4116-120	16384 x 1 (120ns)	8/29.95
2118	16384 x 1 (150ns) (5v)	4.95
MK4816	2048 x 8 (300ns) (5v)	24.95
4164-200	65536 x 1 (200ns) (5v)	6.25
4164-150	65536 x 1 (150ns) (5v)	7.25

5V = single 5 volt supply

EPROMS

1702	256 x 8 (1us)	4.50
2708	1024 x 8 (450ns)	3.95
2758	1024 x 8 (450ns) (5v)	5.95
2716	2048 x 8 (450ns) (5v)	3.95
2716-1	2048 x 8 (350ns) (5v)	6.25
TMS2716	2048 x 8 (450ns)	7.95
TMS2532	4096 x 8 (450ns) (5v)	7.95
2732	4096 x 8 (450ns) (5v)	4.95
2732-250	4096 x 8 (250ns) (5v)	12.95
2732-200	4096 x 8 (200ns) (5v)	16.95
2764	8192 x 8 (450ns) (5v)	16.95
2764-250	8192 x 8 (250ns) (5v)	18.95
2764-200	8192 x 8 (200ns) (5v)	19.95
TMS2564	8192 x 8 (450ns) (5v)	24.95
MC68764	8192 x 8 (450ns) (5v)(24 pin)	call

5v = Single 5 Volt Supply

EPROM ERASERS

	Timer	Capacity Chip	Intensity (uW/Cm²)	
PE-14		6	5,200	83.00
PE-14T	X	6	5,200	119.00
PE-24T	X	9	6,700	175.00
PL-265T	X	20	6,700	255.00
PR-125T	X	16	15,000	349.00
PR-320	X	32	15,000	595.00

DISC CONTROLLERS

1771	16.95
1791	29.95
1793	38.95
1795	54.95
1797	54.95
6843	34.95
8272	39.95
UPD765	39.95
1691	18.95
2143	18.95

INTERFACE

8T26	1.69
8T28	2.49
8T95	.99
8T96	.99
8T97	.99
8T98	.99
DM8131	2.95
DP8304	2.29
DS8835	1.99
DS8836	.99

MISC.

3242	7.95
3341	4.95
MC3470	4.95
MC3480	9.00
11C90	13.95
95H90	7.95
2513-001 UP	9.95
2513-002 LOW	9.95

SOUND CHIPS

76477	3.95
76489	8.95
AY3-8910	12.95
MC3340	1.49

CRT CONTROLLERS

6845	14.95
68B45	35.95
HD46505SP	15.95
6847	12.25
68047	24.95
8275	29.95
7220	99.95
CRT5027	39.95
CRT5037	49.95
DP8350	49.95

BIT-RATE GENERATORS

MC14411	11.95
BR1941	11.95
4702	12.95
COM5016	16.95
COM8116	10.95
MM5307	10.95

UARTS

AY3-1014	6.95
AY5-1013	3.95
PT1472	9.95
TR1602	3.95
2350	9.95
2651	8.95
TMS6011	5.95
IM6402	7.95
IM6403	8.95
INS8250	14.95

KEYBOARD CHIPS

AY5-2376	11.95
AY5-3600	11.95
74C922	See 74C00
74C923	Series Prices

CLOCK CIRCUITS

MM5314	4.95
MM5369	3.95
MM5375	4.95
MM58167	8.95
MM58174	11.95
MSM5832	6.95

Z-80

2.5 Mhz

Z80-CPU	3.95
Z80-CTC	5.95
Z80-DART	15.25
Z80-DMA	17.50
Z80-PIO	5.75
Z80-SIO/0	18.50
Z80-SIO/1	18.50
Z80-SIO/2	18.50
Z80-SIO/9	16.95

4.0 Mhz

Z80A-CPU	6.00
Z80A-CTC	8.65
Z80A-DART	18.75
Z80A-DMA	27.50
Z80A-PIO	6.00
Z80A-SIO/0	22.50
Z80A-SIO/1	22.50
Z80A-SIO/2	22.50
Z80A-SIO/9	19.95

6.0 Mhz

Z80B-CPU	17.95
Z80B-CTC	15.50
Z80B-PIO	15.50

ZILOG

Z6132	34.95
Z8671	39.95

CRYSTALS

32.768 khz	1.95
1.0 mhz	4.95
1.8432	4.95
2.0	3.95
2.097152	3.95
2.4576	3.95
3.2768	3.95
3.579535	3.95
4.0	3.95
5.0	3.95
5.0688	3.95
5.185	3.95
5.7143	3.95
6.0	3.95
6.144	3.95
6.5536	3.95
8.0	3.95
10.7836	3.95
14.31818	3.95
15.0	3.95
16.0	3.95
18.0	3.95
18.432	3.95
20.0	3.95
22.1184	3.95
32.0	3.95

DATA ACQUISITION

ADC0800	15.55
ADC0804	3.49
ADC0809	4.49
ADC0817	9.95
DAC0800	4.95
DAC0806	1.95
DAC0808	2.95
DAC1020	8.25
DAC1022	5.95
MC1408L6	1.95
MC1408L8	2.95

8000

8035	5.95
8039	6.95
INS-8060	17.95
INS-8073	24.95
8080	3.95
8085	5.95
8085A-2	11.95
8086	29.95
8087	CALL
8088	39.95
8089	89.95
8155	7.95
8156	8.95
8185	29.95
8185-2	39.95
8741	39.95
8748	29.95
8755	32.00

8200

8202	29.95
8203	39.95
8205	3.50
8212	1.80
8214	3.85
8216	1.75
8224	2.25
8226	1.80
8228	3.49
8237	19.95
8238	4.49
8243	4.45
8250	10.95
8251	4.49
8253	6.95
8253-5	7.95
8255	4.49
8255-5	5.25
8257	7.95
8257-5	8.95
8259	6.90
8259-5	7.50
8272	39.95
8275	29.95
8279	8.95
8279-5	10.00
8282	6.50
8283	6.50
8284	5.50
8286	6.50
8287	6.50
8288	25.00
8289	49.95

FUNCTION GENERATORS

MC4024	3.95
LM566	1.49
XR2206	3.75
8038	3.95

INTERSIL

ICL7103	9.50
ICL7106	9.95
ICL7107	12.95
ICL8038	3.95
ICM7107A	5.59
ICM7208	15.95

6800

68000	99.95
6800	4.95
6802	7.95
6808	13.90
6809E	19.95
6809	12.95
6810	2.95
6820	4.95
6821	3.25
6828	14.95
6840	12.95
6843	34.95
6844	25.95
6845	14.95
6847	12.25
6850	3.45
6852	5.75
6860	9.95
6862	11.95
6875	6.95
6880	2.25
6883	24.95
68047	24.95
68488	19.95

6800 = 1MHZ

68B00	10.95
68B02	22.25
68B09E	29.95
68B09	29.95
68B10	7.95
68B21	12.95
68B45	35.95
68B50	12.95

68B00 = 2 MHZ

6500

1 MHZ

6502	5.95
6504	6.95
6505	8.95
6507	9.95
6520	4.35
6522	8.75
6532	11.25
6545	22.50
6551	11.85

2 MHZ

6502A	9.95
6522A	11.70
6532A	12.40
6545A	28.50
6551A	12.95

3 MHZ

6502B	14.95

EXAR

XR 2206	3.75
XR 2207	3.85
XR 2208	3.90
XR 2211	5.25
XR 2240	3.25

9000 SERIES

9316	1.00
9334	2.50
9368	3.95
9401	9.95
9601	.75
9602	1.50
96S02	1.95

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Circle 237 on inquiry card.

2716 16K EPROMS $3.95 EACH

2732 32K EPROMS $4.95 EACH

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74LS00

74LS00	.24	74LS86	.39	74LS169	1.75	74LS323	2.75
74LS01	.25	74LS90	.55	74LS170	1.49	74LS324	1.75
74LS02	.25	74LS91	.89	74LS173	.69	74LS352	1.29
74LS03	.25	74LS92	.55	74LS174	.55	74LS353	1.29
74LS04	.24	74LS93	.55	74LS175	.55	74LS363	1.35
74LS05	.25	74LS95	.75	74LS181	2.15	74LS364	1.95
74LS08	.28	74LS96	.89	74LS189	8.95	74LS365	.49
74LS09	.29	74LS107	.39	74LS190	.89	74LS366	.49
74LS10	.25	74LS109	.39	74LS191	.89	74LS367	.45
74LS11	.35	74LS112	.39	74LS192	.79	74LS368	.45
74LS12	.35	74LS113	.39	74LS193	.79	74LS373	.99
74LS13	.45	74LS114	.39	74LS194	.69	74LS374	.99
74LS14	.59	74LS122	.45	74LS195	.69	74LS377	1.39
74LS15	.35	74LS123	.79	74LS196	.79	74LS378	1.18
74LS20	.25	74LS124	2.90	74LS197	.79	74LS379	1.35
74LS21	.29	74LS125	.49	74LS221	.89	74LS385	1.90
74LS22	.25	74LS126	.49	74LS240	.95	74LS386	.45
74LS26	.29	74LS132	.59	74LS241	.99	74LS390	1.19
74LS27	.29	74LS133	.59	74LS242	.99	74LS393	1.19
74LS28	.35	74LS136	.39	74LS243	.99	74LS395	1.19
74LS30	.25	74LS137	.99	74LS244	.99	74LS399	1.49
74LS32	.29	74LS138	.55	74LS245	1.49	74LS424	2.95
74LS33	.55	74LS139	.55	74LS247	.75	74LS447	.37
74LS37	.35	74LS145	1.20	74LS248	.99	74LS490	1.95
74LS38	.35	74LS147	2.49	74LS249	.99	74LS624	3.99
74LS40	.25	74LS148	1.35	74LS251	.59	74LS668	1.69
74LS42	.49	74LS151	.55	74LS253	.59	74LS669	1.89
74LS47	.75	74LS153	.55	74LS257	.59	74LS670	1.49
74LS48	.75	74LS154	1.90	74LS258	.59	74LS674	9.65
74LS49	.75	74LS155	.69	74LS259	2.75	74LS682	3.20
74LS51	.25	74LS156	.69	74LS260	.59	74LS683	3.20
74LS54	.29	74LS157	.65	74LS266	.55	74LS684	3.20
74LS55	.29	74LS158	.59	74LS273	1.49	74LS685	3.20
74LS63	1.25	74LS160	.69	74LS275	3.35	74LS688	2.40
74LS73	.39	74LS161	.65	74LS279	.49	74LS689	3.20
74LS74	.35	74LS162	.69	74LS280	1.98	74LS783	24.95
74LS75	.39	74LS163	.65	74LS283	.69	81LS95	1.49
74LS76	.39	74LS164	.69	74LS290	.89	81LS96	1.49
74LS78	.49	74LS165	.95	74LS293	.89	81LS97	1.49
74LS83	.60	74LS166	1.95	74LS295	.99	81LS98	1.49
74LS85	.69	74LS168	1.75	74LS298	.89	25LS2521	2.80
						25LS2569	4.25

IC SOCKETS

	1-99	100
8 pin ST	.13	.11
14 pin ST	.15	.12
16 pin ST	.17	.13
18 pin ST	.20	.18
20 pin ST	.29	.27
22 pin ST	.30	.27
24 pin ST	.30	.27
28 pin ST	.40	.32
40 pin ST	.49	.39
ST = SOLDERTAIL		
8 pin WW	.59	.49
14 pin WW	.69	.52
16 pin WW	.69	.58
18 pin WW	.99	.90
20 pin WW	1.09	.98
22 pin WW	1.39	1.28
24 pin WW	1.49	1.35
28 pin WW	1.69	1.49
40 pin WW	1.99	1.80
WW = WIREWRAP		
16 pin ZIF	6.75	call
24 pin ZIF	9.95	call
ZIF = TEXTOOL (Zero Insertion Force)		

CONNECTORS

RS232 MALE	2.95
RS232 FEMALE	3.50
RS232 FEMALE RIGHT ANGLE	5.25
RS232 HOOD	1.25
S-100 ST	3.95
S-100 WW	4.95

DIP SWITCHES

4 POSITION	.85
5 POSITION	.90
6 POSITION	.90
7 POSITION	.95
8 POSITION	.95

7400

7400	.19	74132	.45
7401	.19	74136	.50
7402	.19	74141	.65
7403	.19	74142	2.95
7404	.19	74143	2.95
7405	.25	74145	.60
7406	.29	74147	1.75
7407	.29	74148	1.20
7408	.24	74150	1.35
7409	.19	74151	.55
7410	.19	74152	.65
7411	.25	74153	.55
7412	.30	74154	1.25
7413	.35	74155	.75
7414	.49	74156	.65
7416	.25	74157	.55
7417	.25	74159	1.65
7420	.19	74160	.85
7421	.35	74161	.69
7422	.35	74162	.85
7423	.29	74163	.69
7425	.29	74164	.85
7426	.29	74165	.85
7427	.29	74166	1.00
7428	.45	74167	2.95
7430	.19	74170	1.65
7432	.29	74172	5.95
7433	.45	74173	.75
7437	.29	74174	.89
7438	.29	74175	.89
7440	.19	74176	.89
7442	.49	74177	.75
7443	.65	74178	1.15
7444	.69	74179	1.75
7445	.69	74180	.75
7446	.69	74181	2.25
7447	.69	74182	.75
7448	.69	74184	2.00
7450	.19	74185	2.00
7451	.23	74186	18.50
7453	.23	74190	1.15
7454	.23	74191	1.15
7460	.23	74192	.79
7470	.35	74193	.79
7472	.29	74194	.85
7473	.34	74195	.85
7474	.33	74196	.79
7475	.45	74197	.75
7476	.35	74198	1.35
7480	.59	74199	1.35
7481	1.10	74221	1.35
7482	.95	74246	1.35
7483	.50	74247	1.25
7485	.59	74248	1.85
7486	.35	74249	1.95
7489	2.15	74251	.75
7490	.35	74259	2.25
7491	.40	74265	1.35
7492	.50	74273	1.95
7493	.35	74276	1.25
7494	.65	74279	.75
7495	.55	74283	2.00
7496	.70	74284	3.75
7497	2.75	74285	3.75
74100	1.75	74290	.95
74107	.30	74293	.75
74109	.45	74298	.85
74110	.45	74351	2.25
74111	.55	74365	.65
74116	1.55	74366	.65
74120	1.20	74367	.65
74121	.29	74368	.65
74122	.45	74376	2.20
74123	.49	74390	1.75
74125	.45	74393	1.35
74126	.45	74425	3.15
74128	.55	74426	.85
		74490	2.55

CMOS

4000	.29	4528	1.19
4001	.25	4531	.95
4002	.25	4532	1.95
4006	.89	4538	1.95
4007	.29	4539	1.95
4008	.95	4543	1.19
4009	.39	4555	.95
4010	.45	4556	.95
4011	.25	4581	1.95
4012	.25	4582	1.95
4013	.38	4584	.75
4014	.79	4585	.75
4015	.39	4702	12.95
4016	.39	74C00	.35
4017	.69	74C02	.35
4018	.79	74C04	.35
4019	.39	74C08	.35
4020	.75	74C10	.35
4021	.79	74C14	.59
4022	.79	74C20	.35
4023	.29	74C30	.35
4024	.65	74C32	.39
4025	.29	74C42	1.29
4026	1.65	74C48	1.99
4027	.45	74C73	.65
4028	.69	74C74	.65
4029	.79	74C76	.80
4030	.39	74C83	1.95
4034	1.95	74C85	1.95
4035	.85	74C86	.39
4040	.75	74C89	4.50
4041	.75	74C90	1.19
4042	.69	74C93	1.75
4043	.85	74C95	.99
4044	.79	74C107	.89
4046	.85	74C150	5.75
4047	.95	74C151	2.25
4049	.35	74C154	3.25
4050	.35	74C157	1.75
4051	.79	74C160	1.19
4053	.79	74C161	1.19
4060	.89	74C162	1.19
4066	.39	74C163	1.19
4068	.39	74C164	1.39
4069	.29	74C165	2.00
4070	.35	74C173	.79
4071	.29	74C174	1.19
4072	.29	74C175	1.19
4073	.29	74C192	1.49
4075	.29	74C193	1.49
4076	.79	74C195	1.39
4078	.29	74C200	5.75
4081	.29	74C221	1.75
4082	.29	74C373	2.45
4085	.95	74C374	2.45
4086	.95	74C901	.39
4093	.49	74C902	.85
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4099	1.95	74C905	10.95
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74S20	.35	74S195	1.49
74S22	.35	74S196	1.49
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74S51	.35	74S244	2.20
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LM311	.64	LM378	2.50	NE592	2.75	LM1877	3.25
LM311H	.89	LM379	4.50	LM703	.89	LM1889	1.95
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H = TO-5 CAN T = TO-220 K = TO-3

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75150	1.95	75454	.39
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75189	1.25	75493	.89
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T = TO-220 K = TO-3
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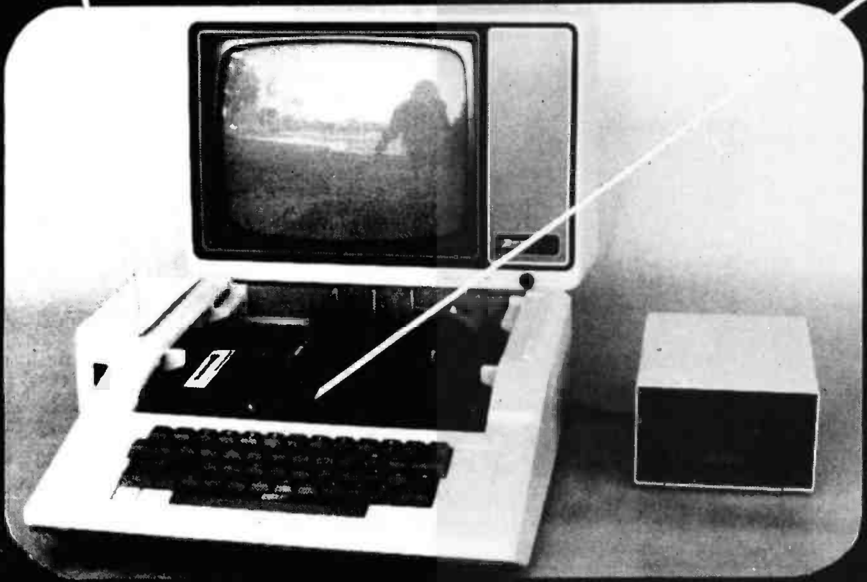

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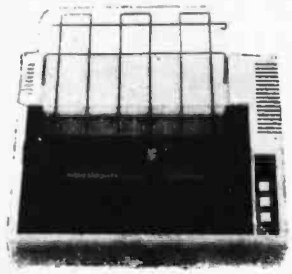

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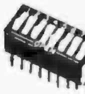

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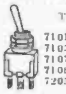
7	.99	.83	.70
8	1.05	.91	.87
12	1.19	.99	.91



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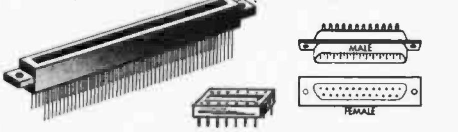
7103	on/off/on	1.39	1.19
7107	mnt. on	1.39	1.19
7108	mnt. on	1.39	1.19
7205	dpdt mnt	1.85	1.65

CONNECTORS



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DA15S female	3.25	3.10	2.90
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DB25P male	2.50	2.35	2.25
DB25S female	3.35	3.15	3.05
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Shugart 851R	MSD2851	1450
Olivetti 802	CAL2802	$1250
Qume DT8	MSD8DT	1450

ECLIPSE 100 $695

INDUSTRIAL S-100 MAINFRAME

Suitable for hospital and industrial applications. Constructed from 304 brushed stainless. Modular 500 watt toroid power supply provides +8volts at 30Amps and ±16volts at 4Amps. Supplied with standard 18 slot Faraday mother board. Auxilary switched AC receptacles. The Eclipse 100 can be either table or rack mounted. Provisions for internally mounting a ten megabyte Winchester disk drive.
The Eclipse 100 is the perfect mainframe to fill the void left by the now defunct TEI Corp. EPS-100 50 Lbs.

VISA
master charge

All merchandise sold by California Digital is premium grade.
Shipping: First five pounds $3.00. Each additional $.50.
Foreign orders: 10% shipping. Excess will be refunded.
California residents add 6½% sales tax. COD's discouraged.
Open accounts extended to state supported educational institutions and companies with a "strong" Dun & Bradstreet.
Warehouse: 15608 Inglewood Blvd. Visitors by appointment.

**TOLL FREE ORDER LINE
(800)421-5041
TECHNICAL & CALIFORNIA
(213)679-9001**

California Digital

Post Office Box 3097 B • Torrance, California 90503

Super Buy $259

SIEMENS FDD 100-8 8'' DISK DRIVE

10 Drives $225 • 100 Drives $209

California Digital has recently participated in the purchase of several thousand Siemens FDD 100-8 floppy disk drives. These units are electronically and physically similar to that of the Shugart 801R disk drive. Any application that will accept an 801R will work with the Siemens FDD 100-8 drive.
All units are new and shipped in factory sealed boxes. Because of the extremely low price we expect a quick sell out. Please reserve your units early. SEA-F1008 17 lbs. Manual and connectors supplied free upon request. Also available: Two drive subsystem supplied in steel enclosure with power supply and fan. $750.00 CAL-2F1008

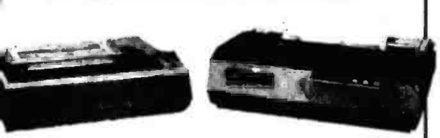
Scotch Diskettes

$19.95

FREE PLASTIC LIBRARY CASE

We have purchased the entire excess inventory of 5¼" Scotch brand diskettes form Digital Equipment Corporation. The diskettes are all single sided double density. Available in soft, ten and sixteen sectors. Like all diskettes purchased from California Digital, these are supplied in polypropylene library storage cases.
Take advantage of this one time offer and stock up for the winter. Prime Scotch diskettes priced below dealer cost. (Soft sector for Apple & IBM) MMM-SD7440 (ten sector) MMM--SD74410 (sixteen) MMM-SD74416 2 lbs.

PRINTERS



MATRIX PRINTERS

Okidata 82A serial & parallel 9.5" paper OKI-82A	459.00
Okidata 83A serial & parallel 15" paper OKI-83A	695.00
Okidata 84A parallel only 15" paper OKI-84AP	1,079.00
Okidata 84A serial & parallel 15" paper OKI-84AS	1,219.00
Epson MX80 with graphics and tractor feed EPS-MX80	
Epson MX80FT with graphics, friction & tractor feed EPS-MX80FT	539.00
Epson MX100 with graphics, 15" paper EPS-MX100	695.00
NEC 8023A parallel 9.5" paper, graphics NEC-8023A	489.00
Anadex 9500A high speed dot matrix printer 15" ADX-9500A	1,279.00
Anadex 9501A 15" paper with graphics ADX-9501A	1,279.00
Texas Instruments 810 serial 15" upper & lower case TEX-810L	1,299.00
Datasouth DS180 high speed 180 char/sec 15" DSI-180	1,295.00
Prowriter 8510 parallel 9.5" PRO-8510P	495.00
Prowriter 8510 serial 9.5" PRO-8510S	639.00
Prowriter II 15" paper PRO-2P	750.00
Printronix P300 high speed printer 300 lines/min. PTX-P300	4,500.00
Printronix P600 high speed printer 600 lines/min PTX-P600	6,150.00
IDS prism 80 column, graphics, (non-color) IDS-P80G	1,150.00
IDS prism 132 COLOR with graphics 15" paper IDS-P132CG	1,650.00
Mannesmann Tally 1805 200 cps serial MAN-1805	1,650.00

WORD PROCESSING PRINTERS

NEC7710 55 char/sec thimble, serial only NEC-7710	2,379.00
NEC7730 same as above parallel only NEC-7730	2,379.00
NEC3510 serial 15" NEC-3510	1,775.00
Diablo 620R101 25 cps serial DBL-620	1,270.00
Diablo 630 40 cps serial DBL-630	2,250.00
Smith Corona TP-1 daisy wheel parallel SCMTP1P	659.00
Smith Corona TP-1 daisy wheel serial SCM-TP1S	659.00
Brother HR11 daisy wheel printer parallel BTH-HR1P	855.00
Brother HR11 serial interface BTH-HR1S	895.00
Diablo 630 DBL-630	2,095.00
Starwriter F10 serial PRO-F10S	1,475.00
Starwriter F10 parallel PRO-F10P	1,475.00

MONITORS

Zenith Z121 green phosphor 12" 40/80 column switch ZTH-Z121	115.00
BMC 12A green phosphor 15 Mhz composit video BMC-12A	88.00
BMC 12EN green phosphor 20 Mhz high resolution BMC-12EN	139.00
NEC JB1201 green phosphor 18 Mhz composit video NEC-JB1201	169.00
NEC JB1260 green phosphor commercial grade composit NEC-1260	129.00
Motorola 23" open frame blk/white composit video MOT-BW23	159.00
Motorola 12" open frame blk/white requires horz sync & pow MOT-BW12	69.00
Conrac 9" open frame requires horz sync & power supply CON-BW9	59.00
(COLOR)	
NEC JC1201 composit color NEC-JC1201	325.00
NEC RGB monitor NEC-1202DM	875.00
BMC 13" Composit video BMC-1400CL	273.00
BMC 13" RGB color monitor BMC-1401RGB	329.00
BMC interface card for Apple II for above RGB BMC-81RGB	149.00
Comrex/Hitachi 13" RGB high res monitor COM-6600	539.00
Comrex/Hitachi 13" Composit color monitor COM-6500	395.00
Amdek color #1 composit video AMD-100	349.00
Amdek color #2 high res RGB color monitor AMD-200	739.00
Amdek color #3 commercial grade color RGB AMD-300	475.00

Direct Connect MODEMS

Hayes Micromodem 100 S-100 modem HYS-100	319.00
Hayes Smart Model RS232 HYS-232	229.00
Hayes Micromodem II Apple direct connect HYS-MM2	279.00
Hayes Chronograph time & date HYS-CHR232	199.00
Novation Cat acoustic connect NOV-CAT	149.00
Novation D Cat direct connect via handset NOV-DCAT	169.00
Novation 212 Autocat Bell 212A NOV-212	595.00
Novation Auto Cat 103 NOV-AUTO	219.00
Universal 103LP direct connect, line powered UDS-103LP	169.00
Universal 103LPJ direct connect, auto answer UDS-103LPJ	209.00
Universal 202 direct connect 1200 baud, half duplex UDS-202LP	189.00
Universal 212LP direct connect 1200 baud, full duplex UDS-212LP	450.00
Signalman Mark I direct connect with terminal cable SGL-MK1	89.00

TERMINALS

Ampex Dialogue 80 green screen, two page, function keys APX-D80C	795.00
Ampex Dialogue 80 amber screen, two page, function keys APX-D80A	795.00
Ampex Dialogue 80 green screen, Selectric keyboard APX-D81G	895.00
Ampex Dialogue 81 amber screen, Selectric keyboard APX-D81A	895.00
Ampex Touch Term screen command for data entry APX-T80	
Wyse horz & vert split screen, metal case, detatch keybd WYS-100	825.00
Televideo 910C emulator TVI-910C	595.00
Televideo 910 Plus block mode TVI-910P	595.00
Televideo 925C detatchable keyboard, 22 function keys TVI-925	795.00
Televideo 950 graphic char., split screen, 22 functions TVI-950	985.00
IBM 3101-10 detatchable keyboard, green IBM-3101	1,195.00
Zenith Z-19 keyboard ZTH-Z19	765.00
Adds Viewpoint A1 detatchable keyboard ADD-VP1	498.00
Adds Viewpoint A2 xy cursor, green screen ADD-VP2	595.00
Adds Viewpoint A3 emulator, ADD-VP3	575.00

APPLE 48K Plus $1195

APPLE BRAND PRODUCTS

APL-48P	Apple Plus 48K RAM	1,195.00
APL-DSK1	Apple disk with controller card	560.00
APL-DSK2	Apple disk without controller card.	495.00

XITEN

XTN-G10	Xiten 10 Megabyte Gallium hard disk	1,995.00
XTN-16K	16K RAM card for Apple II	69.00

RANA SYSTEMS

RAN-APL1	Apple add on disk drive with controller	525.00
RAN-APL2	Apple add on drive without controller	395.00

CALIFORNIA COMPUTER SYSTEMS

CCS-7710	Asynchronous Serial Interface	125.00
CCS-7728	Centronics Parallel Interface	95.00
CCS-7720	Apple Parallel Interface	95.00
CCS-7114	12K Rom/Prom Module	115.00
CCS-7424	Calendar/Clock Module	95.00
CCS-7440	Programmable Timer	95.00
CCS-7811B	Arithmetic Processor for Apple II plus	319.00

MOUNTAIN COMPUTERS, INC.

MTN-CPS	CPS Multifunction Card	169.00
MTN-TCLK	Clock/Calendar	
MTN-STLK	Supertalker SD200	149.00
MTN-ROMF	Rom Plus with Keyboard filter	169.00
MTN-ROMRTR	Rom Writer with Eprom socket	145.00
MTN-ADDA	A-D/D-A Converter	269.00
MTN-BSR	X-10 Control Card for BSR system	149.00

MICRO SOFT

MSF-SFTCRD	Microsoft Z-80 CPU card	249.00
MSF-16KRAM	Microsoft 16K RAM card	125.00

VISTA

VSA-A800	Vista 8" controller card	489.00
VSA-VIS80	Vista Vision 80	289.00
MCI-CNTRL	Micro Sci disk drive controller	89.00

FOURTH DIMENSION

FDN-SPRDRV	Super Drive-35 track Apple add on	329.00

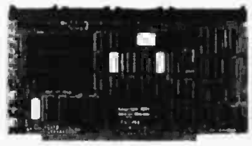
SORRENTO VALLEY ASSOC

SVA-221	Single sided, single density controller	360.00
SVA-222	Double sided, single density controller	360.00
SVA-223	Single or double sided, double density	475.00

ADVANCED BUSINESS TECH

ABT-13KEYN	13-Key pad for new Apple	95.00

S-100 BOARDS



16 BIT MICROPROCESSORS

GBT-8687	Godbout 8086/8087 Microprocessor board	495.00
GBT-8687	Godbout 8088/8085 dual 8 bit microprocessor	359.00
SEA-8086	Seattle Computer 16 bit micro two board set	669.00
TEC-8086	Tecmar Computer 16 bit microprocessor	595.00
LOM-8086	Lomas Data Systems Lighting One	call

SINGLE BOARD COMPUTERS

WAV-BLT1	Wavemate Bullet 1 with floppy, 256K (not S-100)	795.00
AMD-Z80	Advanced Micro Digital floppy & 64K	750.00
TEL-FDC1	Teletek FDC1 Single board NEC765 controller	675.00

8 BIT MICROPROCESSORS

GBT-Z80	Godbout Z80 8 bit CPU 24 bit extended address	250.00
CCS-2810	California Computer Z-80 microprocessor	275.00
SDS-SBC200	SD Systems SBC-200 Z-80 microprocessor	275.00
MSM-Z80	Measurement System Z-80 2810 microprocessor	425.00
TAR-Z80	Tarbell Electronics Z-80 with two RS232 ports	395.00

FLOPPY DISK CONTROLLERS

GBT-DSK1	Godbout Disk One double density NEC-765	395.00
MDS-DJ2	Morrow Designs Disk Jockey II with CPM	350.00
MDS-DJ1	Morrow Designs Disk Jockey I single density	225.00
CCS-2422	California Computer 2422 with CPM	339.00
TAR-DDC	Tarbell Electronics double density controller	419.00
TAR-SDC	Tarbell Electronics single density controller	279.00

CPM OPERATING SYSTEM

GBT-CPM22	Godbout CPM 2.2 for Disk One 8 bit operation	160.00
GBT-CPM860	Godbout CPM 86 for Disk One for use with 8088	265.00
GBT-CPM86	Godbout CPM 86 for operation with 8086 board	265.00

HARD DISK CONTROLLER

GBT-DSK2	Godbout Disk II hard disk controller	695.00
GBT-DSK3	Godbout Disk III hard disk controller	
MDS-W506	Morrow Designs Winchester for Seagate 506	495.00
WDI-1000	Western Digital WD-1000 (not S-100)	495.00

EPROM BOARDS

ADS-PB100	Ackerman Digital Prom Blaster 100	275.00
SDS-P100	SD Systems Prom-100 programmer	260.00
SSM-PB1	SSM Prom programmer up to 2716	195.00
DGR-P32	Digital Research 32K Eprom read only board	105.00

STATIC MEMORY BOARDS

CAL-S64	California Digital Static 64 8/16 bit (6167)	595.00
GBT-R16	Godbout Ram 16 64K memory 8/16 bit	760.00
GBT-R17	Godbout Ram 17 64K memory 8 bit 24 bit add	395.00
GBT-R20	Godbout Ram 20 32k static memory 4K bound	375.00
GBT-R21	Godbout Ram 21 128K 8/16 bit static memory	995.00
CCS-2116	California Comuter 2116 16K static memory	335.00

DYNAMIC MEMORY BOARDS

CAL-D256	California Digital 256K dynamic memory 8 bit	495.00
SDS-EX3	SD Systems Expandoram III 256K dynamic	795.00
CCS-2065	California Computers 2065 64K dynamic	395.00
MSM-DMB64	Measurement Systems DMB6400 (Alpha Micro)	595.00

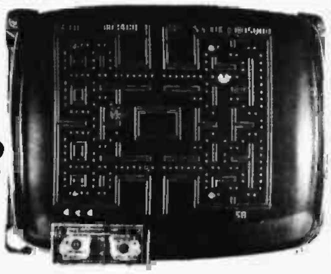
INTERFACE BOARDS

MDS-SW1	Morrow Designs Switchboard 2 serial/4 parallel	239.00
MDS-MTL1	Morrow Designs Multiboard 3 serial/2 parallel	275.00
GBT-133A	Godbout Interfacer I, 2 serial ports	199.00
GBT-150A	Godbout Interfacer II, 1 serial/3 parallel	199.00
GBT-135A	Godbout Interfacer III with 5 serial ports	495.00
GBT-138A	Godbout Interfacer III, with 8 serial ports	585.00
GBT-187A	Godbout Interfacer IV, 3 serial/2 parallel	295.00
CCS-2710	California Computer 4 port serial interface	295.00
CCS-2720	California Computer 2 serial / 2 parallel	295.00
CCS-2720	California Computer 4 port parallel	219.00

SPECIAL FUNCTION BOARDS

HYS-M100	D.C. Hayes Micromodem S-100 FCC approved	325.00
ADS-N100	Ackerman Digital Noisemaker with Vortrax module	119.00
OTC-CC100	OT Computer clock calendar board	135.00
SCN-M100	Scion Microangelo, graphics monochrome	965.00
GBT-SPC1	Godbout Spectrum 100 color video board	399.00
TEC-AD212	Tecmar A/D 12 bit accuracy, 16 channel	485.00
GBT-SYS1	Godbout System support board	350.00
GBT-SYS9511	Godbout System Support with 8231/9511 math chip	539.00
MUL-TB1	Mullins extender board with test probe	79.00
MUL-ICB10	Mullins Opto-isolator controls 8 channels	179.00
ADS-KG100	Ackerman Digital Kluge prototype board	149.00
IOT-W100	I/O Technology wire wrap prototype board	49.00
ART-WW100	Artec Electronics Wire wrap proto board	25.00
ART-GP100	Artec Electronics General purpose solder	25.00
CAL-MB18	California Digital 18 slot motherboard	35.00

23" APPLE MONITOR $159



Ideal monitor for classroom demonstrations.

Ever try gathering a classroom of students around a 12" monitor? Here is your opportunity to purchase a 23" high resolution monochrome monitor.
These units accept standard composite video signals generated by most personal computers including the Apple and IBM. Attatch it to your computer and in seconds your shooting down Klingons in wide screen video.
MOT-BW23 35 lbs. Units are open frame and for safety should be enclosed. Walnut grained enclosure for above $25.00 additional. CAL-ENC23 15 lbs.

VISA

master charge

All merchandise sold by California Digital is premium grade.
Shipping: First five pounds $3.00. Each additional $.50.
Foreign orders: 10% shipping. Excess will be refunded.
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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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ADVANCED COMPUTER PRODUCTS

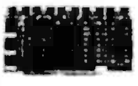
SEND $2.00 for 104 PAGE CATALOG

16K Apple™ Ramcard

LIST 195
ACP
$69.95

- Full 1 year warranty
- Top quality — gold fingers
- Expand Apple II 48K to 64K
- Compatible with Z-80 Softcard™
- Allows system to run with CP/M™, PASCAL, DOS 3.3, COBAL, Visicalc, etc.
- Supplied with extra 16K RAM & has (2) LED's

32K STATIC RAM



2 or 4 MHz
Expandable
Uses
2114L's

16K 4 MHz Kit	$159.95
16K 4 MHz A&T	217.95
32K 4 MHz Kit	$199.95 ~~289.95~~
• 32K 4 MHz A&T	• 339.00
BARE BOARD	39.95
Bare Bd w/all parts less mem.	99.95

BARE BOARDS

S-100 Sound Board	$34.95
8080A CPU	34.95
32K Static RAM (2114)	34.95
8K EPROM (2708)	24.95
2708/2716 EPROM	34.95
ACP Proto Board	22.95
Vector 8800 Proto	22.20
Vector 8803 11 slot MB	29.95
ACP Extender with connector	18.95
13 Slot Mother Board (WMC)	32.95
9 Slot Mother Board (WMC)	29.95
8 Slot Mother Bd (Expandable)	34.95
Floppy PCB (8" SHUGART)	39.95
S100 (AY5-8910) Sound Board	34.95
Apple Sound Board	24.95

UV "EPROM" ERASER

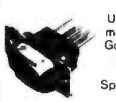
Model UVs-11E
$79.95
Holds 4 EPROM's at a time.

Model S-52T $325.00

16K Memory Expansion Kits for Apple/TRS-80

8 pcs 4116 16K 200/250nS
Specify computer $12.95
CALL FOR VOLUME PRICING

"D" SUB CONNECTORS



Unreal price. DB37 male, DB25 female. Gold PC mount with mounting holes. Mfg. AMP. Specify 25 or 37 pins.

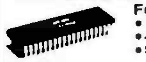
BD37 $2.50 DB25 $1.95

Astec RF Modulator

for COLOR & B/W

P/N 1082 Channel 3 or 4 $6.95

1200 BAUD MODEM IC



Features:
- 1200 Baud
- 40 Pin
- 5Volts Only

SL1200 .... $129.00

64K CMOS RAM

S100 (200nS)

Uses 2716's or 6116's $349.00

Assembled & Tested $399.00

MOSTEK 4K RAMS

29¢ ea.

200,000 pieces in stock — priced to move. Same as MK4027 except 1mS refresh. MK4015 4Kx1 RAM.

PMI "Super Beta" LOW POWER AMPLIFIER

INTERNALLY COMPENSATED
P/N OP12GJ

list $6.95
ACP $1.95

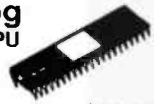
Voffset = 1.0 mV
Ibias = 5.0mA
Gain = 40V/mV
(quantity limited)

4K STATIC RAM SELL-OFF

10/$9.90

Same as TMS4044 but designed specifically for Z-80 based systems. This is a full-spec 4Kx1 RAM, 450nS. Order P/N Zilog 6104-4 while supply lasts.

Zilog Z8 CPU



with TINY BASIC Debug prog. $49.95
Plus 6132 companion quasi-static RAM 29.95

Stepper Motor

NEW
USED IN DATA PRODUCTS PRINTER
$19.95 ea.

CONNECTORS

DB25P (RS232)	$3.25
DB25S Female	3.75
Hood	1.25
Set with Hood, Sale	7.50
22/44 S/T, KIM	2.95
43/86 S/T, MOT	6.50
50/100 S-100 Connector W/W	4.95
50/100 S-100 Connector S/T	3.95

PARALLEL ALPHA NUMERIC PRINTER

19 Column Printer prints 16 numerical columns plus 3 columns which have math, alpha and other notations. Each wheel has 12 positions with position 12 blank. Position 11 on numerical columns have decimal point or #. Utilizes 2.75" wide adding machine tape and a dual color ink ribbon. Input data parallel with four bit BCD comparator circuit (schematic provided). Print rate, 3 lines per second. Operating voltage 22-28VDC with typical cycle time of 340mS. Size 6½"W x 3⅛"H x 5⅜"Dp. New. $17.50 ea. 3/$45

MICROPROCESSORS

Z8001	$99.00	8008-1	$14.95	6802P	14.95
Z8002	69.00	2901	9.90	8035	14.95
Z80	9.95	2901A	14.95	8039	12.95
Z80A	11.95	9900JL	49.95	8073N	34.95
F-8 (3850)	16.95	6502	9.95	8755	49.95
2650	16.95	6502A	16.95	8748	49.95
1802	9.75	IM6100	29.95	6809	30.00
8080A	4.75	6800	11.75	8086	49.95
8085	14.95	6800B	19.95	68000	129.95

RAMS

CALL FOR QTY PRICING

6116/2016	$7.95	2147	$5.99	5290	$1.99
8264-64K	8.50	411	5.99	5298	1.49
4116-2	1.99	414	4.69	6508	4.50
4116-2	8/12.95	1101	.99	6518	6.79
2101	3.99	1103	.99	6561	3.79
2102	.79	4027	4.69	6604	3.99
21L02-2	1.49	4044	3.99	6605	7.99
21L02-4	1.29	4050	4.69	9130	8.99
2111	3.49	4060	4.69	9140	8.99
2112	3.49	4096	3.99	93415	6.99
2114	1.99	4115	1.49	93425	6.99
2114L-2	3.25	4200	7.95		
2114L-4	2.29	4402	1.99		
2125	8.99	5280	4.60		

64K only $8.50

SUPPORT

8155	$9.95	8259	$8.95	68047	$22.95
9156	9.95	8275	19.95	68488	19.95
8202	29.95	8279	9.50	46505	22.95
8205	2.69	6810	4.75	6520	6.95
8212	2.75	6820	6.50	6522	9.95
8214	4.95	6821	6.50	6530-X	24.95
8216	2.75	6828	10.50	6532	17.95
8224	2.95	6834	16.95	6551	19.95
8226	2.95	6845	22.95	Z80-PIO	6.50
8228	3.95	6847	27.95	Z80A-PIO	9.50
8243	9.50	6850	5.25	Z80-CTC	6.50
8250	14.95	6852	5.25	Z80A-CTC	9.50
8251	6.50	6860	10.95	Z80-DMA	19.95
8253	11.95	6862	10.95	Z80A-DMA	27.95
8255	4.50	6875	5.95	Z80-SIO	24.95
8257	9.50	6880	2.49	Z80A-SIO	29.95

MOS PROMS

2764 (8Kx8) TS	$69.95	2708 (450nS)	$5.75
2732 (4Kx8) TS	12.95	2708 (650nS)	5.25
2716/2516; 5V (2Kx8) TS	7.95	1702A	5.75
TMS2716, 5V, 12V	17.95	MM5203AO	14.50
2758, 5V, (450nS)	3.50	MM5204Q	9.95

HI-TECH

2513-001 (5V) Upper	$9.50	DAC08	$9.95
2513-005 (5V) Lower	10.95	DAC100	9.95
2513-ADM3 (5V) Lower	14.95	8038 Function Generator	4.50
MCM66710 ASCII Shifted	12.95	MC4024 VCO	2.95
MCM66740 Math Symbol	13.95	LM566 VCO	1.95
MCM66750 Alpha Control	13.45	XR2206 Function Generator	5.25
1771-01 8" & Minifloppy	24.95	TR1602B (5V, 12V)	3.95
1781 Dual Floppy	29.95	AY51013 (5V, 12V)	4.95
1791-01 Dual Floppy	36.95	AY51014A/1612 (5-14V)	6.95
1791-02 Dual Floppy	44.95	AY51015A/1863 (5V)	6.95
1793 DD, DS Floppy	44.95	IM6402	7.95
1797 DD, DS Floppy	54.95	IM6403	8.95
1691 Data Separator	18.95	2350 USRT	9.95
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8700 8 bit Binary	13.50	MC14411	11.95
8701 10 bit Binary	22.00	4702	14.95
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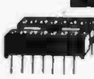
8750 3½ Digit BCD	13.95	INS8250	15.95
1408L6 6 bit	3.95	AY5-2376	13.75
1408L8 8 bit	5.95	AY5-3600	13.75
DAC01 D to A	5.95	MM5740AAC	8.95

SOCKETS



LOW PROFILE SOCKETS (TIN)

	1-24	25-49	50-100
8 pin LP	.16	.15	.14
14 pin LP	.20	.19	.18
16 pin LP	.22	.21	.20
18 pin LP	.29	.28	.27
20 pin LP	.34	.32	.30
22 pin LP	.29	.27	.24
24 pin LP	.38	.37	.36
28 pin LP	.45	.44	.43
40 pin LP	.60	.59	.58

3L WIREWRAP SOCKETS (GOLD)

	1-24	25-49	50-100
8 pin WW	.55	.54	.49
10 pin WW (Tin)	.65	.63	.58
14 pin WW	.75	.73	.67
16 pin WW	.80	.77	.70
18 pin WW	.95	.90	.81
20 pin WW	1.15	1.08	.99
22 pin WW	1.45	1.35	1.23
24 pin WW	1.35	1.26	1.14
28 pin WW	1.60	1.53	1.38
40 pin WW	2.20	2.09	1.89

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LM301CN	.35	LM1556N	1.50
LM304H	1.98	LM1820N	.95
LM305H	1.89	LM1850N	.95
LM306H	3.25	LM1889N	3.10
LM307CN	.29	LM2111N	1.75
LM308CN	.98	LM2900N	.99
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LM310CN	1.25	LM2917N	2.95
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LM312H	1.75	CA3018T	1.99
LM317T	1.70	CA3021T	3.49
LM318CN	1.49	CA3023T	2.99
LM319N/H	1.25	CA3035T	2.75
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LM320T-XX*	1.39	CA3046N	1.29
LM320H-XX*	1.25	LM3053N	1.49
LM323K	4.95	CA3059N	3.19
LM324N	.95	CA3060N	3.19
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LM339N	.95	CA3080T	1.29
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LM340H-XX*	1.25	CA3083N	1.55
LM344H	1.95	CA3086N	.80
LM348N	1.20	CA3089N	2.99
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LM360N	1.49	CA3130T	1.30
LM372N	1.95	CA3140T	1.19
LM376N	3.75	CA3146N	2.49
LM377N	2.75	CA3160T	1.19
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LM381N	1.79	CA3410N	.59
LM383T	1.95	MC3423N	1.49
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LM387N	1.40	SG3524N	3.95
LM390N	1.95	CA3600N	3.39
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NE555V	.39	LM3905N	1.19
NE556N	.98	LM3909N	.98
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NE566H/V	1.75	LM3916N	3.75
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NE592N	2.75	RC4136N	1.10
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LM711N/H	.39	ULN2001	1.25
LM715N	1.95	ULN2003	1.50
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LM733N/H	.98	SN75451N	.35
LM739N	1.15	SN75452N	.49
LM741CN/H	.33	SN75453N	.49
LM741CN-14	.19	SN75454N	.49
LM747N/H	.75	SN75491N	.89
LM748N/H	.39	SN75492N	.89
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LM1310N	1.90	SN75494N	.89
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MC1358	1.75		

74S00

74S00	$ .39	74S124	3.69	74S244	$2.99
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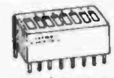
74S03	.45	74S134	.66	74S253	1.35
74S04	.52	74S135	1.15	74S257	1.29
74S05	.52	74S136	1.69	74S258	1.29
74S08	.49	74S138	1.29	74S260	.75
74S09	.49	74S139	1.29	74S280	2.79
74S10	.42	74S140	.73	74S287	2.99
74S11	.42	74S151	1.29	74S288	2.55
74S15	.42	74S153	1.29	74S373	3.10
74S20	.42	74S157	1.29	74S374	3.10
74S22	.42	74S158	1.29	74S387	2.75
74S30	.42	74S160	2.79	74S471	7.95
74S32	.49	74S174	1.49	74S472	7.95
74S38	1.19	74S175	1.49	74S473	7.95
74S40	.49	74S188	2.69	74S474	9.95
74S51	.42	74S194	1.89	74S475	9.95
74S64	.46	74S195	1.89	74S570	5.75
74S65	.46	74S196	1.89	74S571	5.75
74S74	.69	74S240	2.75	74S572	8.95
74S86	.72	74S241	2.75	74S573	8.95
74S112	.72	74S242	2.99	74S940	2.90
74S113	.72	74S243	2.99	74S941	2.90
74S114	.72				

DIP SWITCHES



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7403	.22	7480	.49	74164	.87
7404	.22	7482	.95	74165	.87
7405	.23	7483	.55	74166	1.20
7406	.35	7485	.65	74167	1.95
7407	.35	7486	.35	74170	1.69
7408	.26	7489	1.75	74172	4.75
7409	.23	7490	.39	74173	.79
7410	.22	7491	.57	74174	.89
7411	.29	7492	.45	74175	.85
7412	.29	7493	.45	74176	.75
7413	.39	7494	.69	74177	.75
7414	.59	7495	.65	74179	1.34
7416	.29	7496	.69	74180	.75
7417	.29	7497	2.90	74181	1.75
7420	.22	74100	2.90	74182	.75
7421	.35	74107	.32	74184	2.25
7422	.29	74109	.37	74185	2.25
7423	.29	74116	1.95	74186	9.95
7425	.29	74121	.29	74188	3.90
7426	.29	74122	.39	74190	1.15
7427	.25	74123	.59	74191	1.15
7429	.45	74125	.39	74192	.85
7430	.23	74126	.44	74193	.85
7432	.29	74128	.59	74194	.85
7437	.25	74132	.69	74195	.68
7438	.29	74136	.75	74196	.85
7439	.29	74139	.95	74197	.85
7440	.19	74141	.79	74198	1.39
7441	.79	74142	2.95	74199	1.39
7442	.57	74143	2.95	74221	1.19
7443	.95	74144	2.95	74251	.95
7444	.95	74145	.62	74273	1.05
7445	.79	74147	1.95	74278	1.89
7446	.79	74148	1.20	74279	.75
7447	.65	74150	1.09	74283	1.40
7448	.79	74151	.67	74284	3.90
7450	.19	74152	.67	74285	3.90
7451	.19	74153	.67	74290	1.25
7453	.19	74154	1.19	74298	.95
7454	.19	74155	.78	74365	.68
7459	.25	74156	.78	74366	.68
7460	.23	74157	.69	74367	.68
7470	.29	74158	1.65	74368	.68
7472	.29	74159	2.49	74390	1.45
7473	.34	74160	.88	74393	1.90
7474	.34			74490	1.90

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74LS00	$ .26	74LS113	$ .43	74LS245	$2.20
74LS01	.28	74LS114	.43	74LS247	1.10
74LS02	.28	74LS122	.55	74LS248	1.10
74LS03	.28	74LS123	1.19	74LS249	1.19
74LS04	.35	74LS124	1.35	74LS251	1.40
74LS05	.28	74LS125	.89	74LS253	1.40
74LS08	.28	74LS126	.52	74LS257	.85
74LS09	.35	74LS132	.79	74LS258	.98
74LS10	.28	74LS136	.49	74LS259	2.95
74LS11	.39	74LS138	.85	74LS260	.65
74LS12	.33	74LS139	.85	74LS261	2.49
74LS13	.47	74LS145	1.25	74LS266	.59
74LS14	.95	74LS148	1.49	74LS273	1.75
74LS15	.33	74LS151	.79	74LS275	4.40
74LS20	.26	74LS153	.79	74LS279	.59
74LS21	.33	74LS154	1.70	74LS283	.99
74LS22	.33	74LS155	1.19	74LS290	.99
74LS26	.33	74LS156	.99	74LS293	.99
74LS27	.33	74LS157	.85	74LS295	1.10
74LS28	.33	74LS158	.75	74LS298	1.19
74LS30	.26	74LS160	1.05	74LS324	1.75
74LS32	.33	74LS161	1.15	74LS347	1.95
74LS33	.55	74LS162	1.05	74LS348	1.95
74LS37	.45	74LS163	1.05	74LS352	1.19
74LS38	.39	74LS164	1.19	74LS353	1.19
74LS40	.26	74LS165	.89	74LS363	1.49
74LS42	.79	74LS166	2.48	74LS365	.69
74LS47	.79	74LS168	1.15	74LS366	.69
74LS48	.95	74LS169	1.15	74LS367	.69
74LS51	.26	74LS170	1.99	74LS368	.69
74LS54	.29	74LS173	.89	74LS373	1.89
74LS55	.29	74LS174	.89	74LS374	1.89
74LS73	.45	74LS175	.89	74LS375	.69
74LS74	.42	74LS181	2.20	74LS377	1.95
74LS75	.59	74LS190	1.15	74LS385	1.95
74LS76	.45	74LS191	1.15	74LS386	.65
74LS78	.45	74LS192	.98	74LS390	1.95
74LS83A	.79	74LS193	.98	74LS393	1.95
74LS85	1.19	74LS194	1.15	74LS395	1.70
74LS86	.45	74LS195	.95	74LS399	2.35
74LS90	.57	74LS196	.89	74LS424	2.95
74LS92	.75	74LS197	.89	74LS668	1.75
74LS93	.75	74LS221	1.15	74LS670	2.29
74LS95	.88	74LS240	1.69	81LS95	1.69
74LS96	.98	74LS242	1.69	81LS96	1.69
74LS107	.45	74LS243	1.69	81LS97	1.69
74LS109	.45	74LS244	1.49	81LS98	1.69
74LS112	.43				

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4022	1.15	4069	.35	4511	1.19
4023	.29	4070	.49	4512	1.39
4024	.75	4071	.35	4515	2.75
4025	.25	4072	.35	4516	1.45
4027	.65	4073	.35	4518	1.39
4028	.85	4075	.35	4520	1.25
4029	1.29	4076	1.29	4555	4.95
4030	.45	4077	.35	4556	.99
4031	3.25	4078	.35	4566	2.25
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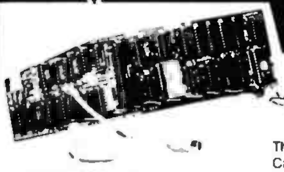

Vision 80

as reviewed in May BYTE pg. 266

This is the widely discussed Cadillac 80 column card for the Apple II. The Vision 80 responds to more Apple text screen commands than any other board. It supports PASCAL. Microsofts Z80 Softcard and can be used as an Intelligent terminal.

List Price.... $395.00 **Special Low Price.... $269.00**

The Vision 80 can also be used in conjunction with the Vision 40 (allows enhanced character sets) and the Vision 20 for lower case.

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      - 64K SP 525
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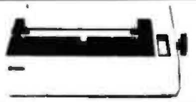
    - 2 RS232 PORTS 269
    - BABY BLUE Z80 CARD 550
- **PROTOTYPE CARD** 69
- **EXTENDER CARD** 29
- **DISK DRIVES - ADD-IN (Compatible)** 239
- **EPSON ADD-ON PRINTER** 429
- **SUPR'MOD V RF MODULATOR** 49
- **EPSON TO IBM CABLE** 49

EPSON



MX80	$429.00
MX80FT	529.00
MX100FT	725.00
Apple I/O w/cable	54.95
Serial I/O w/cable	95.00
Serial I/O w/2k & cable	129.00
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Printer Pal (P80)	29.95
Printer Pal (P100)	39.95

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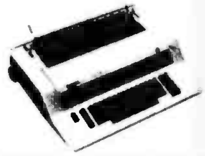

Letter quality Daisy Wheel Typewriter interfaces to Apple, Atari, NEC, TRS80 and RS232 Serial ports.

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ES100RO Comp. Print	$1690	$1395
ES100 Typewriter Print	1195	1050
GO10 Apple I/O card	349	189
GO11 Other I/O's	349	299
I/O Cable	49	29

C. Itoh

STARWRITER F-10
40 CPS Daisy Wheel $1475

PRO-WRITER 8510A
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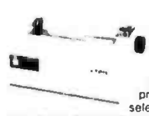

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82A 120 cps w/tractor	$499.00
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Apple Card	49.95
Apple Cable	19.95
Serial Card w/2K	129.95
Graphics ROM (82A/83A)	75.00

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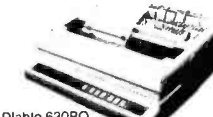

Diablo 630RO
$2095

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	LIST	ACP
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IDS Paper Tiger 560G	1395	1099
Prism 132 (color)	1995	1675

NEC 8023

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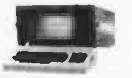

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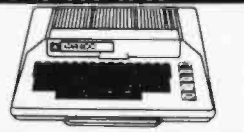
ATARI



MODEL	LIST	ACP
800 with 16K	$1080.00	$689.95
800 with 48K	1280.00	789.95
800 with 32K + 128K		1295.00
810 Disk Drive	600.00	469.95
825 Printer	999.00	699.95
830 Acoustic Modem	199.00	159.95
850 Interface Module	219.95	189.95
Atari Visicalc	200.00	169.00
Atari PAC-MAN		CALL
Microtek 16K RAM	99.00	75.00
Microtek 32K RAM	199.00	149.00
Axalon 128K RAM		CALL
400 with 16K	399.95	329.95

5¼" DISK DRIVES

TM100-1	SSDD	$219.95
SA400	SSDD	249.95
TM100-2	DSDD	298.95
TM100-3	SSDD	298.95
TM100-4	DSDD	419.95
B-51	SSDD	224.95
B-52	DSDD	334.95
B-91	SSDD	359.95
B-92	DSDD	459.95

5¼" Cabinets with Power Supply
Single cabinet w/power supply $69.95
Dual cabinet w/powersupply 94.95

8" DISK DRIVES

SA801R	SSDD	$395.00
SA851R	DSDD	549.00
TM848-1	SSDD	425.00
TM848-2	DSDD	575.00
DT-8	DSDD	525.00
FDD100-8	SSDD	299.00
FDD200-8	DSDD	399.00
V1000	Case/Power Supply	375.00
Dual 8" Power Supply		$99.00

APPLE System Saver FAN

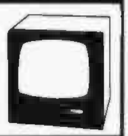
Surge Suppressor Fan
Double Outlet Receptacle $79.95

SANYO

FCC CLASS 2 APPROVED

MODEL	LIST	ACP
4509 9" B/W	$210	$169
5109CX 9" Green	220	179
8012C 12" B/W	250	219
8012CX 12" Green	260	229
6013 13" Color	470	422
6113 13" RGB	995	889
NEW Down & Dirty		
2012 12" B/W	145	139
2112 12" Green	169	155

USI INTERNATIONAL — USI Computer Products



SANYO EQUIVALENT

MODEL	LIST	ACP
Pi I 9" Green	$199	$159
Pi II 12" Green	199	149
Pi III 12" Orange	249	199

TERMINALS

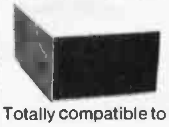
TELEVIDEO

910C	$599
920C	769
925C	749
950	969

SOROC

IQ 120	$695
IQ 130	595
IQ 140	999

FOURTH DIMENSION SYSTEMS



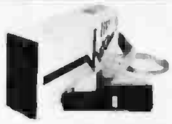
Apple II Compatible Disk Drive

Totally compatible to Apple Drives.

only **$299.00**

Controller $99.00
Just plug in and run.

Vista Computer Company



Add 8" Disk Drives To Your Apple II
Up To 2.4 Megabyte!
Now "TRIMLINE V1100" with Tandon Thinline DS DD Drives.

Tandon Dual DS DD	$1995.00
Oume Dual DS DD	1895.00
Shugart Dual 801R	1495.00

apple computer Authorized Dealer

ON DISK FOR APPLE
SAVE UP TO 40% OFF

	ACP
Visicalc 3.3	$189
Supercalc	189
Visi Trend/Visi Plot	235
Visi Dex	199
Visi File	199
Visi Plot	159
Desk top Plan II/III	199
Visi Schedule	239
Visi Term	89
Zork	34
Versa Form	287
dBase II Ashton-Tate	489
Wordstar	235
Mail Merge	82
Spell Star	159
Data Star	189
Calc Star	189
Super Sort	132
Spellguard	219
DB Master (new)	178
DB Utility	72
PFS II/III	69
Report II/III	69
Locksmith 4.0	74
Accounting Plus	1195
Microcourier	229
Microtelegraph	229

HEWLETT PACKARD

HP85A Computer	$1985
HP87 Computer	1945
• 82907A 32K Model	239
• 82908A 64K Model	349
• 82909A 128K Model	599
• 82900A CP/M with 64K	425
HP125 Computer	1985
7470 Low Cost Plotter	1265
9895A 8" Dual Floppy	5135

HEWLETT PACKARD CALCULATORS

HP41C	Prog. Scientific	$189
HP41CV	w/2.2K Memory	256
HP41	Memory Module	26
HP41	Quad RAM	83
HP41	Card Reader	169
HP41	Printer	292
HP41	Optical Wand	99
HP-IL	Interface Loop	119
HP11C	Advanced Scientific	119
HP12C	Financial	129
HP34C	Prog. Scientific	112
HP38C	Prog. Business	116

apple computer Authorized Dealer

	LIST	ACP
Apple II Plus w/48K	$1530.00	$1099.00
Apple II Plus w/64K	1729.00	1199.00
Apple II System Special w/64K, Z80 Card, Vision 80	2519.00	1775.00
Apple III w/128K	3495.00	2895.00
Apple III w/256K	4295.00	3495.00
ProFile Hard Disk Drive	3499.00	2899.00
Vista Apple III Timecard	195.00	169.00

"Apple Products Available In-store Only"

APPLE HARDWARE

	LIST	ACP
Apple II Disk II w/Contror'r	$645.00	$529.00
Apple II Disk II w/o	525.00	449.00
Apple Family System	2495.00	1995.00
Prototype Card	24.00	21.95
IEEE-488 Interface	450.00	375.00
Extended Warranty - 1 yr	225.00	199.00
Super Serial Card	195.00	174.95
Language Card	195.00	169.95
Graphic Tablet w/IO	795.00	695.00

"Available In-store Only"

MORE HARDWARE

	LIST	ACP
MICROSOFT		
Z80 Softcard	$395.00	$256.00
16K Ramcard	195.00	129.00
The Premium Package	899.00	579.00
SSM		
AIO-II 4 Function Serial/Parallel	225.00	179.00
AIO Serial/Parallel	195.00	165.00
KEYBOARD COMPANY		
Numeric Keypad	149.95	124.95
Apple II Joystick	49.95	44.50
Apple II Handcontrollers	29.95	25.95
PROMETHEUS		
VERSAbox Spool/Buf'r	249.00	199.00
VERSAcard Four-in-1	199.00	166.00
AUTO-DOC diagnostics	99.00	82.00
VISTA COMPUTER CO.		
Vision 80 80x24 Card	395.00	269.00
Vision 40 40 col. enhance	199.00	149.00
Vision 20 Lo case ROM	29.95	25.00
A800 8" DS. DD Controller	595.00	499.00
PROM Development Bd	595.00	399.00
GB75 IBM typewriter I/O	195.00	169.00
40 Char Type-ahead Buffer	49.95	35.00
VIDEX		
Videoterm 80x24 Card	345.00	279.00
Keyboard Enhancer II	149.00	129.00
Soft Switch	35.00	30.00
Function Strip Keys	79.00	69.00
PRACTICAL PERIPHERALS		
16K Microbuffer	259.00	220.00
32K Microbuffer	299.00	253.00
Snapshot Option	69.00	59.00
VOTRAX		
Type n' Talk Speech	375.00	339.00
SCOTT INSTRUMENTS		
Voice Recognit'n VET80	799.00	675.00
CORVUS		
5 Mb Hard Disk	3750.00	2995.00
10 Mb Hard Disk	5350.00	4325.00
20 Mb Hard Disk	6450.00	5240.00
ORANGE MICRO		
The Grappler I/O	195.00	135.00
SATURN SYSTEMS		
32K RAM Card	239.00	189.00
64K RAM Card	425.00	355.00
128K RAM Card	599.00	505.00
NOVATION		
Apple-Cat II	389.00	329.00
HAYES MICROCOMPUTER		
Hayes Chronograph	249.00	229.00
Micromodem II	349.00	289.00
Smartmodem	299.00	229.00
MOUNTAIN COMPUTER		
CPS Multifunction	239.00	169.00
RAM Plus	189.00	139.00
Expansion Chassis	750.00	699.00
Music System	395.00	335.00
100,000 Day Clock	375.00	325.00
The Clock	280.00	249.00
A/D plus D/A	350.00	299.00
Supertalker	199.00	169.00
Introl X-10 Controller	200.00	175.00
ROM Plus	155.00	129.00
Keyboard Filter ROM	55.00	44.00
Copy ROM	55.00	44.00
ROM Writer	175.00	159.00
M&R ENTERPRISES		
Sup'rterm 80x24 Card	395.00	279.00
Sup'rSwitcher 6 Amp Power Supply	295.00	239.00
Sup'rMod II RF Modulator	35.00	28.00
Apple Fan	55.00	43.00
ALS		
The "Z" Card Z80 card	295.00	219.00
Smarterm 80x24 Card	349.00	279.00
The Synergizer Package	699.00	549.00

16K RAM CARD

Apple II 16K
Compatible with
Z80 Softcard™ ... PASCAL CP/M™
Full 1 year Warranty. Top Quality by COEX

NEW LOW PRICE **$69.95**

Also from COEX NEW EPSON Parallel Interface for Apple.
With cable $54.95

TOLL FREE 800-854-8230
TWX 910-595-1565

Mail Order: P.O. Box 17329 Irvine, CA 92713
Retail: 1310B E. Edinger, Santa Ana CA 92705 (714) 558-8813
542 W. Trimble, San Jose, CA 95131 (408) 946-7010

TERMS: MO, Cashier's Check, Bank Wire, Personal checks allow 2 weeks for processing. Include Drivers License and credit card #'s Visa, AMEX, CB add 3% service charge. Add 3% shipping & handling or $2.50, whichever is greater. Add 10% for foreign orders or US Parcel Post. Include Telephone number. NO CODs. Prices subject to change without notice. Some items subject to prior sale. We reserve the right to substitute manufacturer. Retail Prices may vary.

Circle 11 on inquiry card.

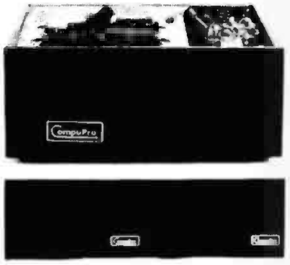
PRIORITY ONE ELECTRONICS

Circle 365 on inquiry card.

1 COMPLETE CompuPro SYSTEMS

FREE SUPERCALC-86! FREE dBASE II!! AND A VISUAL 50 TERMINAL FOR ONLY $1.00

WHY SETTLE FOR LESS?!



PERFORMANCE, QUALITY, RELIABILITY

HIGH PERFORMANCE SYSTEMS DESIGNED TO EXPAND WITH YOUR NEEDS

All CompuPro systems have been designed with your future in mind. Each system is expandable so you can upgrade your system as your needs continue to grow. Hard disk storage is also available with the new DISK 2 DMA Winchester disk controller. Unlike many "personal" computers, your CompuPro system will not become obsolete when it is time to expand. The modular design of the IEEE 696/S-100 bus allows you to plug in additional boards when they are needed. CompuPro system components feature the latest state-of-the-art technology to prevent obsolescence.

Each CompuPro system component is fully assembled and tested under rigorous burn-in conditions at the factory and then shipped to Priority 1 Electronics, your authorized CompuPro Systems Center, for final integration and configuration. CompuPro systems carry the best warranty in the business: on full year. The Qume drives have a full six month warranty, the best drive warranty anywhere. The components are integrated into a complete system by a factory trained Priority 1 Electronics technician. The systems are then partially disassembled for shipping. After a short time for unpacking and check-out, your CompuPro system will be ready to load and go!

SYSTEM BASICS

All systems include a CPU 8085/88 Dual Processor or CPU (8085 runs at 6MHz, the 8088 runs at 8MHz); Disk 1 lightning fast DMA floppy disk controller; CP/M® 2.2 and CP/M 86™ operating systems; Sorcim's SuperCalc-86™ electronic spread sheet program; two double-sided, double-density Qume DT-8 disk drives In an attractive desk top enclosure: rugged Desk Enclosure 2 with 20 slot actively terminated motherboard, fan, air and line filters, and constant voltage power supply for years of reliable operation; internal I/O cables and floppy disk data cable; complete documentation for each system component with a system integration guide. In addition to the above hardware and software, each configuration adds a unique combination of RAM, I/O, and other special purpose boards.

System 816/A — Entry Level Single-User System

System 816/A is an excellent choice for an entry level, single user system that's designed with future expansion in mind. 816/A includes Interfacer 4 (three serial I/O ports, parallel port, and Centronics/Epson-style port), two RAM 17s for 128K of fast, static memory, and System Support 1 (clock/calendar, RAM/ROM/match processor options, RS-232C serial port, interrupt controllers, interval timers, and more), and Ashton-Tate's dBase Junior™, an upgradeable subset of their popular dBase II data base management software. This combination of components means superb computing today with an option for future expansion — all the way up to a multi-user system. System 816/A is priced at $5495.00, a savings of over $1000.00 compared to all components purchase separately.

BKGBTSYS816ADA	*Single User System Desk Top, Assembled & Tested*	**$5495.00**
BKGBTSYS816ADC	*Single User System Desk Top, 200 hr. Burn-in*	**$609[illegible].00**
BKVSL50BW	*Visual 50 Black & White with Purchase of above System*	**$1.00**

System 816/B — M-Drive Single user System

System 816/B is an ultra-high performance single user system which includes Interfacer 3-5 (five serial ports), 256K of fast, static RAM, System Support 1, and Ashton-Tate's complete dBase II™ data base management software. Plus, System 816/B's implementation of CP/M® includes M-Drive software, which turns the system RAM into a pseudo-disk drive for exceptionally fast computing. This system sells for only $6995.00, a savings of over $1800.00 compared to all components purchased separately.

BKGBTSYS816BDA	*M-Drive System Desk Top, Assembled & Tested*	**$6995.00**
BKGBTSYS816BDC	*M-Drive System Desk Top, 200 hr. Burn-in*	**$7795.00**
BKVSL50BW	*Visual 50 Black & White with Purchase of above System*	**$1.00**

System 816/C — Entry Level Multi-User System

System 816/C is the only high performance multi-user system which allows both 8 and 16 bit programs to run simultaneously; it also makes for an unparalleled single user system. It includes Interfacer 3-8 (eight serial ports), 384K of fast, static RAM, System Suport 1, dBase II™, SuperCalc-86™, M-Drive software, and CompuPro's MP/M 816™ multi-user operating system that allows you to run both 8 and 16 bit software *simultaneously*. System 816/C suports up to three users simply by adding appropriate terminals: for more users, just add more CompuPro RAM and terminals. The system is priced at $8995.00, a savings of over $2300.00 compared to all components purchased separately.

BKGBTSYS816CDA	*Multi-User System Desk Top, Assembled & Tested*	**$8995.00**
BKGBTSYS816CDC	Multi User System Desk Top, 200 hr. Burn-in	**$10,045.00**
BKPDBTLV9252P*	*TeleVideo 925 with 2nd page of memory - with purchase of above system*	**$1.00**

Limit 1 terminal at $1.00 per system. Purchase of 8' RS232 Cable, Part Number* **CNDRS2328F *at $19.95, is required for system/terminal integration.*

Rack mount and CSC systems are also available: please call or write for details. All CompuPro systems are shipped via motor or air freight collect: please specify at time of order. All boards are shipped in standard configurations.

**CP/M, CP/M 86, and MP/M are trademarks of Digital Research. MP/M 816 is used under license from Digital Research. SuperCalc-86 is a trademark of SORCIM. dBase II and dBase Junior are trademarks of Ashton-Tate.*

MITSUBISHI ELECTRIC

Better Than QUME! Better Than SHUGART!

8", Double-sided, double-density, interchangeable with QUME & Shugart

BK MITM289463	*Sh. Weight 16 lbs.*	$450.00
BK MITM289463M	*Manual*	**$ 10.00**

2 or More $435.00 each

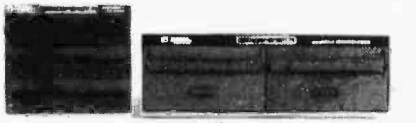
Shugart 801R

Single sided, double density - most popular 8" drive

BKSHU801R	*$394.00 ea. or 2 or more (16 lbs) for*	**$389.00**
BKSHUSA801RM	*Manual for 801R drives*	**$ 10.00**

INTERNATIONAL INSTRUMENTATION, INC.

OUR BEST!!



UNIVERSAL DISK ENCLOSURES

• Accepts any combination of 8" drives (QUME/Shugart 801R type or ½ size Tandon type) • Also accepts hard disks • Positive pressure • Optional Disk environment monitor shows supply voltage and internal cabinet temperature • Internal power and data cables provided.

UNIVERSAL DRIVE CABINET complete with power supply, fan and filter, and all internal cables for attachment of two 8" floppy drives.

BKIIIUDE004	Dual Drive Cabinet (Sh Wt. 40 lbs)	$495.00	**$450.00**
BKIIIUDE004	With purchase of two 8" Disk Drives		**$399.00**
BKIIIUDE004EM	w/Environmental Monitor installed	$584.95	**$535.00**
BKIIIUDE004EM	With purchase of two 8" Disk Drives		**$485.00**
BKIIIUDE004AUG	Dual Drive cabinet with Augmentation power supply module to increase 5V supply from 6 amps to 9 amps for use with two hard disks or 4 Tandon drives. Also includes Disk Environment Monitor (45 lbs.)	$733.00	**$650.00**
BKIIIUDERCK	19" Rack Mount kit UDE004		**$ 69.95**

THIN THREE DRIVE CABINET complete with power supply, and all internal cables for attachment of three thin 8" floppy drives (Tankdon type). One AC power connector is also provided for use with full size drive.

BKIIIUDETT	Three Drive Cabinet (Sh. Wt. 35 lbs)	$495.00	**$450.00**
BKIIIUDETTTEM	with Environmental Monitor installed	$584.95	**$535.00**

VISUAL 50

(See page 287 for more information)

- *Low profile detached keyboard features sculptured keys with matte finish*
- Screen tilts and swivels
- 80 x 24 display with 25th status line
- 7 x 9 dot matrix with full decenders
- RS-232 Serial interface w/auxiliary RS-232 port
- 128 Character ASCII set and 31 character line drawing set

INTRODUCTORY OFFER!!

BJVSL50BW	Non glare Black & White	$695.00	**$650.00**
BJVSL50GN	P31 green display	$750.00	**$685.00**

(Shipping Weight 37 lbs.)

NEW! Hayes SMARTMODEM

• Auto Answer, Auto Dial, Full or Half-Duplex, Loop Back Serial binary, and asynchronous data formats with 7 or 8 data bits, 1 or 2 stop bits, odd, even or no parity • 0-300/1200 baud • RS232C interface • Z80 Microprocessor with 2Kb control program • 40 character command buffer • Size 1.5" x 5.5" x 9.6"

BKDCH0200P	Smartmodem (Sh. Wt. 6 lbs)	$279.00	**$225.00**
BKDCH0400P	Smartmodem 1200 baud (6 lbs)	$699.00	**$599.00**
BKDCH0300P	Chronograph (Sh. Wt. 3 lbs)	$249.00	**$205.00**
BKDCH0100P	Micromodem 100 (Sh. Wt. 4 lbs)	$399.00	**$325.00**
BKDCH29010	CP/M® 8" Terminal Program for	above	**$ 25.00**
BKDCH0000P	Micromodem II	$379.00	**$299.00**

PRIORITY ONE ELECTRONICS

Circle 365 on inquiry card.

SGL WABER
LINE MONITOR POWER CONDITIONERS

Before you plug in your computer, you'd better consider how you are going to insure or protect your investment from unwanted electrical pollution.

DATAGARD Performance Specifications

	DG315P, DG315S and DG315R	DG115P and DG115S
Maximum spike energy dissipation	50 joules one time 25 joules repeated usage self restoring	50 joules one time 25 joules repeated usage self restoring
Maximum spike voltage	7,000 volts	6,000 volts
Clamping spike voltage	55 volts	155 volts
Surge current clamping ratio	No greater than 1.5:1	No greater than 2.03:1
Maximum spike current (For an 8 x 20 micro-second spike pulse)	2,000 amps	2,000 amps
Clamping response time	10 nanoseconds (10×10^{-9} sec)	10 nanoseconds (10×10^{-9} sec)
Noise rejection Filter network Frequency range Attenuation	1KHz to 100 MHz 20 to 40 dB (voltage ratio)	
Mode noise protection	Transverse and common	
Leakage current	Leakage to ground lead does not exceed 10 microamperes	Leakage to ground lead does not exceed 10 microamperes

DG115 SERIES
SINGLE STAGE SPIKE PROTECTION

MODEL	DESCRIPTION	WT.	LIST	1-9	10-24
BKWBRDG115P	Wall unit plug in	2	$49.95	$39.95	$34.95
BKWBRDG115S	6 outlet strip w/SW&LT	3	$61.95	$49.95	$42.00

DG315
3 STAGE SPIKE FILTER AND FOUR STAGE NOISE FILTER

MODEL	DESCRIPTION	WT.	LIST	1-9	10-24
BKWBRDG315P	Wall unit plug in	2	$153.95	$119.95	$ 99.95
BKWBRDG315S	6 outlet strip w/SW&LT	3	$193.95	$149.95	$119.95
BKWBRDG315R	6 outlet rack w/SW&LT	8	$193.95	$149.95	$119.95

SANYO

FCC CLASS 2 APPROVED DATA DISPLAY MONITORS

SPECIFICATIONS:

Viewing Screen	12" diagonal; 75 square inches DM2112 P31 phosphor
Scanning System	525 lines; 60 fields/second, overscan
Horizontal Resolution	600 lines, center
Signal Input	1.0 volt p-p composite video; 75 ohms

BKSYODM2112

List Price: $160.00 **SALE: $119.00**

OTHER SANYO MONITORS ON SALE TOO!!

Part No.	Description	List Price	SALE
BKSYOVM4509	9" B&W P4, 10MHz (15 lbs)	$190.00	$149.00
BKSYODM5109CX	9" Green, P31, 10MHz (15 lbs)	$200.00	$159.00
BKSYODM8012CX	12" B&W P4, 18MHz (24 lbs)	$250.00	$195.00
BKSYODM8112CX	12" GReen, P31, 18MHz (24 lbs.)	$260.00	$199.00
BKSYOVMC6013	13" Color 16 x 64 (35 lbs)	$470.00	$375.00
BKSYODM6113*	13" RGB Color (35 lbs)	$895.00	$795.00

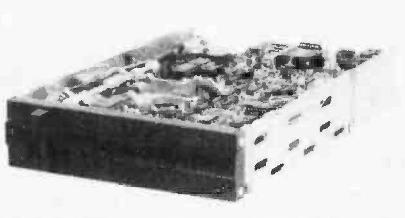
*As used with IBM P.C.

V-100 VISTA DISK CABINET

● Desk or rack mountable ● Internal power and data cables ● Drives pull out for easy service and maintenance

BKVISV100 Disk Drive Cabinet $449.00
List Price $495.00 (Sh. Wt. 43 lbs.)
BKVISV100 W/purchase of two 8" Disk Drives $399.00

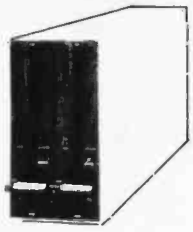
Tandon
8-INCH THIN LINE



Exactly one-half the height of any other model.
Proprietary, high-resolution, read-write heads patented by Tandon
D.C. only operation - no A.C. required
Industry standard interface.
Three millisecond track-to-track access time (9 lbs.)

BKTNDTM8481	*Single Sided* $380.00	2 or more	$370.00
BKTNDTM8482	*Double Sided* $495.00	2 or more	$485.00

DUAL THIN LINE CABINET by JMR COMPUTERS



● Fan Cooled
● 24V @ 4A 5A Surge
● 5V @ 2A
● Scratch Resistant Baked Enamel Finish

BKJMRTLC Cabinet & Power Supply List $200.00 **$180.00**

BUY THE CABINET AND DRIVES TOGETHER:

BKPO8JMRTND1 w/two TNDTM8481's $920.00
BKPO8JMRTND2 w/two TNDTM8482's $1150.00
Includes Power Cables

APPLE DISK DRIVES

Give your APPLE II® a Fourth Dimension — the totally compatible 5¼" drive that takes your system farther, faster. With read/write electronics so advanced that reading errors are virtually eliminated. With a track zero microswitch that keeps boot and track access smooth and quiet. With the ability to read half-track software and up to 143,360 bytes on DOS 3.3*. With similar performance on DOS 3.2.1*, Pascal® or CP/M® operating systems. And, the disk enclosure mates perfectly with APPLE cabinetry.

EXTENDED WARRANTY NEW!!

Fourth Dimension offers a 12 month parts and labor warranty at no cost to you! (Gee, this really looks *good!*)

BKFDS40A List Price $329.00 **SALE: $289.00**

Shugart Interchangeable

BKFDS40AC* APPLE II® Disk Drive Controller $115.00
*Sold only with purchase of Fourth Dimension Drive

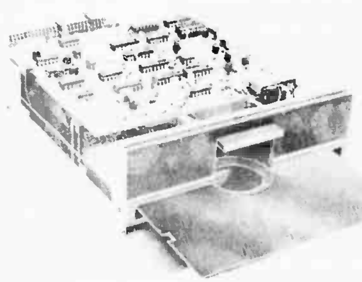
CHECK YOUR MAILBOX FOR YOUR 1982 FALL ENGINEERING SELECTION GUIDE FROM PRIORITY ONE ELECTRONICS

Tandon
WE JUST BURNED TANDON'S PRICE SHEET!

Priority One Electronics has burned up Tandon's price sheet with our special purchase of Tandon TM100-1 5¼" 40 track double density disk drives! We purchased a large quantity of new, factory-sealed drives from a large OEM who simply bought too many. This is strictly a "one-shot" deal; when these are gone there will be no more! In fact, we are selling these drives below our regular cost as a volume purchaser! At these low prices, these drives will not last long! So, if you ever thought of expanding the disk capacity of your computer, now is the time!

Tandon drives are known throughout the industry for their quality and reliability. That is why major computer manufacturers such as IBM have chosen Tandon drives for inclusion in their products. The TM100-1 is the same drive used in IBM's Personal Computer. Now you can add more disk storage to your PC and save hundreds of dollars! But you don't have to own an IBM Personal Computer to take advantage of this incredible Tandon sale! The Tandon TM100-1 has the industry standard interface for 5¼" drives so it is compatible with just about every computer on the market!

SPECIFICATIONS:	TM100-1
TPI	48
Tracks/Diskette	40
Capacity Per Side (unformatted)Double Density	250KB
Access Time	
Track-to-Track	5 ms
Average	75 ms
Head Settle Time	15 ms
Mechanical Dimensions: Width: 5.75 in. Height: 3.25 in. Depth: 8.00 in.	
DC Voltage Requirements:	+12/+5
Current Requirements	900mA/600mA



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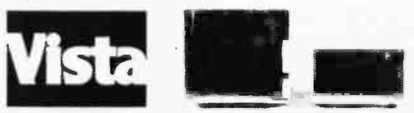

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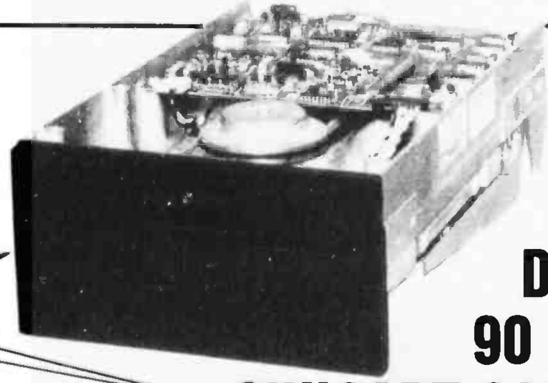

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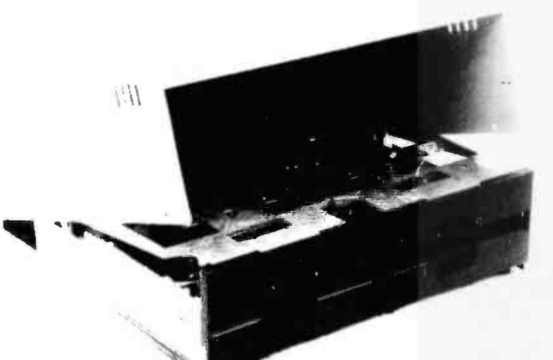

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Unclassified Ads

WANTED: Contributions of computers, software, and consultation sought by a Peace Corps volunteer in Anguilla. The new Social Security office is in the process of installing a microcomputer to benefit statistics and record keeping. They will work with manufacturers, dealers in testing, applications, etc. Craig Snively, POB 243, Anguilla, West Indies, 809-4972-451 or Telex: 301 ADMIN AXA LA.

FOR SALE: CDC cartridge disk drive Model 9427H with base, cover, and full maintenance manuals. Recently aligned and checked out by Alpha-Micro dealer on AM100-T computer system. Asking $1950. Sam Ulin, POB 216, Claymont, DE 19703. (302) 475-7355 5-10 p.m.

FOR SALE: IBM Personal Computer, 64K, color monitor board, Sanyo medium-resolution color monitor, and one disk drive. Includes DOS, subscription to PC Magazine, adventure game, and disk accessories. Used only two months, must sell. Best offer over $2500. Susan Glinert-Cole, RFD 2, South Windham, ME 04082.

FOR SALE: Mohawk Data Sciences Model 4025 digital-tape transport, condition like new, 9-track, ½-inch tape width, 10½-inch reels. Many spare parts including heads, servo-drive motors, complete mechanical subassembly, etc. Also, two sets of shcematics and documentation. Mounted in 6-foot MDS computer rack. Original price $5937, asking $420. FOB Albuquerque. Gus Simmons, Box 584, North Hwy. 14, Cedar Crest, NM 87008. (505) 281-3590.

FOR SALE: Heath H-8 microcomputer with 48K RAM, H-19 video terminal, H-8-5 cassette interface, H-8-4 four-port serial interface, dual H-17 floppy disk, and H-14 line printer. Also includes HDOS operating system, MBASIC, and Zenith Electronic Typing word processor. Worth more than $4000 in kit form, asking $290C. Scott Thompson, 306 Palmetto St., Bennettsville, SC 29512. (803) 479-4794.

FOR SALE: Two IBM communication terminals with one ASCII RS-232C interface. $1000 total. Components may be purchased separately or as package. L. Leff, Box 274, Polytechnic Institute of New York, 333 Jay St., Brooklyn, NY 11201.

FOR SALE: IDS Paper Tiger Model 440G printer in excellent condition. Includes 2K buffer option for graphics, cable, and Computer Station Apple Pascal software allowing screen dump to printer. All for $400. Originally cost $1350. Bill Mack, 1650 Sunset Strip, Sunrise, FL 33313. (305) 735-5627.

FOR SALE OR TRADE: Atari 800 with 32K, disk drive, three games, OS/A+ with assembly language, Zenith green screen, two joysticks, and sound amplifier. Many extras. All technical help available. $1550. Mark Seidenfeld, 24 Cedar Lane, Monsey, NY 10952. (914) 425-0936 after 6 p.m.

FOR SALE: Heath H-19 terminal, H-8 computer, H-8-5 serial/cassette interface, H-8 8K memory, Trionyx M-H8 (48K), and Panasonic cassette recorder. $1250. Scott Halsted, 303 East Fernhill Lane, Oak Ridge, TN 37830. (615) 482-5003.

FOR SALE: Televideo 950 terminal in perfect condition. $800. Also, a SOROC 120 in good condition. $500. Craig Rudlin, 185 Freeman St. Apt. 243, Brookline MA 02146. (617) 566-7247.

WANTED: Used Apple II disk drive (DOS 3.3) with controller card. Give price and pertinent details. James Poljanec, 2910 San Miguel, Abilene, TX 79605.

FOR SALE: Three 33ASR Teletypes, two Teleray (Model 3311), one DECwriter II, and four Multi-Tech FM300 couplers. Excellent condition. FOB. Best offer accepted 30 days from date of ad in BYTE. Charles Weinman, Luverne High School, Luverne, MN 56156.

FOR SALE: Artec Model 853 word processor and Selectric ball printer. Ideal for conversion to letter-quality printer for minicomputer or microcomputer. In working order, with original manual. $150 FOB. Donald E. Weihl, 56 South 65th St., Belleville, IL 62223. (618) 397-3455.

FOR SALE: Heath H-8 computer with 64K RAM; H-17 disk system with three 5¼-inch, single-sided, 40-track drives; H-14 printer; H-19 terminal; and acoustic modem. Includes HDOS 2.0, CP/M 2.02, and more than 90 disks of software. Best offer over $1800 within 30 days of publication date. John Efird, 1109 Southeast Cypress Lane, Palm Bay, FL 32905. (305) 724-9092.

FOR SALE: Processor Technology SOL-20 terminal computer with S-100 bus with five expansion slots, 8080A processor, parallel and serial communications interface, 16K RAM, cassette and video interface, and SOLOS personality module allowing full stand-alone terminal operation. Also included are cassette BASIC and advanced BASIC. This is in a kit form (about 80 percent complete) with full documentation. Original cost: $1800. Asking $500 or best offer. Mike Spindler, 16803 Shrub Oak Dr., Humble, TX 77338.

FOR SALE: Z80 processor board, Mostek STD-Bus Model #MDX-CPU2. Won as door prize. Has never been out of bag. List price approximately $375; will sell for $175 or best offer. Dave Olson, 6202 Peabody Ave. N. Oak Park Heights, MN 55082. (612) 439-1825.

FOR SALE: Apple II Plus computer with serial and parallel boards, four disk drives, Sanyo monitor, Applesoft BASIC compiler, Visicalc, other games, and business software. $3000. John Garuti, 35-36 190th St., Flushing, NY 11358. (212) 278-7900.

FOR SALE: Ohio Scientific CD-23 hard disk in near perfect condition. Well maintained and operational. $3600 or best offer. George Massemburg, 2323 Corinth Ave., West Los Angeles, CA 90064. (213) 477-2004 days.

FOR SALE: ELF II microcomputer in excellent condition. The unit comes with a 4K RAM board, power supply, giant board, video board, ASCII keyboard, Tiny BASIC, and all cases and manuals. Worth more than $400, but I will accept the best offer. Raymond Giannamore, 83 Harwood Rd., Waterbury, CT 06706. (203) 574-4225.

WANTED: Tax-deductible contributions of TRS-80 Model I or other microcomputer equipment for nonprofit organization. Drives and printers especially welcome. Dr. Robert Epstein, Executive Director, Cambridge Center for Behavioral Studies Inc., 11 Ware St., Cambridge, MA 02138. (617) 495-9020.

FOR SALE: Commodore 2022 tractor-feed printer. Prints uppercase and lowercase, PET graphics, expanded characters, and formatted lines. Dustcover, cable, manual, and several programs included. $575. Steve Leth, 783 E4 Essex Ave., Erial, NJ 08081. (215) 629-0600 ex. 3164 days, (609) 346-9116 evenings.

FOR SALE: Shugart SA-400 single-density, 35-track floppy-disk drive. Used, with manuals, $225. Motorola MEK6800D2 evaluation kit with 5-volt power supply and edge connector, cassette interface doesn't work; $150. George Risk Model 753 keyboard. Assembled, never used. Ken Bartlett, 1180 Reed Ave. #39, Sunnyvale, CA 94086. (408) 249-7759.

FOR SALE: TRS-80 software, brand new with original documentation. Communications Package (26-1149), $20. Astrology (26-1605), $15. BASIC Programming Assistant, $8. Pensa-write and Pensa-mail, $8. System-to-BASIC Utility, $10. RSM-2D; $15. TLDIS; $8. Duplik and Renum; $8. Cfetch and Cwrite, $5. Scarfman, $10. Big 5 Attack Force, $10. George Kwascha, 8007 Mahogany Dr., Charlotte, NC 28212. (704) 535-7575.

FOR SALE: Heath ET-3400 microprocessor trainer, assembled with manual. Asking $175. Include SASE for written inquiries. Julian King, 515 Spruce St., Roselle Park, NJ 07204. (201) 245-5048.

FOR SALE: Shugart SA-800 disk drive. Excellent condition with door-lock option. Guaranteed working., no problems; $250. Will consider swap. Greg Blanck, 2265 Murray Hill Rd., Cleveland, OH 44106. (216) 421-0814 (during summer: 1369 Tanwood Dr., Baldwin, NY 11510. (516) 223-4692).

FOR SALE: Pertec 6840 9-track tape drive, software, and interface to enable an S-100 CP/M microcomputer to read and write IBM-compatible 9-track tapes. $2500. Also have Microsoft COBOL-80, license transferable, $300. IBM-to-CP/M disk-conversion program; $30. Faulkner White, 44 Briarwood, Irvine, CA 92714. (714) 857-2029.

FOR SALE: TRS-80 computer, Level 2, 16K. Includes all original equipment, huge software library, light pen, and cassettes, including two Editor/Assemblers, FS1 Flight Simulator, Sargon II, Super Nova, and 26 other store-bought programs (worth more than $500). Also includes large number of typed-in magazine programs. $950 or best offer. Shipping extra. Sean SeLegue, 9630 Lemona Ave., Sepulveda, CA 91343. (213) 894-2585.

FOR SALE: SwTPC 6800 computer system including 4K RAM, 6800 microprocessor serial interface, motherboard, power supply, PR-40 alphanumeric printer. Also, CT-1024 terminal with serial and parallel interfaces, computer- and manual-controlled cursor boards, power supply, and memory board. Also, AC-30 cassette interface. Available individually or as a set. Many components also available. Earl Wiese, 3434 W St., Lincoln, NE 68503. (402) 467-2254.

WANTED: One each 3622 and 8111 PROMs that are used on the IMSAI MPU-B board. If the PROMs are not available, I would like a copy of the codes in these PROMs from anyone using this board. Doug Baker, R.R. 3, Box 11, Charlotte, TN 37036.

FOR SALE: TRS-80 16K Model I Level II with cassette drive including about $300 worth of software; $700 or will trade for Apple. Also, want PC-100C printer and TI-59 software. Troy Underwood, POB 133, Yreka, CA 96097. (916) 459-3667.

WANTED: Circuit diagrams for SOL Helios II Persci/270 Assembly, with 200131 disk drive; in particular, Assembly 200263-007 Rev R/S. Name your price. C. S. Hopman, B.P. 225, Noumea, New Caledonia, South Pacific.

FOR SALE: Large quantities of Motorola 4164 64K by 1, 150 ns of dynamic RAM chips for $12. Also, Intel 8203 dynamic RAM controller for $45. All chips are brand new and fully functional. Please send check or money order. Kourosh Hamzei, 28120 Peacock Ridge Rd. Apt 304, Palos Verdes, CA 90274.

WANTED: Maintenance manual for Mini-MAS video-display terminal from Micro Applications Systems. Will pay reasonable charge for original or duplicate copy. I can copy; will provide deposit while copying. Harold Corbin, 11704 Ibsen Dr., Rockville, MD 20852. (301) 881-7571.

FOR SALE: Radio Shack Quick Printer II line printer, like new; $100. Apple II 3.3 disk-controller card, brand new; $25. TRS-80 pocket computer, used once; $100. Jim Arsenault, 684A Honeyspot Rd., Stratford, CT 06497. (203) 368-2332 days.

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Unclassified Ads

FOR SALE: Heath H-9 video terminal modified for 24 by 80 and uppercase/lowercase display; $275. SwTPC AC-30; $20. ASCII keyboard; $25. Many parts, including 6800s and I/O chips. Heath HW010 SSB transceiver with HP23A power supply; $425. SASE for complete list. T. Glaser, R.R. 1 Box 312, Rochester, MN 55901, (507) 285-9871.

FOR SALE: Heath H-88 computer with cassette interface, manuals, system software, and two game tapes. Still under warranty, never used, wired and tested, can't tell from new. $1050 cashier's check only; I pay shipping and insurance. Mike Huttinger, 728 Smalley Dr., Norman, OK 73071, (405) 321-6749.

WANTED: I need a 6800 assembler and editor, preferably on cassette, 300 bps KC standard. Either the SwTPC version or the TSC version. I will gladly pay all charges. V. J. Silva, 43 Ayers St., Waterbury, CT 06706.

WANTED: Curta miniature mechanical hand-operated calculator. Michael Rainey, 5627 Columbia, St. Louis, MO 63139, (314) 781-3994.

FOR SALE: 20-slot S-100 motherboard, 64K memory board, serial/parallel I/O board, and 25-A power supply. All are major manufacturers' boards; some need parts to be complete. All with documentation. Make offer. Also, a Heathkit H-9 terminal with uppercase/lowercase and 24-line conversion; $250. Steve Sherman, 940 Poplar Ave., Boulder, CO 80302, (303) 440-0472 evenings.

WANTED: APF Imagination Machine programs. Also, inforamtion as to compatibility of Atari, Intellivision, and other cartridges with APF equipment. B. Orr, 2515 Greencastle Court, Oxnard, CA 93030, (805) 985-4696.

WANTED: Apple II Plus users who would like to correspond and exchange programs and ideas with 22-year-old male graduate student. My system is complete and my software collection is large and diversified. Please send information about yourself and your system. Mark A. Brown, University of Idaho, POB 3488, Moscow, ID 83843.

WANTED: A mint, fully assembled Apple I computer. Wanted by a serious investor; replies from original owners only. Please send picture and complete description. Paul Hoffman, 2109 Shattuck, Berkeley, CA 94704.

FOR SALE: Altair 680b KCACR. Hard-to-find audio cassette I/O board for the Altair 680b microcomputer. Includes board, cables, documentation, and BASIC-language software; $100. Robert W. Senser, POB 3152, Laramie, WY 82071, (307) 745-7082.

FOR SALE: Micro Technology Unlimited equipment for KIM-1: card cage, visible memory, 16K RAM, PROM I/O, disk controller with CODOS operating system, Qume DT-8 disk drive, and KIM-1 microcomputer. This is a complete, working system except for terminal; BASIC, FORTH, and assembler included; all KIM and MTU documentation. Bill Michelfelder, Cascade Rd., Keene, NY 12942, (518) 576-4751.

FOR SALE: Talk to your TRS-80 and have it answer you! Radio Shack Voxbox voice-recognition unit and voice synthesizer. Voxbox requires Level II, 16K; voice synthesizer, Level I or II, 4K. Brand new in original boxes. Never hooked up. $275. May consider separating. Martin J. Schroeder, 702L Eagle Heights, Madison, WI 53705.

FOR SALE: Back issues of BYTE from July 1976 to June 1980. All in excellent condition; reasonably priced. Larry Jaycox, 1829 Forester Dr., Cincinnati, OH 45240, (513) 851-9184.

FOR SALE: DEC LSI-11 equipment: KD-11F processor with KEV-11 floating-point chip, four MSV-11CD 32K RAMs, two DLV-11 serial units, REV-11 bootstrap, RXV-11 with RX-01 dual floppy-disk drive, two H9270 backplanes and card cages, two H780 power supplies, quad-extender card, wire-wrap protocard with Q-bus chip kit. Also includes manuals, cables, software, spare parts, and other items. Best offer over $2000. Kenneth A. Scharf, 851 Southwest 64th Terrace, North Lauderdale, FL 33068, (305) 979-4047 days, 972-1451 evenings and weekends.

FOR SALE: New Heath H-89 all-in-one computer (assembled April 1982) with all manuals. Includes 48K memory, built-in floppy drive, HDOS (Ver. 2.0) operating system, Heath BASIC Programming Course (new), and Heath Users Group (HUG) catalog. A $3100 value for $2575. Shipped postpaid in the U.S. Joe Douglas, 5014 Romford Dr., Corpus Christi, TX 78413, (512) 991-7949.

FOR SALE: TRS-80 Model I Level II, with LNW expansion interface, 48K RS-232C, CTR-80 recorder, and covers; $800. Exatron Stringy/Floppy with starter kit and Level III BASIC; $200. Also, Heathkit H-14 printer; $350. Jack McIlnay, 5620 Del Paz, Colorado Springs, CO 80918, (303) 599-5701.

WANTED: TRS-80 Model I or III with disks, in good operating condition. Needed for training ex-offenders. Donations are tax-deductible and cheerfully accepted. Roger Logue, Prisoner Release Ministry, Joliet, IL, (815) 723-8998.

WANTED: To exchange by mail with other ZX81 computer owners any software, programs, and ideas for the ZX81 with optional 16K memory module. William A. Axsom, 661 Northwest 75th Terrace, Plantation, FL 33317.

FOR SALE: DEC PDP-8/E processor and five RK05 disk drives with connecting cables. Also, two DEC 861C power controls. Best offer takes all or any part. Call for more information. Greg McDonald, (301) 559-3830.

WANTED: Back issues of BYTE, Vol. 1, #1 through Vol. 7, #3 and Kilobaud Microcomputing, #1 through #59. Issues should be complete and in excellent condition. Send list of volumes and their condition. Ouatannens W, Melkwezerstr 39, B-3350 Linter, Belgium, West Europe.

FOR SALE: Complete 9-track magnetic tape system. Pertek NRZI formatter Model F849, two each Pertek Model 7840-9 6-inch reel, half-inch tape, 12.5 ips read-after-write tape drives, plus full documentation and cables. Simple parallel interface to processor. Unused. Originally $9000; make offer; cash or trade. Andy Werback, 3670 Weedin Court, San Jose, CA 95132, (408) 262-8622.

BOMB

BYTE's Ongoing Monitor Box

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Spritely Colored Winner

Steve Ciarcia is back in the number-one spot. His "High-Resolution Sprite-Oriented Color Graphics" secured him first place in the August BOMB contest. He'll receive the $100 kitty. Second place goes to Harold Abelson for his Logo primer, "A Beginner's Guide to Logo." He'll be awarded the second-place prize of $50. And a very close third place goes to technical editor George Stewart for his article "Program Generators." Congratulations, George.

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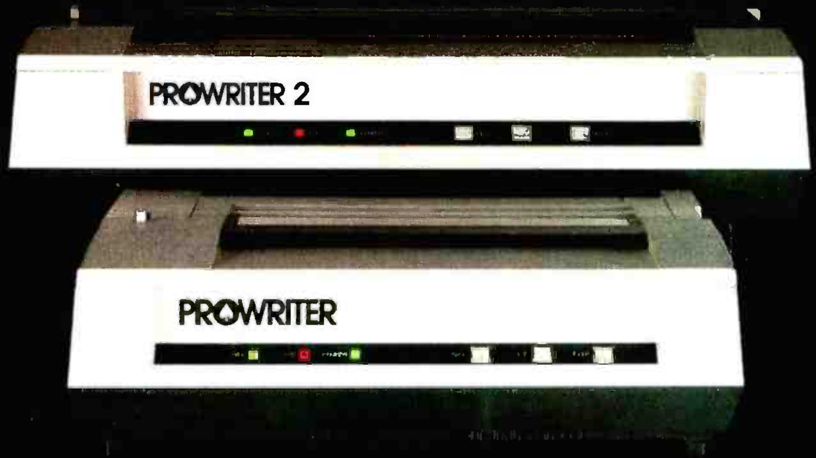
The Prowriters: business printers—and more. The "more" is a dot-matrix process with more dots. It gives you denser, correspondence quality copy (as opposed to business quality copy, which looks like a bad job of spray-painting).

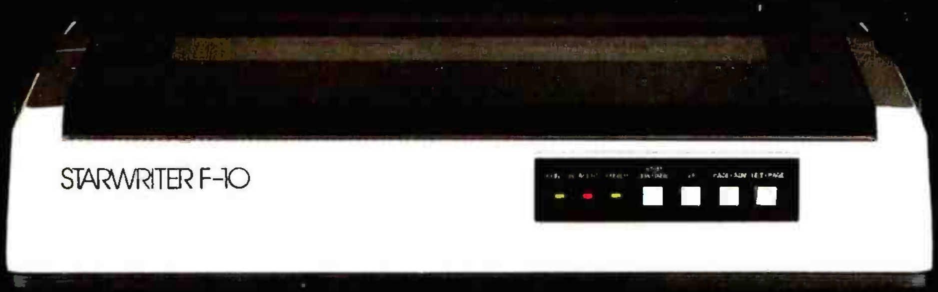
Prowriter: 120 cps. 80 columns dot matrix compressable to 136. 10" carriage. Parallel or serial interface.

Prowriter 2: Same as Prowriter, except 15" carriage allows full 136 columns in normal print mode. Parallel or serial interface.



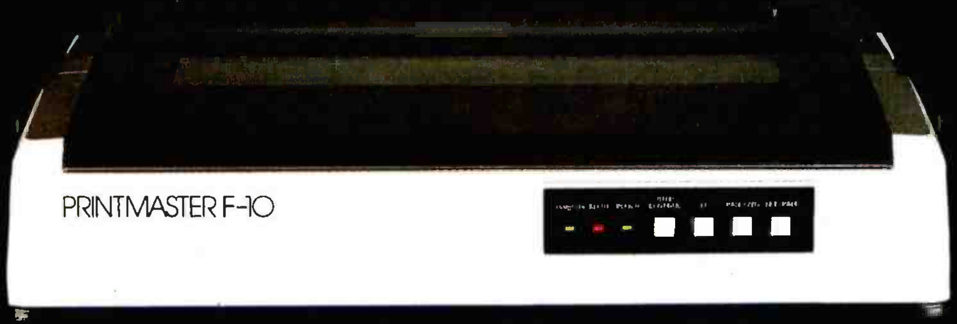
THE STAR.

The Starwriter F-10. In short (or more precisely, in a sleek 6" high, 30-pound unit), it gives you more of just about everything—except bulk and noise—than any other printer in its price range. It's a 40 cps letter-quality daisy-wheel with a bunch of built-in functions to simplify and speed up word processing. It plugs into almost any micro on the market, serial or parallel.



THE MASTER.

The Printmaster F-10. Does all the same good stuff as the Starwriter except, at 55 cps, the Master does it faster.



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