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# BYTE<sup>®</sup>

the small systems journal



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\*U.S. Pat. No. 4121283



Model SDI High-Resolution Color Graphics Interface

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

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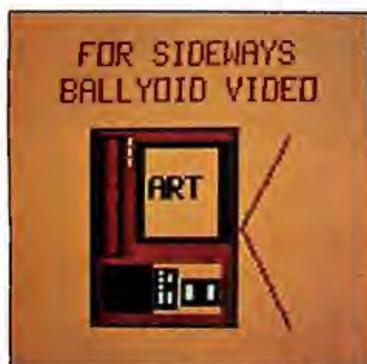


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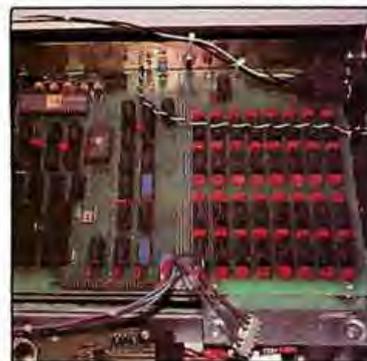
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## In This Issue

The cover for this issue of BYTE is a still from a 90-minute computer-animated cartoon called *The Works*. The photo was provided by Dick Lundin and Lance Williams and is constructed from quadric surfaces and polygons, using texture-mapping and normal-perturbation techniques. The background was painted by Paul Xanter—programming credit also goes to Tom Duff and Duane Palyka. A trailer of *The Works* was shown at SIGGRAPH '80 (page 172), although the film itself may not be finished for another two years.

A number of the articles for this month's theme were solicited with the help of Jay Nickson and Ken Lodding; their editorial begins on page 6. Both are employed by DEC (Digital Equipment Corporation); Jay is the manager of the *human interface* program for simplifying man/machine communications, Ken is a senior software engineer whose long-term interests intermix art and computer graphics.

## Publisher's Note

As most readers will have observed, the September Fifth anniversary issue marked the beginning of a new phase for BYTE. The jump from a 300-page to a 400-page issue means a 33% increase in the material presented to our readers each month.

Because advertisements tend to be more visible than editorial content (especially in a technical journal), some readers may suspect that the larger issues mean merely more ads. But, in fact, the larger issues have approximately one third more editorial content. The new size does create design and manufacturing problems, however. The solution to these problems includes a redesign of the editorial pages of BYTE to make the editorial content easier to find and use. We expect the new format to be implemented early in 1981.

We are confident that the increased editorial content and new format will make BYTE even more of a bargain as well as a more useful tool for our readers. And that, after all, is what it's all about.

Virginia Londoner  
Publisher

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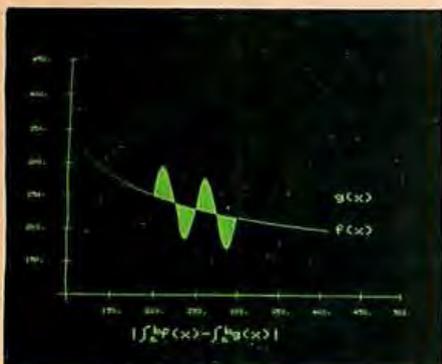
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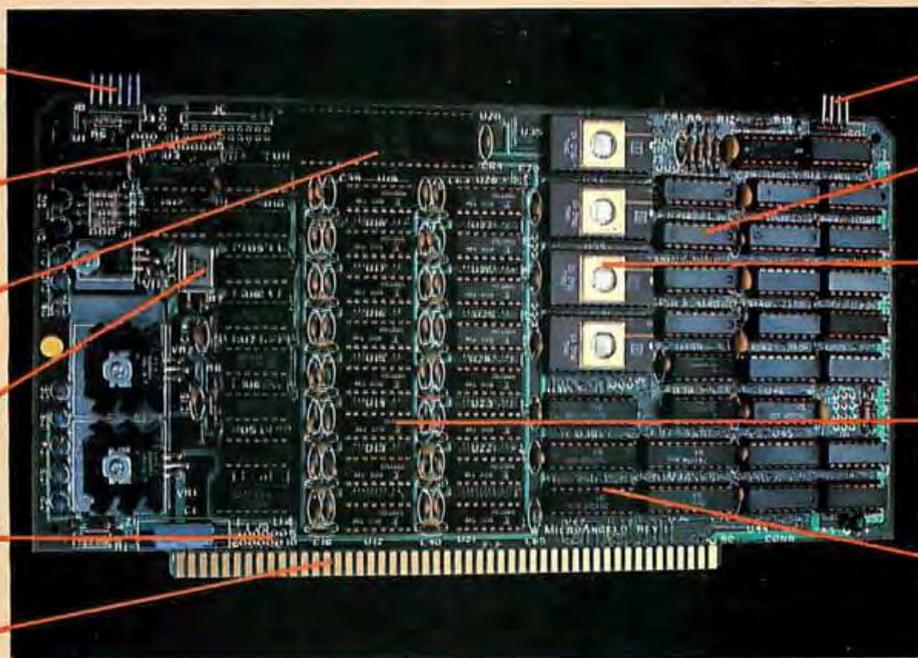
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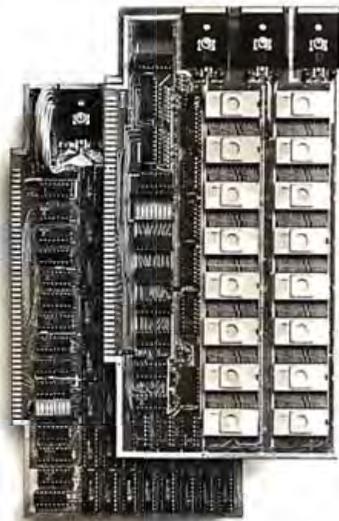
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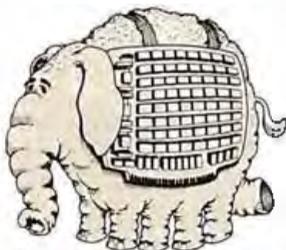
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# Editorial

## The World of Computer Graphics

Guest Editorial by Ken Lodding and Jay Nickson

Man is a visual animal. He surrounds himself with graphic images. Images are employed to convey information, to explain concepts, and to communicate feelings. The ability to draw is instinctive. It materializes in infants soon after the start of verbal development, perhaps to complement the slowly developing verbal skills. Although the ability to draw tends not to become as fully developed as verbal skills, images continue to provide much of the adult human communications ability. Pictures are a primary information-carrying channel: the histogram accompanying a financial article, the plot of a mathematical function, and the illustrations in *BYTE* are but a few examples.

The importance of graphics for conveying information arises from the nature of man's visual system. The eye provides an extremely high-bandwidth information channel for transferring the data to be processed by the brain's optic center. The importance of this channel can be seen from the redundancy built into the system and from the distribution of optic nerve fibers in the brain. It is believed that no less than six different brain sites are directly serviced by connecting optic nerve fibers. (See reference 4.) The fundamental importance of visual information is reflected in the old adage, "seeing is believing," and in the observation that *understand* is one of the synonyms of the word *see*. Text fails to use our native abilities to comprehend information fully because it presents data in a linear, sequential fashion. Contrast this with graphical images, which can be processed in a single viewing—a phenomenon called *preattentive perception*. (See reference 6.)

The computer has become a primary source or conveyor of information, yet the main interface between man and machine has remained the serially oriented text display. The net result is that, as the volume of data available to be presented increases, the user's communication channel becomes swamped with an avalanche of text output. The volume of this avalanche far too often restricts the comprehension of the information. The information is obscured as effectively as if it had been encrypted. The spectacle of the computer user literally buried under reams of printed output has ceased to be an amusing cartoon and has become a nightmare for too many. To cope with the flood of information, the computer user is turning to graphics.

The information-transfer rate of a graph can be many orders of magnitude greater than an equivalent text presentation. Conceptually, a graph has greater information density than a table. Compare the plot of a sine curve with a table of sine values. Each value within the table corresponds to a specific point on the graph. However, the plot displays a far greater number of points than could the most extended table. A high information-transfer rate results from the greater data density and the faster operation of the human mind and visual system. Patterns, periodic functions, trends, and comparisons can often be obtained "by inspection" of a graph, while understanding a tabular display requires much more time and effort. This is not, however, accomplished without a cost. The only penalty paid for speed is the loss of precision: a graph cannot be read to the same number of significant digits as can be obtained from a table. This loss of precision is not a problem, as the specific data value of interest can be extracted from the function or table of data used to generate the plot initially.

### About the Authors

Ken Lodding and Jay Nickson are employed by the Digital Equipment Corporation in Merrimack, New Hampshire.



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In addition to presenting data in a rapid, meaningful fashion, an important benefit of computer graphics is the ability to present images realistically. Plotting a topological surface, modeling DNA, creating an architectural rendering, and simulating a pilot's view from the cockpit of an aircraft are all enhanced by presenting the image in a manner which gives the viewer a sense that the picture is not an illusion. To achieve greater realism, a prime factor is to provide the illusion of depth. Perspective, hidden-line removal, shading, and highlighting all provide depth cues to the viewer. This month's computer-generated cover by Lance Williams of the New York Institute of Technology clearly illustrates the current state of the art as applied to an artistic endeavor. The same techniques are available and can be employed when graphically representing numeric data.

### Three-Dimensional Graphics

To provide the illusion of depth, a three-dimensional model can be defined. Establishing the viewer's geometric relationship to the model and following the rules of perspective, the model image is mathematically projected onto a two-dimensional viewing plane. Although providing good visual depth cues (eg: parallel lines appearing to meet at a point), there is no real illusion of depth; in other words, the model image is still "flat." To correct this, the phenomenon of *stereopsis* (from the Greek, meaning "solid sight") can be employed. You may be familiar with the 1847 Brewster stereoscope. Here, the approach taken to give the illusion of depth was to photograph the same scene twice, having moved the camera about 6 cm sideways between photos. The two images could then be viewed through a stereoscope that utilized a prism and lens system to alter the image paths to the eye, so that the two views seemed to originate from a common point. (The old-fashioned stereopticon and the modern View-Master are variations on this theme.) The observer's visual system fused the two images, giving the illusion of a three-dimensional image.

Various computer-graphic techniques using the same principles have been developed. A common technique is to employ glasses with electro-optic shutter eyepieces to provide the image separation. With the electro-optic glasses, the *cyclopic* video display presents left- and right-perspective images in alternate frames, which are then synchronized with the electro-optic shutters. The left eye is presented with the left stereograph, while the right eye's view is blanked by the optical shutter; the image and shutter swap for the right eye. The viewer's internal visual system fuses the image to give the appearance of depth. For an example of this, see "The Future of Computer Graphics," page 22.

A different approach to providing left and right images to the visual system uses color to separate the images. Using a device called an *anaglyph*, the left view is presented in one color, and the right in a different color. Color filters control which eye sees what view. A program for generating and viewing anaglyphs is presented in the article "Three-Dimensional Graphics for the Apple II." (See page 148.) While the traditional colors employed are red and green, any two colors and corresponding filters could be used, because the illusion is based on the separation of the images, and has nothing to do with the particular colors. The phenomenon is as apparent to a



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color-blind person as it is to a viewer with normal color vision. For those interested in further information, the book *Seeing* is an excellent reference on vision in general and stereopsis in particular. (See reference 4.)

A more recent and unique approach to presenting three-dimensional images is SpaceGraph, developed by Dr Larry Sher. His technique uses a vibrating mirror and a video display. The technique is to generate on the display two-dimensional "slices" of the three-dimensional object to be viewed. The slices are rapidly generated in synchronization with the dynamic motion of the mirror, the front slice being generated when the mirror is extended toward the viewer, the back slice when the mirror is concaved away from the viewer, and the intermediate slices as appropriate for the travel of the mirror between these extremes. The rapid sequence of images is fused by the viewer's visual system to give the illusion of a "space filling" object. (See reference 7.)

Those adventuresome souls who find three-dimensions insufficient for their purposes can use computer graphics as an aid for visualizing objects which, theoretically, exist in four or more dimensions. If you are interested in this area, *Hypergraphics* is a good introduction to the subject. (See reference 3.) The book includes hyperstereograms of such objects as hypercubes or tesseract, hypercones, and other denizens of higher dimensions.

Animation is another technique that can assist in user comprehension of data. Often we are dealing with information gathered at discrete intervals over a period of time. Here, the problem of analyzing data is one of

understanding what is occurring to the data elements over some length of time. Animation provides a looking glass into the time domain. Flowing, three-dimensional images can represent anything from an economic world model to a bridge under stress.

### Hidden Benefits

There are times when animation provides the viewer with unexpected information—information which, in retrospect, was present but not readily discernible by any other method of examination. An interesting example of this situation involves the simulation of an internal combustion engine. The simulation, performed at a research laboratory, wrote out data in the conventional manner: stacks of numbers. At the same laboratory, some time after the engine simulation had been completed and used for experiments, a different group of researchers developed a computer-animation system. The engine simulation was selected as a good demonstration of the new graphics software, and a computer-generated film was produced. During the screening of the film it was noticed that small rectangular elements, used to represent idealized gas packets, displayed a strange, unexpected oscillation at their endpoints. Review of the animation software provided no explanation for this erratic behavior. Close examination of output from the original simulation revealed that the oscillations were indeed present. This fact had not been previously noticed because the information had been obscured by a combination of the tremendous amount of data, the smallness of the oscillation, and the extended period over which it occurred. What had in fact been found were acoustical-wave phenomena occurring within the cylinder of the engine, which could potentially be used for the development of more efficient engines. The events went unnoticed until a computer-generated movie was constructed.

In the 30 years since its beginnings, computer-generated graphics has grown steadily, but not spectacularly. Previously the costs of both the display and the computer resources needed to support graphic displays have limited the impact. Rapidly falling memory prices and television technology have renewed the interest in computer graphics. The combination of a television raster display and a memory-intensive, bit-mapped architecture makes possible a graphic system capable of providing full-color, dynamic images with previously unheard of realism and economy. "Micrograph, Part 1: Developing an Instruction Set for a Raster-Scan Display," describes the design and construction of a color-display processor that costs approximately \$250 to build. (See page 64.) This is possible only because of the plummeting cost of hardware. This is a cost reduction of three orders of magnitude in 15 years, with color added for free!

### Graphics Software

The advent of inexpensive graphics hardware has, not unexpectedly, spurred the development of graphics software. The traditional approach for supporting graphics has been to provide a collection of subroutines that perform the graphic-display functions. These subroutines are called from languages whose orientation is toward the manipulation of text and numerical data. This approach is fine if you only want to accumulate data and make a

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## Serial Interface.

The RS-232 standard assures maximum compatibility with a variety of serial devices. For example, with the AIO you can connect your Apple\* to a video terminal to get 80 characters per line instead of 40, a modem to use time-sharing services, or a printer for hard copy. The serial interface is software programmable, features three handshaking lines, and includes a rotary switch to select from 7 standard baud rates. On-board firmware provides a powerful driver routine so you won't need to write any software to utilize the interface.

## Parallel Interface.

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## Two boards in one.

The AIO is the only board on the market that can interface the Apple to both serial and parallel devices. It can even do both at the same time. That's the kind of innovative design and solid value that's been going into SSM products since the beginning of personal computing.

The AIO comes complete with serial PROM's, serial and parallel cables, and complete documentation including software listings.

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# Maybe we can save you a call

Many people have called with the same questions about the AIO. We'll answer those and a few more here.

**Q:** Does the AIO have hardware handshaking?  
**A:** Yes. The serial port accommodates 3 types—RTS, CTS, and DCD. The parallel port handles ACK, ACK, BSY, STB, and STB.

**Q:** What equipment can be used with the AIO?  
**A:** A partial list of devices that have actually been tested with the AIO includes: IDS 440 Paper Tiger, Centronics 779, Qume Sprint 5, NEC Spinwriter, Comprint, Heathkit HH, IDS 125, IDS 225, Hazeltine 1500, Lear Siegler ADM-3, DTC 300, AJ 841.

**Q:** Does the AIO work with Pascal?  
**A:** Yes. The current AIO serial firmware works great with Pascal. If you want to run the parallel port, or both the serial and parallel ports with Pascal, order our "Pascal Patcher Disk."

**Q:** What kind of firmware option is available for the parallel interface?  
**A:** Two PROM's that the user installs on the AIO card in place of the Serial Firmware PROM's provide: Variable margins, Variable page length, Variable indentations, and Auto-line-feed on carriage return.

**Q:** How do I interface my new printer to my Apple using my AIO card?  
**A:** Interconnection diagrams for many popular printers and other devices are contained in the AIO Manual. If your printer is not mentioned, please contact SSM's Technical Support Dept. and they will help you with the proper connections.

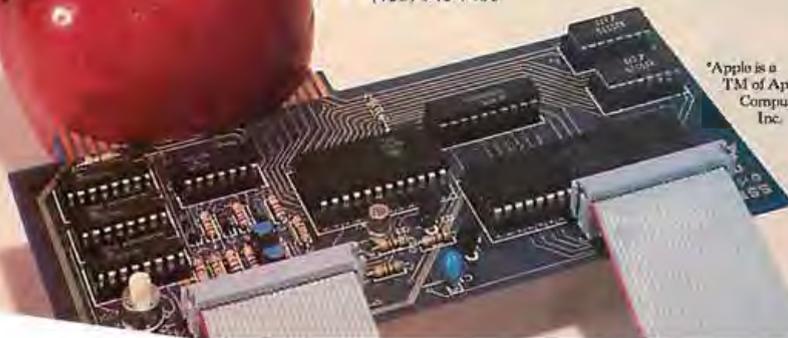
**Q:** I want to use my Apple as a dumb terminal with a modem on a timesharing service like The Source. Can I do that with the AIO?  
**A:** Yes. A "Dumb Terminal Routine" is listed in the AIO Manual. It provides for full and half duplex, and also checks for presence of a carrier.

**Q:** What length cables are provided?  
**A:** For the serial port, a 12 inch ribbon cable with a DB-25 socket on the user end is supplied. For the parallel port, a 72 inch ribbon cable with an unterminated user end is provided. Other cables are available on special volume orders.

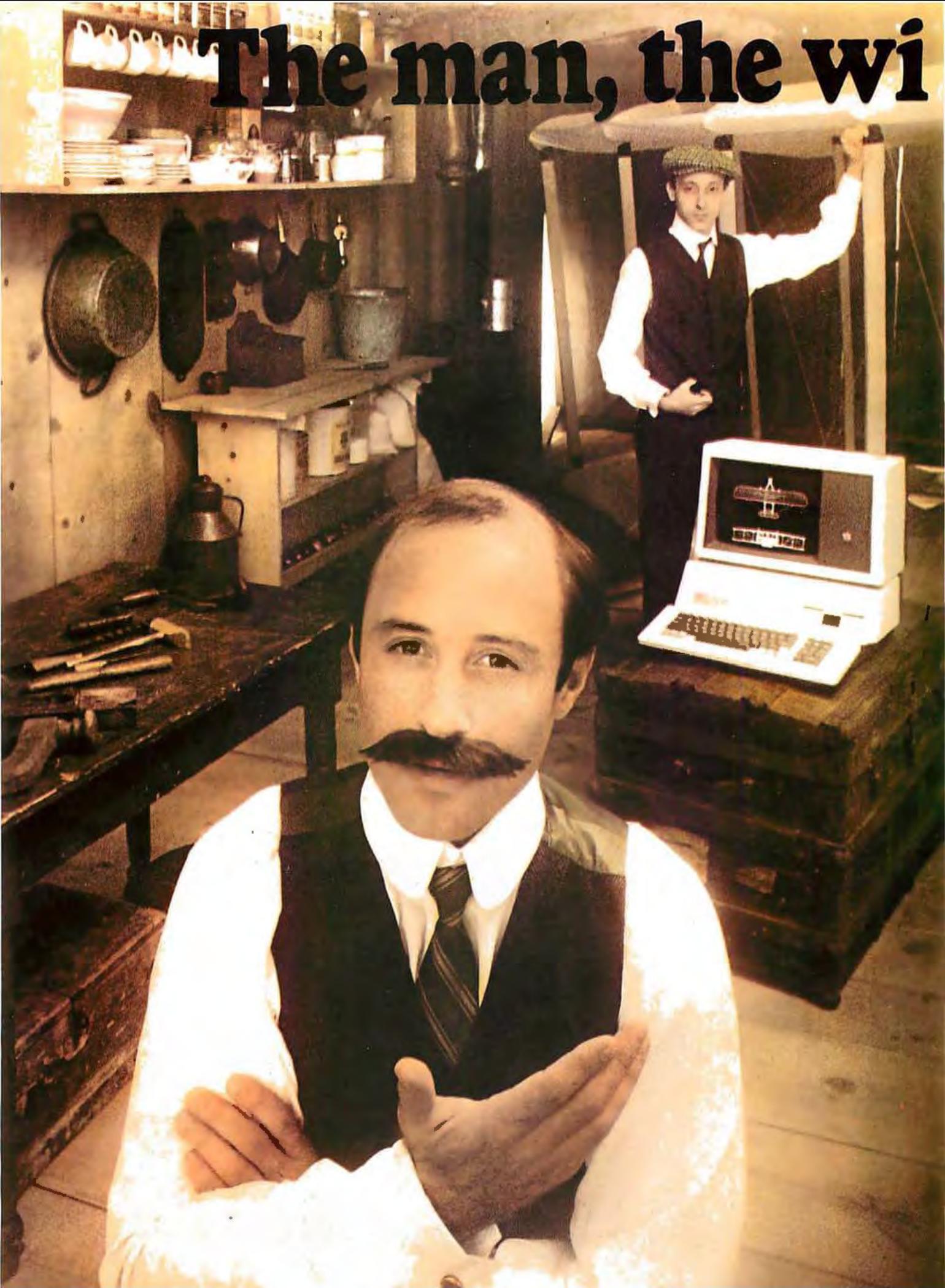
The AIO is just one of several boards for the Apple that SSM will be introducing over the next year. We are also receptive to developing products to meet special OEM requirements. So please contact us if you have a need and there is nothing available to meet it.



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# The man, the wi



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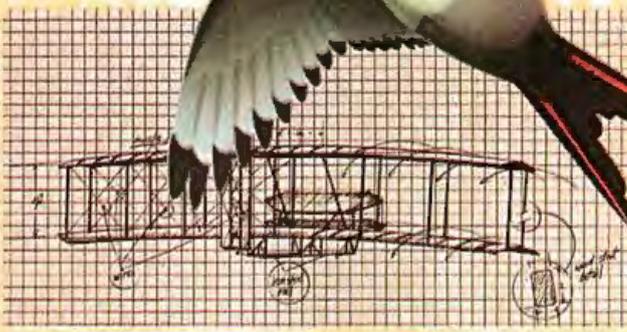
Apple's existing software library includes a program that plots the shape of an airfoil, given its parameters.

that's unparalleled for analyzing alternative paths of design and modeling a wide variety of physical processes.

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100 companies also supply peripherals for Apple because Apple is the most popular personal computer with the least complicated interface.

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Fluent in the same language that helped to design the 747, Apple FORTRAN lets you tackle differential equations at the touch of a key. And since more than 170 companies also offer software for the Apple family, you can have one of the most impressive program libraries ever...including vast subroutine libraries for math, science, engineering and statistics. When you write

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picture from it. The subroutine approach excludes the possibility of treating graphical objects as variables within the language, or using them within statements and expressions. Some research work has been done which includes the concept of graphical objects and operators within a language structure. To date, there have been a number of different approaches to the problem of handling graphical objects. Deeply intertwined in the problem is our fundamental lack of understanding of how to provide graphics support. Viewed from the perspective of a language, what fundamental primitives must be provided? What are the appropriate data types? How are expressions constructed? What operators need to be provided? The list of unknowns goes on and on. "Language Control Structures for Easy Electronic Visualization," by Dr Tom DeFanti, addresses this area. (See page 90.) Some examples of other, experimental, graphics languages are given in references 2 and 5. SHAZAM (Smalltalk's sHaded imAge Zippy Animated Moviemaker) is an interesting animated-movie language written in Smalltalk. (See reference 1.) In no way does this list exhaust the progress that has been made in graphics languages, but rather it reflects a small sampling of recent work.

All the aspects of graphics we have discussed allow us to construct windows into universes, real or imaginary. Computer graphics is exciting because with this tool we can witness the unraveling of a DNA molecule, or the collision of galaxies. We can watch the structure of the universe as it expands from the moment of the theoretical big bang, or, reversing entropy, see it collapse into the primordial particle. We can plot a mathematical function, view an economic trend, or travel faster than light to where robotic insects populate metallic worlds. Best of all, we can make it all seem real, because we can see it! ■

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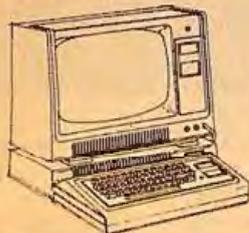
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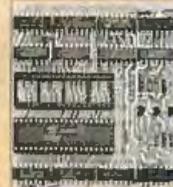
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# Letters

## Moore Praise Comes FORTH

If FORTH is trickery, give me more trickery.

In my view, FORTH is a common-sense approach to programming. Granted, there are also bits of pure genius thrown in.

It makes sense to put all the routines used by the operating system, compiler, parser, editor, etc, in one dictionary conveniently accessible to the user at all times. That is, if they will fit. One of the bits of genius of FORTH is that they do indeed fit with room to spare for user-defined routines. The result is instant liberation from the "systems man" who tries but can't please everyone. It is your computer, and with FORTH you have access to everything on it.

It makes sense to use a stack to pass parameters between routines and to separate this stack from the return-address stack. You end up with a language that is designed to compute rather than to be read. Every step in FORTH is directed toward computing a result. FORTH is a sequence of com-

mands rather than statements as found in BASIC or Pascal. The functions of computing and documentation are separated. Hence I strongly disagree with Gregg Williams' advice (see August 1980 BYTE, page 130) that the user should introduce intermediate variables to improve readability. I concur with his objective, but I would encourage their use only in the commentary where they belong. There is no point to introducing unnecessary variables in the computing process. In the commentary, intermediate variables can and should be used very effectively to help describe the computations that are occurring on the stack without interfering with the process.

While FORTH takes away the expository statement, it does give back an important documenting feature, namely relative ease in preparing precise common-language definitions of each routine. All FORTH routines have a describable goal, and most of the action takes place on the stack. Hence FORTH routines tend to be simpler to describe. I have never seen a glossary for a language or operating system that comes

even close to the completeness and conciseness of the fig-FORTH glossary supplied by the FORTH Interest Group. It is a gem, a complete English-language description of FORTH. Every routine on the computer is concisely defined in English.

You have to have faith that taking the sacred function of documenting out of the language and turning it over to the user to do as he sees fit will work. After a while, you begin to wonder if Milton Friedman didn't write FORTH for his television series *Free to Choose*.

Finally, it makes sense to give the programmer a shot at controlling the compiler, especially when the compiler has access to all the routines of the system. C H Moore has shown with FORTH that compilers do not have to be large inflexible systems which try to take into account every eventuality and really can't do it. The result of this bit of FORTH trickery is a powerful compiler so tiny that it can be made interactive and used on line with no batch processing, linking loader, or other monstrosity which we are accustomed to associate with a compiler.

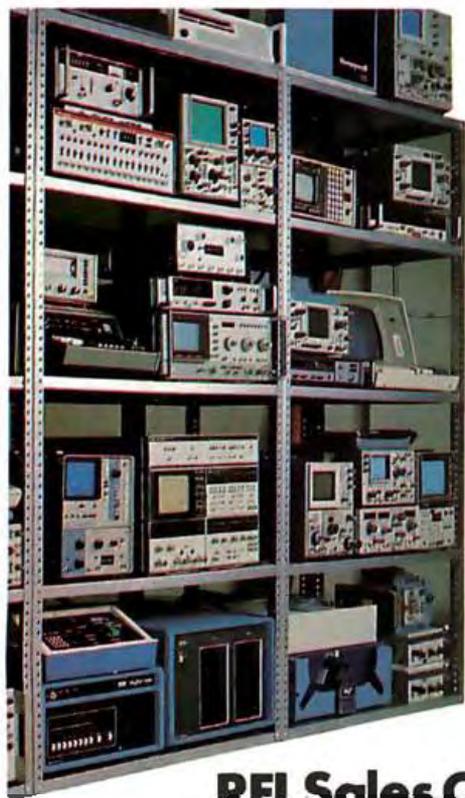
How small (or big) is tiny? The fig-FORTH system supplied by the FORTH Interest Group for the 6502 contains 220 primitive routines (not including the Editor or Assembler) that occupy a total of 6221 bytes. By my count, 34 of these routines are compiler functions, and they occupy a total of 982 bytes. My guess is that this is an order of magnitude smaller than other compilers of comparable power. That is trickery.

If there ever is a contest for the all-time ingenious software development, I would like to nominate C H Moore's best, the { ;CODE } routine and/or its logical extension  
{ <BUILDS ... DOES> }.

Edgar H Fey Jr  
Edgar H Fey Jewelers Inc  
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## Flash: Magic Exists!

I was delighted to see an issue of BYTE devoted to FORTH. As a user of and tinkerer with STOIC for 5 years, I heartily agree with the various authors' ravings about the extensibility, flexibility, and increase in productivity provided by FORTH. I was, however, amused at the many ways in which postfix (reverse-Polish) notation was rational-



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ized as being a better or more efficient way to do things even though it renders programs "write only" or at best difficult to read.

Since maintainability of programs becomes even more critical when productivity is increased tenfold or more, I feel that the requirement of postfix notation by FORTH is a serious shortcoming. There is nothing mystical about postfix notation; all compilers and interpreters must eventually reach this form because that is the order in which the computer must carry out its operations.

Over the past two years Jeff Morris and I have added various superstructures onto FORTH (one per application) that

attempted to combine the better features of Pascal (eg: record structures, algebraic notation) with the power and flexibility of FORTH. The outcome of all of these experiments was a conceptual breakthrough which resulted in the invention of Magic. Magic has all the advantages of FORTH, plus, Magic programs are readable (thus maintainable).

For example, the FORTH (or Magic) statement:

$$B@ C@ + A@ * A!$$

can also be written in Magic as:

$$A := A * (B + C)$$

and in fact compiles in three fewer words (since the @s are not needed), and the FORTH (or Magic) statement:

$$A@ B@ = IF$$

can also be written in Magic as:

$$IF(A.EQ.B)$$

Magic is a major enhancement to the basic compilation structure of FORTH (a metaFORTH), not simply an add-on superstructure. Magic programs typically compile more slowly (due to the increased complexity of the compiler) but require less memory and run faster than equivalent FORTH programs.

The concept of metaFORTH is discussed briefly in the article by Kim Harris. (See "FORTH Extensibility: or How to Write a Compiler in Twenty-five Words or Less," August 1980 BYTE, page 164.) This is the direction of the future and will be the source of some super-powerful programming tools in the next decade. Magic is a first step in that direction.

I hope and expect that new metaFORTH languages such as Magic will be developed so that FORTH users can have their cake and eat it too. The time has come to stop justifying the unreadability of postfix notation.

Arnold Epstein PhD  
Director, Software Development  
Octek Inc  
7 Corporate Pl  
5 Bedford St  
Burlington MA 01803

#### Needs Tektronix Secrets

Can a BYTE reader help me? I have a Tektronix 4051 computer which came with a BASIC interpreter. Some of my programs must run faster, and I would like to rewrite them in machine code. Tektronix states that machine code is unsupported on the 4051 and suggests spending another \$10,500 for a faster Model 4052. Someone somewhere is programming the 4051 in machine code, as "Space Tag" on the demonstration tape is in machine code and runs incredibly faster than ordinary BASIC programs.

Richard Daily  
800 Charlesgate Dr  
St Louis MO 63122

#### Information Please

I recently acquired a Video Brain home computer built by A Umtech Company. The serial number is 003087 and the model number is 101A. It was built in either Santa Clara or Sunnyvale,

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California. I understand it has a Fairchild F-8 8-bit microprocessor. It has 1 K bytes of programmable memory and 4 K bytes of read-only memory.

What I am looking for are cartridge programs, which have a 45-terminal bus, the expander sets, or anything that would be interchangeable. Also, any information or leads would be gratefully appreciated by me and my friends.

Richard L Rowland  
7072 Kenwood  
Las Vegas NV 89117

### An Overlooked FORTH Vendor

The staff at Datricon Corporation was both delighted and disappointed with the August 1980 BYTE. Our delight stems from the extensive coverage of the language FORTH and Charles H Moore's interesting article, "The Evolution of FORTH, an Unusual Language," page 76.

However, we were disappointed with BYTE's failure to mention Datricon's ACS 12-PRO or Datricon's 4 K D-FORTH. Datricon's implementation of FORTH resides in 4 K bytes of EPROM (erasable programmable read-only memory), produces code that can be placed into ROM (read-only memory), and provides for interrupt handling and the automatic setting of the data-transfer rate. Our ACS 12-PRO, with D-FORTH and the STD BUS interface, is a very powerful 6800-based single-board computer. A development package is also available for generating application EPROMs.

Jed W Heald, President  
Datricon Corporation  
7911 NE 33rd Dr  
Suite 200  
Portland OR 97211

We at BYTE were surprised to find additional FORTH vendors advertising in our August 1980 issue. Other vendors include Rockwell International (for the AIM microcomputer, see page 67 of the August 1980 BYTE), Kenyon Microsystems (for 6809 systems, see page 104 of the same issue), Sirius Systems (for the Radio Shack TRS-80, see page 171), Quality Software (for the Exidy Sorcerer, see page 208), Eric Rehnke (for the KIM, SYM, and AIM computers, see page 290), the Software Farm (for the TRS-80, see page 292), and Professional Management Services (for the Alpha Micro, see page 294). FORTH vendors not listed in the August 1980 BYTE are invited to submit a two-paragraph product release, which will be published in a future BYTE "What's New?" column....GW

### FORTH Is Better Than LISP, He Cs

Unlike BYTE's earlier issue on LISP, the August issue on FORTH did an excellent job in making this intriguing language readily understood. The articles did not come right out and say that FORTH is so machine-efficient due to the user preprocessing his logic into postfix notation, but most readers should realize this.

Although I can tolerate that sort of notation for a desk calculator, it is unbearable for computer data processing. Although the C language is philosophically different, it is a threaded language which is much preferable.

Dick Sims  
185 Freeman St, Apt 951  
Brookline MA 02146

### Check Out a Computer

I always look forward to the new issue of BYTE and was especially eager to read the July 1980, Computers and Education issue. Arthur Luehrmann's article, "Computer Illiteracy—A National Crisis and a Solution for It," page 88, struck home on a point with which I wholeheartedly agree: "this country's general public is woefully ill-prepared to live and work in the Age of Information."

I was, however, disturbed by the fact that the role of public libraries was never mentioned. Public libraries are in a unique position to help solve the problem: they serve people of all ages, regardless of educational background; they are generally open more hours than schools; they are, perhaps more than any other institution, vitally interested in an information-aware public; they specialize in providing access to information, and they are free.

Many public libraries have microcomputers available for public use and provide a complement of interactive programs for individuals to learn with. Libraries that have done this report extensive and enthusiastic use of the equipment.

It's a sorry fact that most people have just never had the opportunity to even see a computer system. Until the opportunity to see, touch, and use computers is afforded, computers will remain shrouded in mystery for the vast majority of people of all ages. The public library is one of the best hopes we have to alleviate this problem.

Carlton A Sears  
Adult Services Coordinator  
Asheville-Buncombe Library System  
67 Haywood St  
Asheville NC 28801

Letters continued on page 122

# A growing line of tools to expand the Apple.

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# The Future of Computer Graphics

Bruce Eric Brown  
and  
Stephen Levine  
Lawrence Livermore National Laboratory  
University of California  
POB 808  
Livermore CA 94550

Predicting the future can place one in a very precarious position. Although technology is moving forward at such a pace that it is almost impossible to look a long way down the road, we *do* have a good idea of what the *near-future* trends will be. So here I will discuss where the trends in computer-generated graphics are headed.

Computer graphics is the fastest-growing segment of the computer industry. Although many existing computers already have graphics capabilities, the future is even brighter. Since personal computer users will make up the largest percentage of the computer graphics market, the standard color television receiver will be the most common

## Editor's note:

*It was only 5 years ago when the first annual computer graphics show was held. The Philadelphia show was sponsored by SIGGRAPH (the Association for Computing Machinery's Special Interest Group on Computer Graphics). At that time, the show attracted ten vendors and a few hundred visitors. SIGGRAPH-80, which was held this summer in Seattle, brought to that city over 100 vendors, about 6000 visitors, and filled twenty-four times the space of SIGGRAPH-75. So you can surmise how the the computer graphics field will continue to grow.....SM*



display device. Research is continually going on in video-generation techniques, and we can expect the quality of video images to improve dramatically.

Also on the horizon is the use of networks. Best of all, the price of graphics systems should continue to fall, and as they do, the number of applications will increase drastically.

## Three Dimensions

This is an exciting time for experimentation with computer

graphics. Looking into our crystal video display, we can see many changes coming within the next few years. True three-dimensional displays will become common. Researchers will finally be able to see their models in three dimensions without the need of special glasses, stereo pairs, or by viewing two-dimensional projections.

Already in existence are integral hologram displays made from computer-generated images. (An example is shown in photo 9.) The



**Photo 1:** A computer-generated composite view of a DNA molecule using both ball-and-stick and space-filling models. Using keyboard control, the configuration of the model can be changed and it can be rotated in any direction. Such models are already assisting scientists in their research and will have an even bigger role in the coming years. Photo courtesy of Nelson Max, Lawrence Livermore National Laboratory.

**Photo 2:** Computer-generated art by Los Angeles artist David M. As you can see, computer graphics could revolutionize the world of art.

**Photo 3:** A perspective view of a two-dimensional array of numbers. Photo courtesy of Melvin L Prueitt, Los Alamos Scientific Laboratory.

**Photo 4:** Census data plotted to show population changes. This is an example of the type of material which could be available on a computer network with wide-band capabilities, such as cable television. Courtesy of Edward Zimmerman, White House.

**Photo 5:** A ground-level view of a computer-generated airport scene used in a real-time flight simulator. Photo courtesy of Marconi Radar Systems.

### Raster-Scan Displays

Low-priced memory will also change the look of computer graphics. Up to the present, the market has been dominated by storage tubes and calligraphic (ie: stroke-writing) displays; however, raster-scan displays can be refreshed from a frame buffer of semiconductor memory. Therefore, in the coming years, we can expect the graphic-terminal market to be dominated by raster-scan devices. The standard display will be a color television receiver connected as a micro-processor-controlled intelligent terminal. The cost of some of these graphics terminals will be at or near the cost of a modern color television receiver.

Raster-scan color television will probably be the graphics standard for the following reasons:

- The US video standard is well established.
- It has a large industry supporting it.
- The cost of developing another standard is prohibitive.
- The great numbers of personal computer users will help determine the trend. Why buy a color output monitor when you already have one or several available at home?

holograms are made by photographing 1080 computer-generated images on 35mm film and transferring them to the hologram. In a few years it will be possible to generate these directly; we might even see a laser-driven, computer-controlled, holographic-image output device.

There are currently several methods in use for displaying three-dimensional television images, but the most promising uses an interlaced television picture. The even scan lines

display an image for viewing with the right eye and the odd scan lines have an image for the left eye. The screen is viewed through a pair of glasses whose lenses are made with PLZT (lead lanthanum zirconate titanate) ceramic. Voltage pulses synchronized with the display of the odd and even fields darken the left and right lenses alternately. As a result, the viewer sees a true three-dimensional image. Photo 10 is a composite view of a display showing the images for both the left and right eyes.

Top-of-the-line video displays will include devices with 1000-line resolution (already available) as well as a number with 2000-line resolution. The cost of these will be significantly higher than that of a modern color television receiver.

On a raster-scan display, each dot on the screen is known as a picture element or pixel. Since each pixel is displayed 30 times a second, the image generator must either generate 30 Hz or store the pixel intensities in memory. Frame-buffer systems usually use dual-ported memory which both stores the image and refreshes the display.

To simplify things, let's assume a square picture with the standard 500 lines and each line containing 500 pixels. To display a completely black-and-white line image with no shades of gray we would need 250,000 (500 by 500) bits or 32 K bytes of memory. In order to display gray levels, the number of bits used for each pixel must be increased. To display color, we either divide the number of bits available among the three primary colors (red, green, and blue) or use a color map. A color map takes each pixel value stored and outputs the three intensities: the most common method is to use 1 byte input and 3 byte output. The number of colors which can be displayed is the product of the number of output intensities for each color. At a given time, only a subset, which is limited by the input values, can be displayed. If we use 8 bits in, 24 bits out, we can display any 256 colors of the 16,777,216 available.

In the near future we should be seeing 2000-line resolution systems with 24 bits per pixel (1 byte for each of the three primary colors and 12 bits per color in the map). 12 megabytes of memory would be needed for such a system. With memory prices expected to continue to fall, in about 5 years the major cost element of such a system would be the monitor and electronics.

### Vector Displays

Although it appears that raster-scan displays will

have the major share of the graphics market, line-drawing (ie: vector-display) systems will continue to grow, though at a slower rate. There are basically two types of line-drawing systems: the storage tube and the refresh calligraphic writer.

Storage tubes available today have higher resolution and greater image stability than most refresh systems. One disadvantage of the storage tube

is the lack of selective erasure. In order to remove one line the entire screen must be erased and redrawn. With refresh displays the line is removed from the display list and the line is redrawn on the next refresh cycle.

Calligraphic displays can display about 20,000 three-dimensional vectors or 100,000 two-dimensional vectors at 30 Hz. In the next few years we can also expect a doubling of these capacities.

Raster-scan display buffers can also be used to display vector images and should begin to replace calligraphic displays as faster hardware becomes available. Many users will probably prefer the somewhat slower speed of the raster scan since they are able to display continuous-tone color images.

### Input

One tool which should see much use in the future is a transparent touch panel mounted over the face of a video screen. As shown in photo 7, an automated nuclear-reactor control room is one of the many possible applications. (Note the lack of switches.)

### Hard Copy

Currently, one of the major problems of graphic terminal users is how to satisfactorily get hard-copy output. The most common method is to use a camera to take a picture of the video screen. A device is also available which records the video output directly on film. Both of these methods leave much to be desired. The final solution may not necessarily come from the manufacturers of graphic terminals. The goal of copying machine companies is a dry method of putting a color image on a piece of paper (like

the current, dry black-and-white-image method).

At present, the device with the highest-quality color output is the film recorder. For raster output devices, the resolution of current recorders is 4000 by 4000 pixels, each with a range of 256 intensities. These devices use



Photo 6 (above): An example of the computer-generated graphics used to train space-shuttle pilots at the Johnson Space Center in Houston, Texas.

Photo 7 (below): The control panel for an experimental fusion reactor at Lawrence Livermore National Laboratory. Transparent touch panels mounted over the color video displays have eliminated most switches. To control the reactor, the operators need only to touch the screen over the desired control area shown on the screen. Photo courtesy of Glenn Spreckert.



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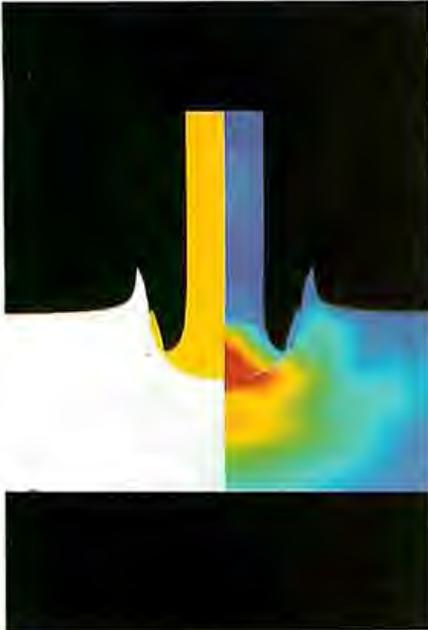
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as many as seven filters and multiple passes are made on the film to create full-color images. Additive-color red,



**Photo 8:** A problem in hydrodynamics illustrated through the use of computer graphics. The photo is part of a series illustrating a steel rod impacting a steel plate. Color changes represent areas of varying stress. In the future, such graphics will be widely used in education. Photo courtesy of Lawrence Livermore National Laboratory.



**Photo 9:** Integral hologram of a molecule created by photographing 1080 computer-generated images on 35mm film and then transferring them to a hologram. In the future computers will be able to generate holograms directly. Photo courtesy of Donald L. Vickers, Lawrence Livermore National Laboratory.

green, and blue filters or subtractive-color yellow, cyan, and magenta filters are used. In both systems, the seventh color is neutral for plotting black-and-white images. We can expect to see more of these recorders available in the near future, and some of the stripped-down models should be available at lower prices.

Another group of devices which fit into this category of film output are COM (computer-output-on-microfilm) devices. Many of those currently available have graphic capability as well as variable intensity. At the present time, COM devices are mainly used for alphanumeric-fiche output. Currently only black-and-white machines are available, although color-fiche machines are expected to be produced in the future. The most important consideration is the need for high-quality, large-format color images. The resolution of current COMs is about 32,000 by 32,000 pixels. Although higher resolution is theoretically possible, such devices will not be produced until a need for them is demonstrated.

Laser recorders may soon capture a portion of the expanding graphics market. Since a laser beam has much more energy to deposit on film than a CRT (ie: video display) image, laser recorders will be much faster than existing methods. On a modern film recorder, one full-intensity pass at 4000 by 4000 pixels takes about 1 minute. To record the same amount of data, the laser requires 1 second or less. The energy of a laser beam is great enough that a split beam could record up to five copies at the same time.

A current weak link in laser systems is the deflection systems. Although solid-state methods are being developed, rotating mirrors are used today. Another drawback with any system that uses film is that unless users have their own processing facilities, film development takes at least 24 hours and sometimes much longer.

The Xerox 6500 color copier can be interfaced to a number of terminals for image-recording, or it can be connected to computers for direct output. Ink-jet plotters, printers with color ribbons, and flat bed-drum plotters with color pens are included in this class of output devices. Continued improvements in speed and color reproduction can be expected.

The brightest future is for the video

disk. Today, these devices can hold 50 minutes (180,000 frames) of video per disk. Although the initial cost is high, the great number of frames available makes this device the ideal output and storage medium.

### Computers — The Future

Although so far I've concentrated on graphics hardware, what about the future of the beast behind the display — the computer?

It seems likely that within a few years the home computer user will have a choice of several 32-bit virtual machines with at least a million words of expandable, central memory, and 100 million words of disk space. This type of system will be ideal for a color-frame buffer system.

### Applications

Since pictures are a very efficient means of communication, the future applications of computer graphics are virtually unlimited. Photo 6 is a photograph of computer-generated graphics used to train space-shuttle pilots. Within the next few years, games and simulations with graphics of nearly the same quality will be available to the personal computer user. The PLZT glasses described earlier will be used to provide three-dimensional images for the would-be space-shuttle or 747 pilot. You can also expect the technology to be put to use in amusement parks. The Disneyland people have already used computer-generated graphics in some of their attractions and are continuing to develop them for future use.

### Networks

There are a number of advantages to having your own, isolated personal computer, but connecting it to a network opens up a vast new world. Networks designed specifically for personal computer users, such as The Source, are already in existence. Unfortunately, the narrow bandwidth of conventional voice-grade telephone lines severely limits graphic capabilities.

One future possibility is the use of cable television for networks with graphic capabilities. Cable is increasingly available in all but the most rural areas and has wide bandwidth, portions of which are not used. Personal computer users could tap into this resource and use the extra bandwidth for local communication nets.

Another possibility is to have the

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**Photo 10:** Interlaced left-eye and right-eye view of a computer-generated image of an aircraft carrier. The image is viewed in three dimensions when the user wears glasses with lenses made of PLZT (lead lanthanum zirconate titanate) ceramic. The lenses by the right and left are darkened alternately by voltage pulses synchronized to the display. Photo courtesy of John A. Roese and Larry E. McCleary, the Naval Ocean Systems Center.

cable-television company provide a main computer to control the network and act as a data base. The range of services which could be provided is virtually limitless. An example is shown in photo 4, where census data has been plotted to show population changes.

**Exploring the Future**

Computer graphics have exciting possibilities as an artistic medium. It's been said that computer-generated color graphics will revolutionize art in the same way that acrylics changed the world of artists who once worked with oil paints. Photo 2 shows computer-generated art by Los Angeles artist David M.

The simulators discussed earlier will also be widely used by filmmakers. Special effects, instead of being animated one frame at a time, could be programmed and filmed in real time. For instance, a director could ask for an airport scene on a clear day, as in photo 5. By changing a parameter, the same scene could be created on a foggy day.

The motion picture industry is in the forefront of developing and using sophisticated systems for computer-generated graphics. Increasingly higher levels of realism will be created in the future and the time-consuming

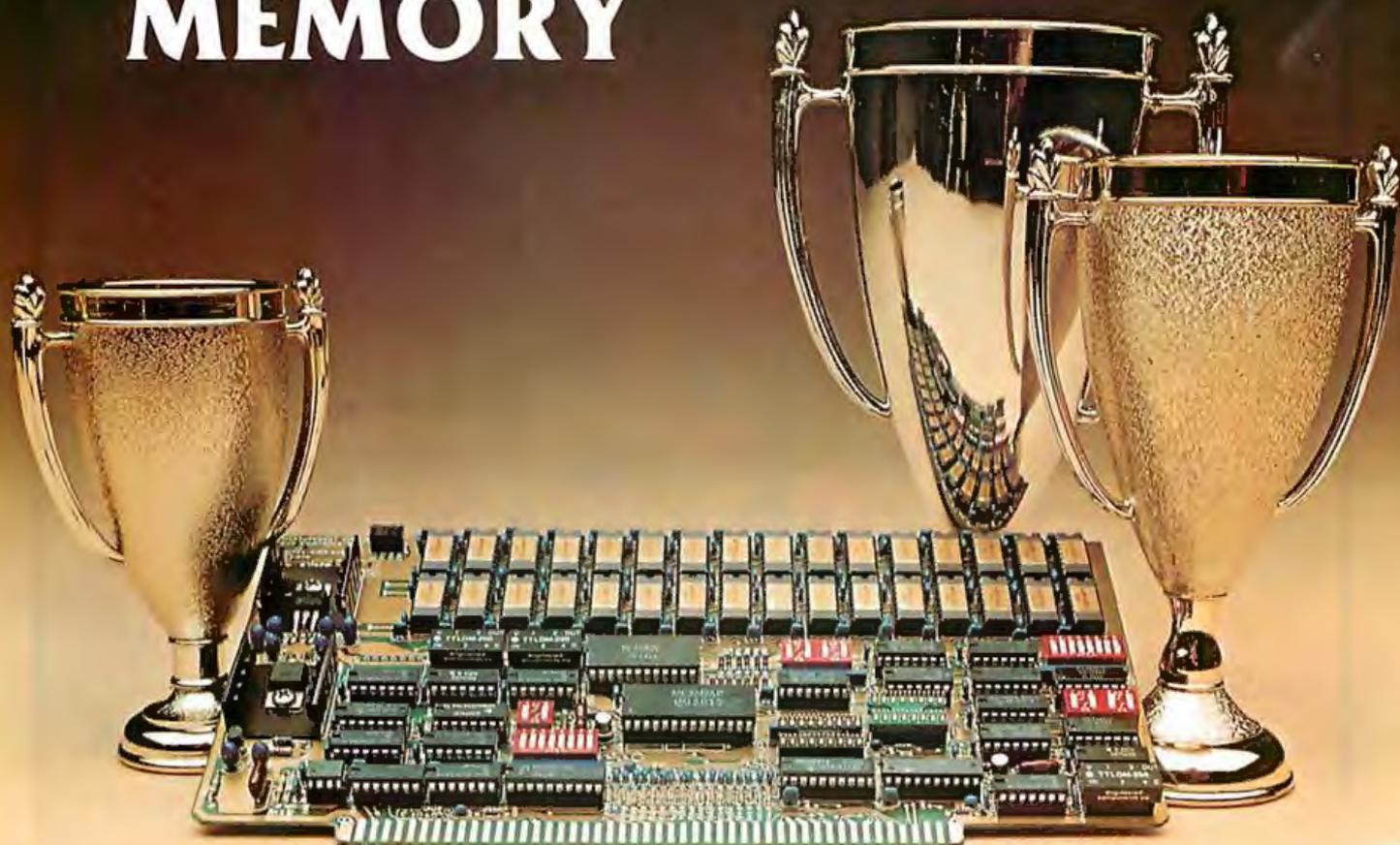
tasks of creating special effects and editing will be performed using laser scanner/recorders and video disks. In terms of dollars, the movies will be one of the largest users of computer graphics for the near future.

Applications, as we've seen, are limited only by our present imaginations. Photo 1 shows a computer-generated composite view of a DNA (deoxyribonucleic acid) molecule using both ball-and-stick and space-filling models. Such displays will speed up the rate of research. The molecule model can be rotated, changed in configuration, and taken home for the scientist to use on his personal computer.

Classroom displays will greatly surpass the audio-visual methods commonly used today. Photo 8 shows a hydrodynamic problem with impact calculations displayed through color changes. A computer display of this sort could be created and updated in the midst of a lecture.

In the wide world of computer-graphic applications, we have only scratched the surface. ■

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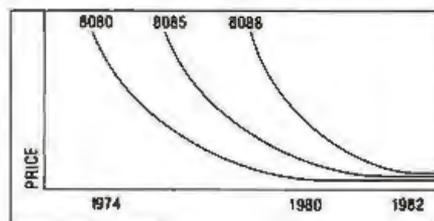
In price-performance races, the iAPX 88 is the one to beat. It's two times faster than the Z-80A and the 6809. And recent benchmark tests show that the iAPX 88, with its 8088 CPU, consistently outperforms its closest competitors in memory efficiency, ease of programming and throughput—by as much as 4 to 1. This is especially important in high-performance tasks such as block moves, character searches, word shifts, and 16-bit multiplies. All critical for applications like word processing, terminal control, scientific instrumentation and industrial control.

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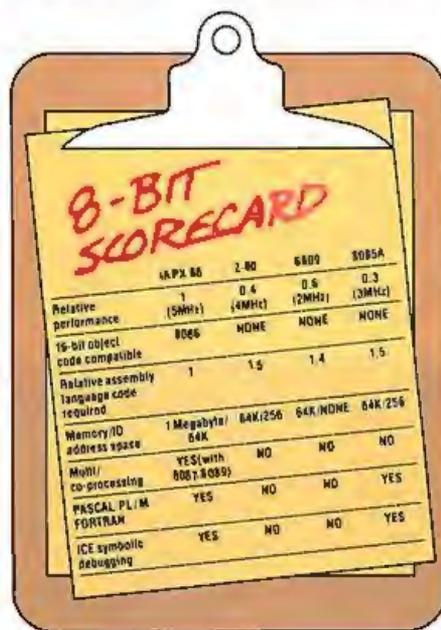
8-Bit Microprocessor Price Trends

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## Home In on the Range! An Ultrasonic Ranging System

Steve Ciarcia  
POB 582  
Glastonbury CT 06033

Each month I try to present a hardware project that is both interesting and relatively easy to build. Unfortunately, it's not as simple as picking a topic and quickly whipping up some circuit. More often than not, I have a number of potential topics and projects on the fire at the same time. Some are in limbo and just waiting for the right parts. Others are postponed when it turns out that the necessary hardware is something that could be better built by NASA (National Aeronautics and Space Administration) than by a computer hobbyist.

One topic that has always interested me is the concept of automatic ranging. I became involved with this idea when I wrote an article entitled "I've Got You In My Scanner," November 1978 *BYTE*, page 76. The original article was about an infrared sensor and parabolic reflector mounted to rotate on a stepper-motor shaft. With computer-controlled stepping, the result was something like the sweep of a radar antenna. The project was sensitive to infrared and visible light.

The scanner, parabolic-reflector, and stepper-motor combination could easily tell the direction of a light source to an angular resolution

of 7.5°. It could make a 180° sweep, stop, and then follow the brightest object in its field of view. By



**Photo 1:** A computer-controlled, stepper-motor-driven infrared and ultrasonic ranging scanner. An infrared-sensitive photo Darlington transistor (GE L14F2) is mounted at the focus of a parabolic reflector, which is attached to the shaft of a stepper motor; the ultrasonic transducer is mounted above it.

The infrared sensor and drive mechanism were described in a previous *Circuit Cellar* article, "I've Got You in My Scanner! A Computer Controlled Stepper Motor Light Scanner."

recognizing the absence of known light sources (when the light path is blocked), it could even function as part of an intrusion alarm.

However, even though it could "see," the infrared scanner could not tell how far an object was in front of it, or detect the presence of a non-luminous body crossing its path. What I really wanted was a device that could provide the computer with range as well as direction. That's when I started hanging around the camera shop.

### Polaroid to the Rescue

The automatic focusing system on the Polaroid SX-70 Sonar OneStep Land camera intrigued me. I had considered tearing a camera apart just to use the ranging unit for my scanner, but sanity prevailed and I went back to designing my own circuit. Somewhere between thoughts of "Who'd really build this thing anyway?" and "I hope everyone can find all these components," I started seeing ads from Polaroid offering just what I wanted, without the camera.

The solution came in the form of an Ultrasonic Ranging System Designer's Kit sold by Polaroid for \$125. The kit contains a technical manual, two instrument-grade electrostatic ultrasonic transducers, a modified SX-70 ultrasonic circuit board, an experimental demonstrator display board, and two Polapulse 6 V batteries. With this unit I was able to enhance my original infrared-scanner

*Diagrams and schematics of the Ultrasonic Ranging System Designer's Kit were provided through the courtesy of Polaroid Corporation.*

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design to include automatic range detection. The new scanner system incorporating the Polaroid unit is shown in photo 1. More on this later.

### Polaroid Ultrasonic Ranging System

The Polaroid Ultrasonic Ranging

System Designer's Kit costs \$125 (This offer is good until December 31, 1980. Photo 2 shows the Designer's Kit as received.), and is available from:

Polaroid Corporation  
Ultrasonic Ranging Marketing

Department 465 E  
20 Ames St  
Cambridge MA 02139  
telephone (800) 225-1618

Two primary components compose the ranging unit. They are the electrostatic transducer (see photo 3) and the ultrasonic transceiver board (see photo 4). Together these components are capable of detecting the presence and distance of objects within a range of approximately 0.9 feet (0.3 meters) to 35 feet (10.6 meters) with a resolution of  $\pm 1.2$  inches ( $\pm 30$  mm, or 0.29% of range).

In operation, a pulse is transmitted toward a target, and the resulting echo is detected. The elapsed time between initial transmission and echo detection can be used to find the distance by taking this round-trip time and multiplying it by the speed of sound. For a transmitted pulse to leave the transducer, strike a target 2 feet (0.61 meters) away, and return to the transducer, it requires 3.55 ms (1.78 ms per foot, or 5.84 ms per meter, during the round trip).

Essential to system operation is the transducer (shown disassembled in photo 5). It acts as a speaker in the transmit mode and as an electrostatic microphone in the receive mode. The transducer is 1.5 inches (38.1 mm) in diameter and consists of a 0.003 inch (0.07 mm)-thick gold-plated foil stretched over a concentrically



Photo 2: Polaroid Ultrasonic Ranging System Designer's Kit, which includes ultrasonic sonar transducers, electronic circuitry, and a detailed specifications booklet.



Photo 3: Close-up view of the Polaroid Ultrasonic Transducer.



Photo 4: Close-up of the ultrasonic circuit board, which contains custom analog and digital integrated circuits.

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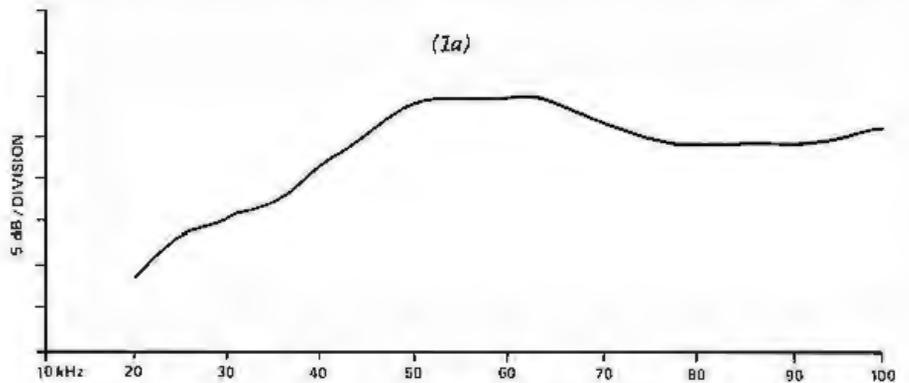


grooved aluminum plate. When the  
metallic backplate is in proximity to  
the foil, it forms a capacitor. The foil  
is the moving element which converts  
electrical energy into sound and the  
returning echo into electrical energy.

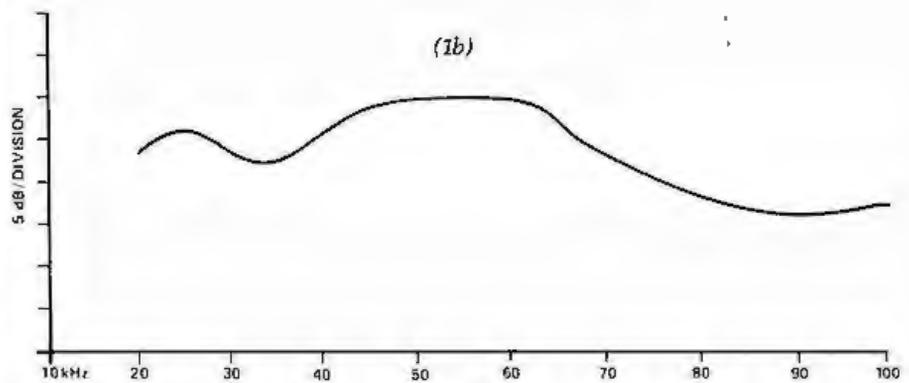
The diameter of the transducer de-  
termines the directionality of the

transducer. The acoustical signal-  
strength lobe pattern, or acceptance  
angle, during operation is shown in  
figure 1. The graph indicates that the  
transducer is fairly directional.

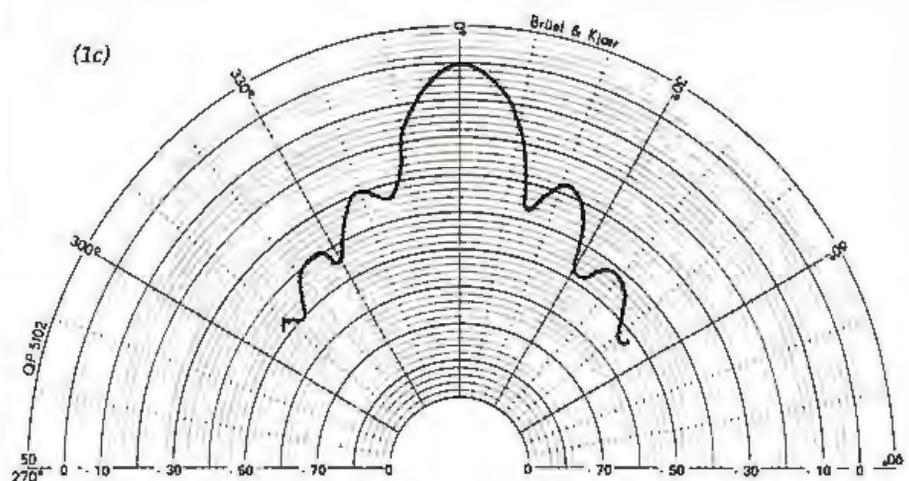
When the unit is activated, the  
transducer emits a sound pulse. The  
crystal-controlled electrical pulse



TYPICAL TRANSMIT RESPONSE



TYPICAL FREE-FIELD RECEIVE RESPONSE



TYPICAL BEAM PATTERN  
AT 50 kHz

Figure 1: Typical transmission frequency-response curve (1a), reception frequency-response curve (1b), and radial-beam pattern (1c) of the Polaroid ultrasonic transducer. The beam pattern was measured at 50 kHz, with dB values normalized to on-axis response.

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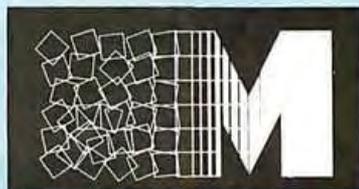
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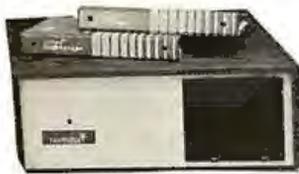
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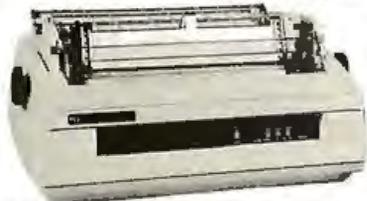
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Photo 5: Expanded view of the Polaroid ultrasonic sonar transducer. Behind a honeycomb grill, a 0.003-inch (0.07 mm)-thick gold-coated foil stretches over a concentrically grooved aluminum plate. The retainer at left holds the parts in place.

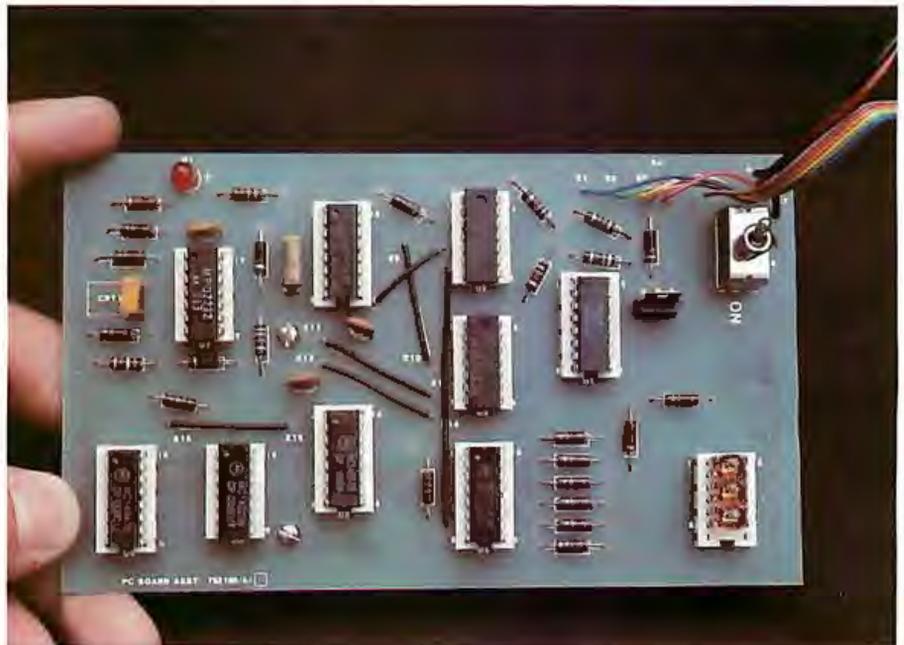


Photo 6: The EDB, which contains the electronic circuitry shown in figure 4. The three-digit LED display is at the upper right.

generated by the driver circuit is a 300 V high-frequency 1 ms "chirp" consisting of fifty-six pulses at four carefully chosen frequencies: eight cycles at 60 kHz, eight cycles at 57 kHz, sixteen cycles at 53 kHz, and twenty-four cycles at 50 kHz. This

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Text continued on page 42

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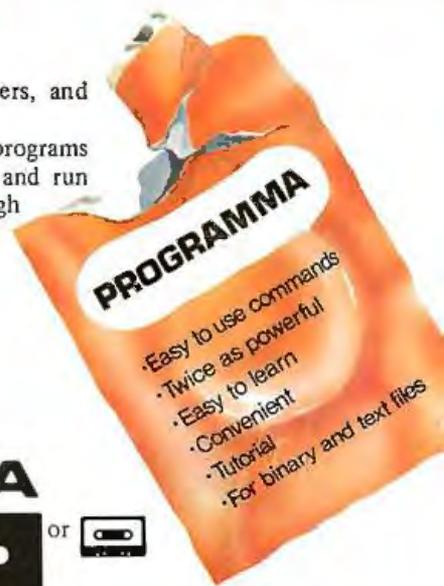
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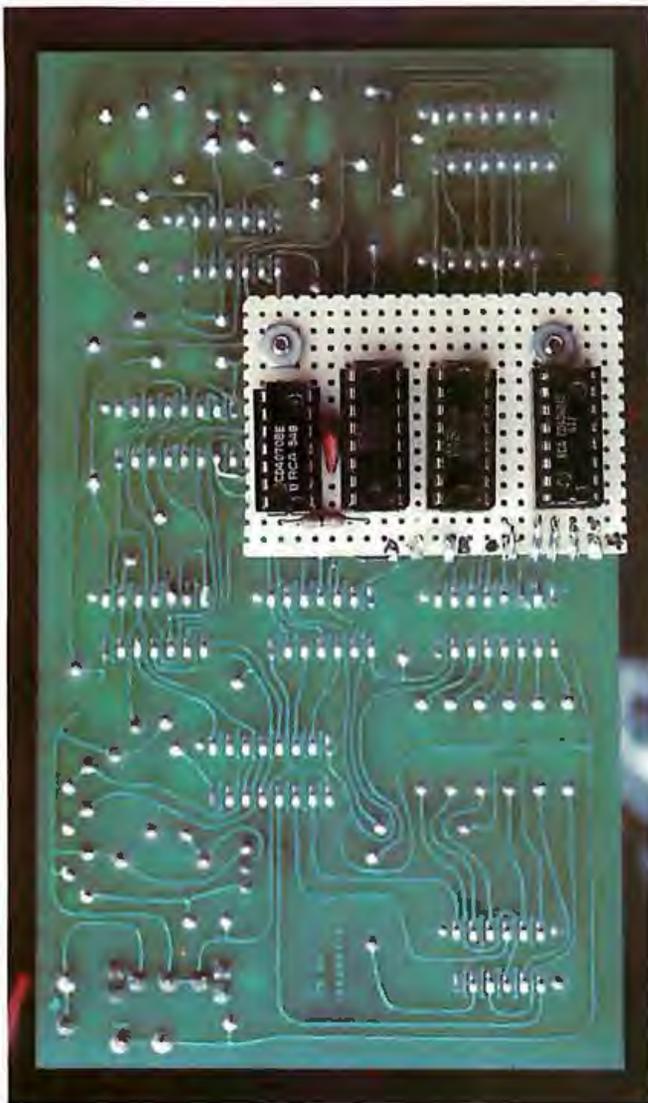


Photo 7: The prototype of the interface circuit of figure 5 has been attached to the EDB. The interface allows a computer to read the three-digit distance value.



Photo 8: Close-up of the back side of the reflector and transducer of the scanner, showing the mounting apparatus.

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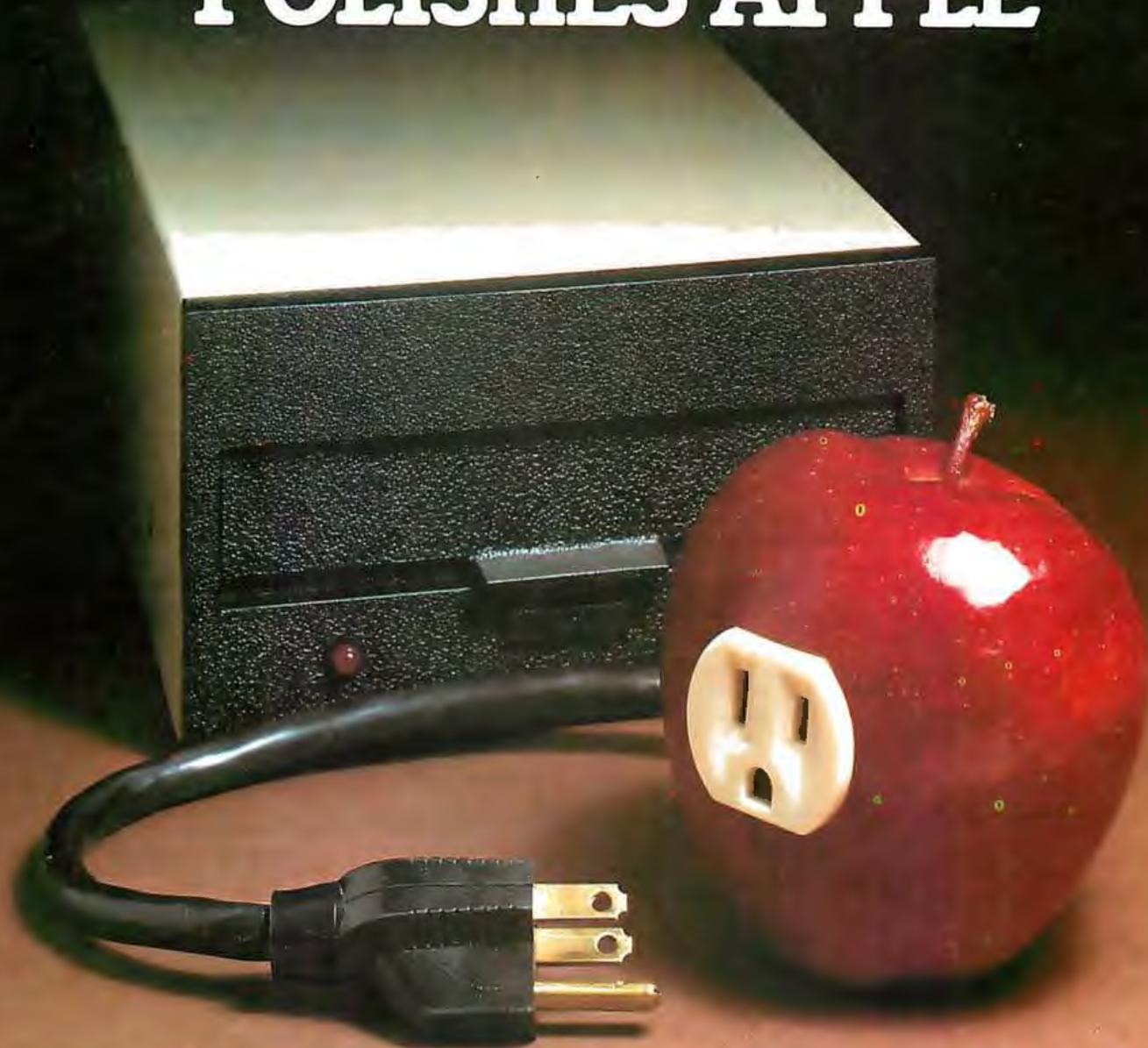
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Text continued from page 38:

The ultrasonic circuit board controls both the transmit and receive operating modes. It contains both digital and analog circuitry. In addition to transmitting the chirp and processing the echo, this circuit also tailors the amplifier sensitivity depending upon the object distance. Lower amplification is needed for close echoes, while higher amplification is needed for distant echoes. This is accomplished by increasing the amplifier gain and Q (ratio of reactance to resistance) in steps. Figure 2 is a block diagram of the ultrasonic circuit board.

### Experimental Demonstration Board

The ultrasonic circuit board previously described is a modified camera assembly. The EDB (Experimental Demonstration Board, shown in photo 6) is not a camera component; it was designed specifically as a user interface to the ultrasonic board.

Text continued on page 48

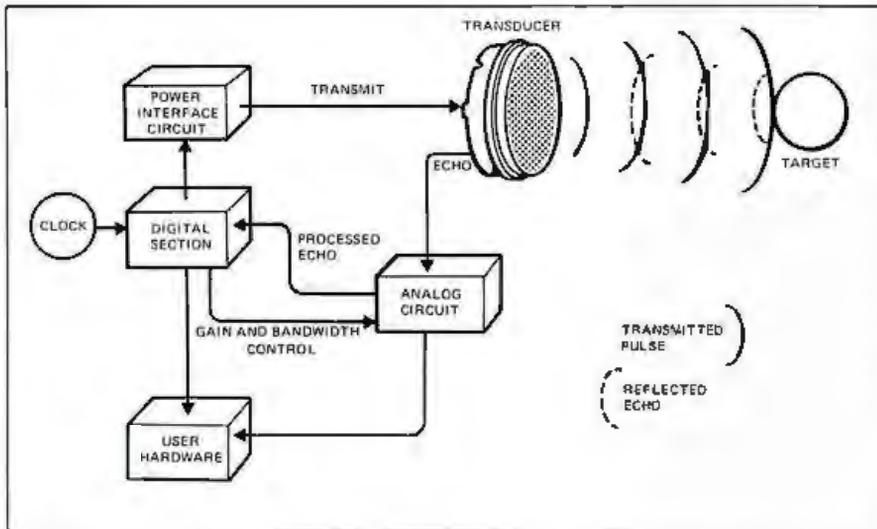


Figure 2: Block diagram of the ultrasonic circuit. The circuit board contains a variety of custom components and is slightly modified from the unit used in SX-70 Land cameras. This circuit, as well as the EDB, is powered by a 6 V Polapulse battery. It seemed to work acceptably with a 5 VDC power supply.

The block labelled "User Hardware" can be the EDB or any interface that can convert the ultrasonic circuit board's time-gated output into useful form.

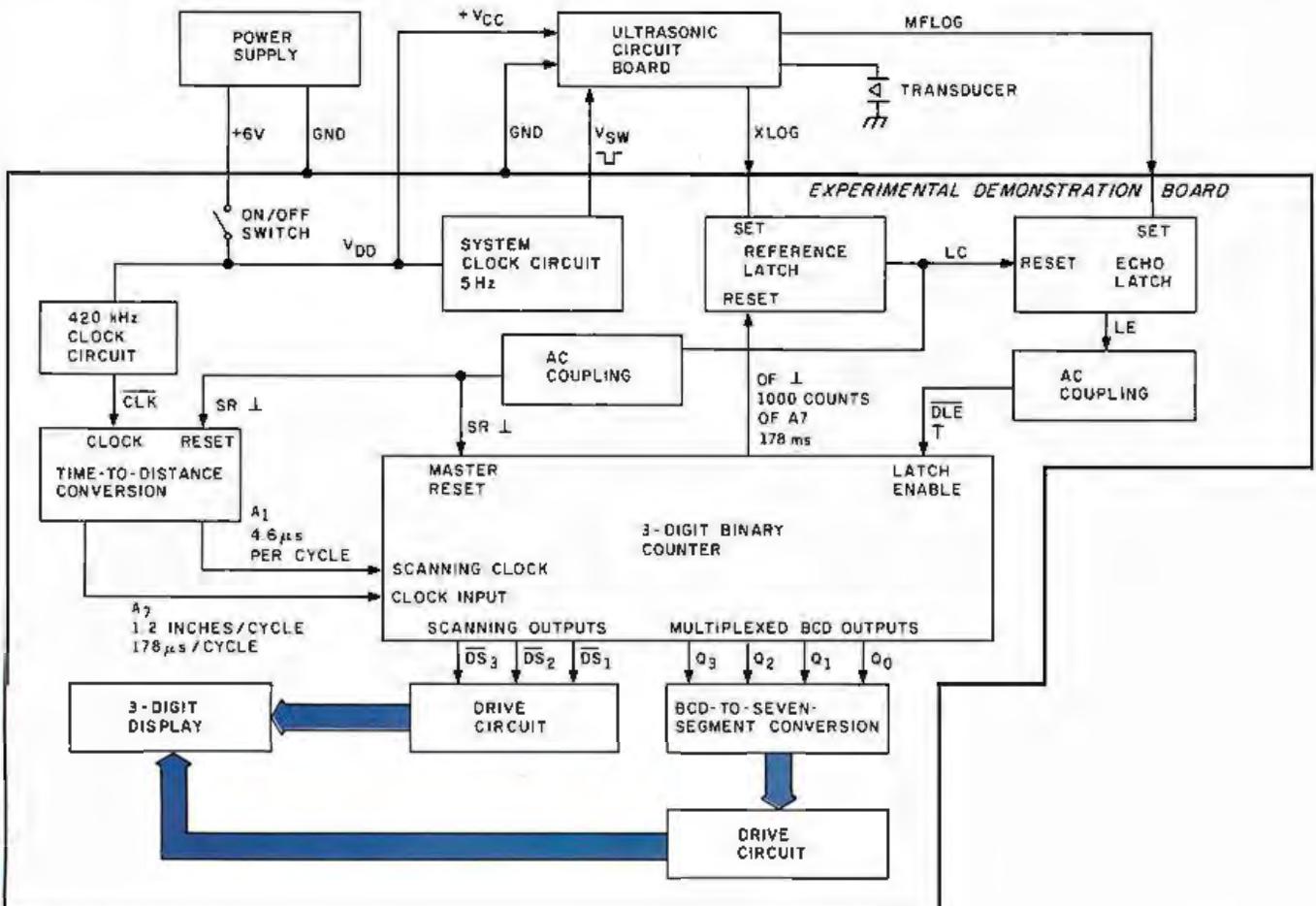


Figure 3: Block diagram of the Polaroid Experimental Demonstration Board.



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Gammon Gambler



Checker King



# PERSONAL SOFTWARE



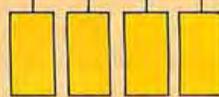
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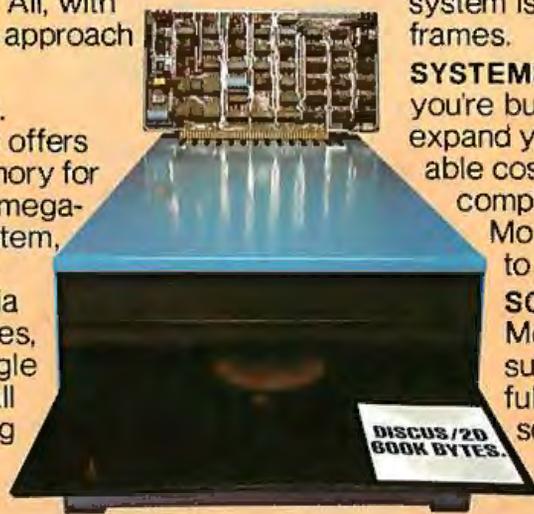
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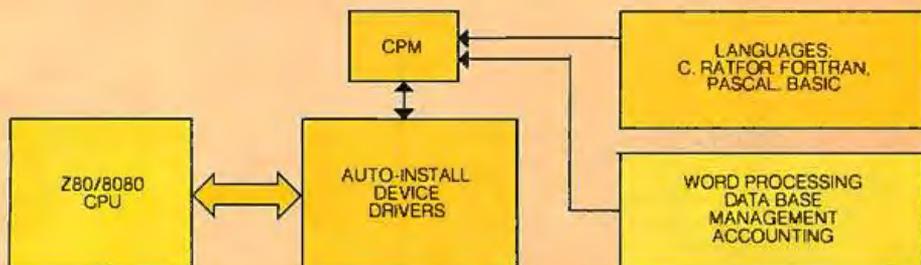
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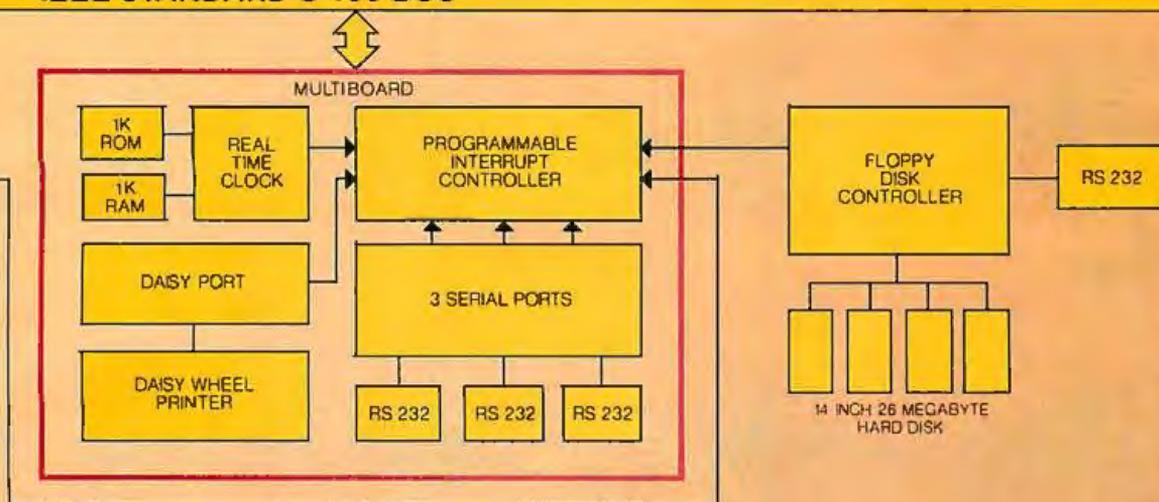
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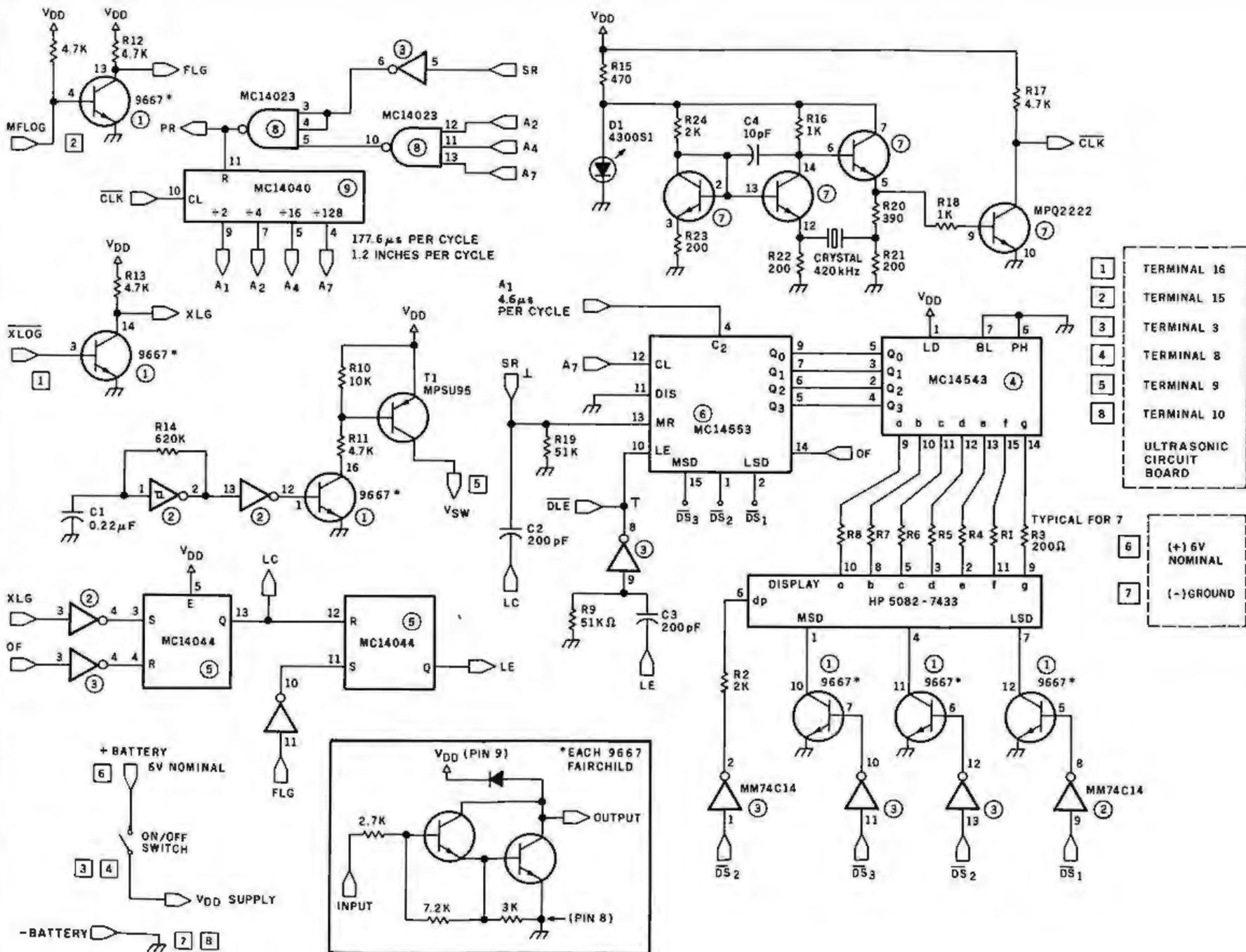
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Figure 4: Schematic diagram of the EDB. This board contains all the necessary circuitry to convert the raw data of the sonar transmitter/receive time interval into a numeric distance value and display it on a three-digit LED display.



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Text continued from page 42:

The EDB contains all the necessary electronic circuitry to convert the transmit/receive time interval into a figure indicating distance (in feet) and present it on a three-digit LED (light-emitting diode) display. Figure 3 is a block diagram of the EDB, while figure 4 shows the schematic diagram.

Connecting the EDB to the computer requires some thought. The output of the EDB is a three-digit display with a numeric output range of 00.9 to 35.0 in increments of 0.1 feet. The multiplexed display is controlled by a three-digit binary counter with strobed digit-select lines. It uses a single BCD (binary-coded decimal)-to-7-segment decoder/driver. At any instant, only one digit is energized, but because of the persistence of human vision, they all appear to be illuminated. Unfortunately, this multiplexed display output is not very computer-compatible and requires additional interface circuitry.

### Decoding the EDB Output

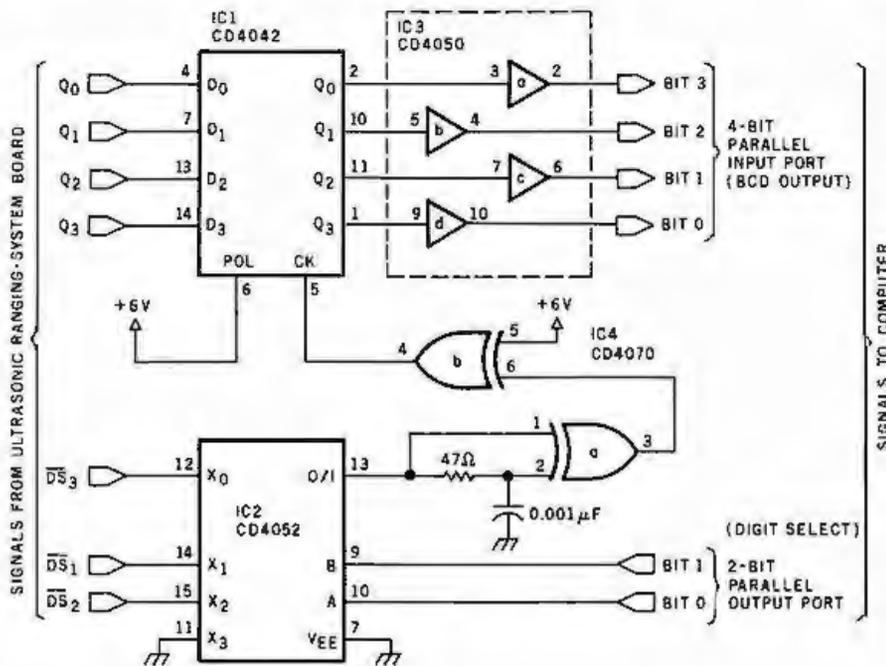
Figure 5 is the schematic diagram of a four-integrated-circuit interface that decodes the counter output on the EDB and latches the digits while the computer reads them. Essentially the circuit consists of a three-input demultiplexer (IC2), an edge detector (IC4), a 4-bit latch (IC1), and an output buffer (IC3). The four-chip circuit is conveniently mounted on a piece of perforated circuit board and attached to the rear of the EDB, as illustrated in photo 7.

When the MSD (most-significant digit) of the LED display is energized, the  $\overline{DS}_3$  line is low. The data on  $Q_0$  thru  $Q_3$  at this time form the BCD value of that number. Similarly, when  $\overline{DS}_2$  goes low, the data lines will hold the second digit value. IC2 is a 4-to-1-line demultiplexer with the three digit strobes as inputs. A 2-bit TTL (transistor-transistor logic)-compatible parallel output from the computer determines which of these channels is routed through the multiplexer. To get  $\overline{DS}_1$ , the LSD (least-significant digit), the input code to the EDB interface would be 00. A binary code of 10 would set channel 3, allowing  $\overline{DS}_3$  to go through. A summary of the codes is given in table 1.

The inputs to IC2 are offset by one channel due to the peculiar timing of the EDB. While the  $\overline{DS}_3$  line is

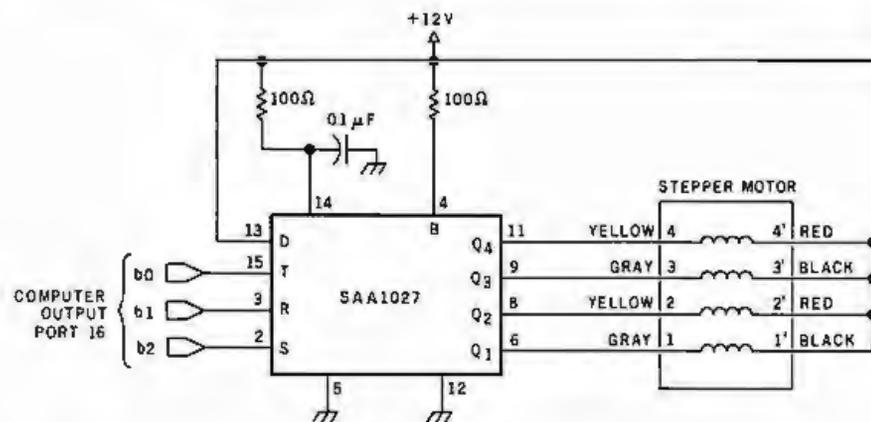
Bit 1	Bit 0	Output Digit to Computer
0	0	$\overline{DS}_1$ (LSD)
0	1	$\overline{DS}_2$
1	0	$\overline{DS}_3$ (MSD)
1	1	n/a

**Table 1:** Correspondence of the 2-bit digit-select codes with the EDB output data sent to the computer.



**Figure 5:** Schematic diagram of an interface that allows a computer to directly read the three-digit LED display of the EDB, using four integrated circuits. Through 2 bits of a parallel output port, the computer sends a digit-select code and then reads the corresponding BCD value of the selected digit through 4 bits of a parallel input port.

Number	Type	+6 V	GND
IC1	CD4042	16	8
IC2	CD4052	16	8
IC3	CD4050	1	8
IC4	CD4070	14	7



**Figure 6:** Stepper motor and controller used in the infrared and ultrasonic scanner. The motor is a North American Philips K82701-P2 type, which turns 7.5° per step. It operates on 12 VDC.

The SAA1027 integrated circuit is available from Signetics or from North American Philips, Cheshire, Connecticut, (203) 272-0301.



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**Listing 1:** A BASIC program that uses the interface circuit shown in figure 5 to read the three-digit distance value from the EDB and display the distance on the computer printer. A sample execution follows the BASIC-language statements.

```

100 REM THIS PROGRAM ALLOWS A COMPUTER TO READ AND DISPLAY
110 REM DISTANCE AS MEASURED BY THE POLAROID ULTRASONIC
120 REM RANGING SYSTEM DEMONSTRATOR BOARD. RANGE .9 TO 35 FT.
130 REM
140 REM
150 GOSUB 250
160 PRINT"DISTANCE TO TARGET IS ";S;" FEET"
170 GOTO 150
180 REM
190 REM
200 REM THIS ROUTINE SETS AND READS THE 3 DIGITS ON THE
210 REM RANGING BOARD.
220 REM IT IS A THREE STEP PROCESS; SET THE DIGIT; READ THE
230 REM DIGIT VALUE; AND MASK OFF EVERYTHING EXCEPT THE 4 BIT
240 REM CHARACTER.
250 FOR T=0 TO 2
260 OUT 16,T
270 S(T)=INP(16)
280 S(T)=S(T) AND 15
285 S=(S(2)*10)+(S(1)*1)+(S(0)*.1)
290 NEXT T
300 RETURN
    
```

RUN

```

DISTANCE TO TARGET IS 3.3 FEET
DISTANCE TO TARGET IS 3.4 FEET
DISTANCE TO TARGET IS 3.5 FEET
DISTANCE TO TARGET IS 3.4 FEET
DISTANCE TO TARGET IS 3.3 FEET
DISTANCE TO TARGET IS 3.4 FEET
DISTANCE TO TARGET IS 3.3 FEET
DISTANCE TO TARGET IS 3.4 FEET
DISTANCE TO TARGET IS 3.4 FEET
DISTANCE TO TARGET IS 3.5 FEET
DISTANCE TO TARGET IS 3.3 FEET
    
```

**Listing 2:** A BASIC program that causes the scanner to make a 180° scanning sweep in twenty-five steps and prints the distance measurements in the form of a bar graph. Figure 7a shows the output from the execution of this program on the system set up in the Circuit Cellar.

```

100 REM THIS PROGRAM MAKES A 180 DEGREE SCAN AND RECORDS THE
110 REM DISTANCE TO SOLID OBJECTS EVERY 7.5 DEGREES.
120 REM
130 REM STEPPER MOTOR CONTROLLER ATTACHED TO PORT 18
140 REM ULTRA SONIC RANGING UNIT ATTACHED TO PORT 16
150 REM
160 REM
170 DIM Z(25)
180 OUT 18,1 :OUT 18,255 :REM PRESET STEPPER CONTROLLER
190 REM
200 REM CLOCKWISE SCAN
210 REM BIT 2 IS SET HIGH AND BIT 0 IS TOGGLED
220 FOR D=0 TO 24
230 OUT 18,5
240 GOSUB 470
250 OUT 18,4
260 NEXT D
270 REM
280 REM COUNTERCLOCKWISE SCAN
290 REM BITS 1 AND 2 ARE HELD HIGH AND BIT ZERO IS TOGGLED
300 FOR D=0 TO 24
310 OUT 18,7
320 GOSUB 570
330 OUT 18,6
340 NEXT D
350 REM
    
```

Listing 2 continued on page 56





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## Listing 2 continued:

```

360 REM
370 REM PLOT RANGES AS BAR GRAPH
380 FOR D=0 TO 24
390 FOR W=1 TO INT(Z(D))
400 PRINT "***";
410 NEXT W
420 PRINT " "
430 NEXT D
440 GOTO 220
450 REM
460 REM
470 REM STEP DELAY AND RANGE SAMPLE ROUTINE
480 FOR T=0 TO 2
490 OUT 16,T
500 S(T)=INP(16) :S(T)= S(T) AND 15
510 NEXT T
520 Z(D)=(S(2)*10)+(S(1)*1)+(S(0)*.1)
530 FOR Q=0 TO 10 :NEXT Q
540 RETURN
550 REM
560 REM
570 FOR Q1=0 TO 100 :NEXT Q1
580 RETURN

```

## Listing 3: A short BASIC program that demonstrates one method for using the ultrasonic scanning device in a security system.

```

100 REM THIS PROGRAM DEMONSTRATES HOW THE ULTRASONIC RANGING
110 REM BOARD CAN BE USED AS AN INTRUSION DETECTOR.
120 REM
130 REM
140 A=1 :GOSUB 220 :REM TAKE FIRST DISTANCE READING
150 GOSUB 330
160 A=2 :GOSUB 220 :REM TAKE SECOND DISTANCE READING
170 IF ABS(X(1))-ABS(X(2))>=.3 THEN GOTO 280
180 IF ABS(X(2))-ABS(X(1))>=.3 THEN GOTO 280
190 GOTO 140 :REM CONTINUE SCAN
200 REM
210 REM
220 FOR T=0 TO 2
230 OUT 16,T
240 S(T)=INP(16) :S(T)=S(T) AND 15
250 NEXT T
260 X(A)=(S(2)*10)+(S(1)*1)+(S(0)*.1)
270 RETURN
280 PRINT " I GOT YOU IN MY SCANNER AT ";X(2);" FEET."
290 REM AN ALARM ROUTINE WOULD BE PLACED HERE
300 GOTO 140
310 REM
320 REM
330 REM SAMPLE RATE DELAY TIMER
340 FOR Y=0 TO 200 :NEXT Y
350 RETURN

```

RUN

I GOT YOU IN MY SCANNER AT 11.4 FEET.

Text continued from page 50:

is held high, and bit 0 is toggled to produce each step. To drive the motor counterclockwise, bits 1 and 2 are held high, and bit 0 is toggled for each step. The new scanner can read the distance at each step.

Listing 2 is a program that causes the scanner to make a 180° scan and prints out the distance measurements

in the form of a bar graph, demonstrated here in figure 7a.

To help you understand the mode of operation and value of the ranging device, I have also sketched the area of the Circuit Cellar where the measurements were taken. (See figure 7b.)

The scanner (the red object in figure 7b) was placed on a tripod at a



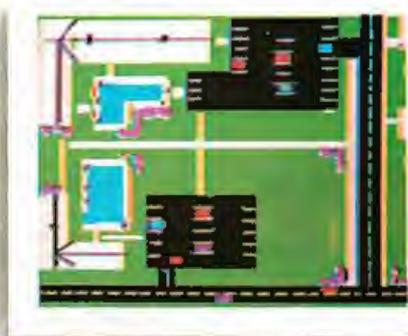
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Videoprints shown were produced by an Apple II with graphics tablet, or by live images on 3/4" videotape.

height of 5 feet (1.5 meters), about 2 feet (0.6 meters) in front of my desk area. The parabolic reflector was pointed 90° to the left of center so that a 180° scan resulted in it ending up pointing 90° right of center. At each of the twenty-five steps it took to reach this point, it measured the distance to the nearest obstruction to its line of detection. For comparison, the blue dotted lines in figure 7b show where each step should have been and what should have been in the way of the sonar "beam."

The program of listing 2 printed the graph bar corresponding to each step,

starting with step 1. At the position reached after step 1, the system recorded a distance of about 5 feet (1.5 meters) to the VTR (videotape recorder) on the counter top. The same result was obtained for the next two steps. At the position reached after step 4 (about 30° around), the scanner was pointing between the stereo system and the TRS-80 computer on the desk to the right. This was indicated by a reading of about 15 feet (4.6 meters), measuring the distance to the bookcase on the far wall.

The next couple of steps had the

TRS-80 directly in the path of the scanner beam, and then the path of the beam was open to the far wall again for a couple of steps. The rest of the scan was similarly significant in that the range detector accurately described the perimeter from its viewpoint. Most important, however, was the demonstration of the sensitivity of the ranging device. At steps 9 and 16, the only object in the path between the scanner and the wall was a 4-inch (10 cm) ceiling-support column about 7 feet (2.1 meters) away. In both cases the obstruction was accurately identified.

We now have a device that can rotate to a particular position and accurately measure the distance to any object it "sees." A practical use of the range detector is as a security device. When the wall is known to be 16 feet (4.8 meters) away from the scanner, a sudden reading of 9 feet (2.7 meters) indicates that someone or something just moved in front of the range detector. The program of listing 3 allows the range detector to be used as a motion detector.

## In Conclusion

I have demonstrated only two uses for the Polaroid Ultrasonic Ranging System Demonstrator Kit. The majority of applications I've heard about thus far have been independent projects that utilize the ranging system *without* the additional capabilities of a computer. They include a walking cane (with audio feedback) for the visually handicapped, a 0 to 35 foot (0 to 11 meter) altimeter for the *Gossamer Albatross* aircraft (for its English Channel crossing), and as an electronic "dip stick" for measuring liquid levels in storage tanks.

I hope that once you realize how easy it is to attach this automatic ranging system to a computer, you'll have as much fun experimenting with it as I have. Unfortunately, a new problem has arisen. Until now, one of the major reasons I haven't attempted to build a robot was the amount of expense and technical effort required to make it "see." Now I'll have to find a new excuse. ■

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# OUR MESSAGE.

## Kinetic String Art for the Apple

Louis Cesa, 305 Doris Ave, Vestal NY 13850

The accompanying photographs were produced using high-resolution graphics on the Apple II computer. As interesting as the pictures are, they do not do justice to the real-time art that takes place on the screen. The photographs show only time slices at different stages in the development of the kinetic string art. On the screen one can see shapes forming and gradually being replaced by other shapes in a continuous display of color and motion.

### Algorithm Description for Kinetic String Art Program

#### 1. Initialize Variables:

```
X1=X2=Y1=Y2=CNT1=CNT2=0;
DIM C(150), TX1(150), TX2(150), TY1(150),
    TY2(150);
AT=1
```

2. Erase the line from TX1(AT), TY1(AT) to TX2(AT), TY2(AT) of color C(AT).

3. If CNT1=0 then choose a new random color and a new random CNT1.  
COLOR=1+RND(3)  
CNT1=5\*(1+RND(10))

4. If CNT2=0 then choose new step sizes for DX1, DY1, DX2 and DY2 and a new random CNT2:  
DX1=RND(9)-4  
DY1=RND(9)-4  
DX2=RND(9)-4  
DY2=RND(9)-4  
CNT2=5\*(1+RND(10))

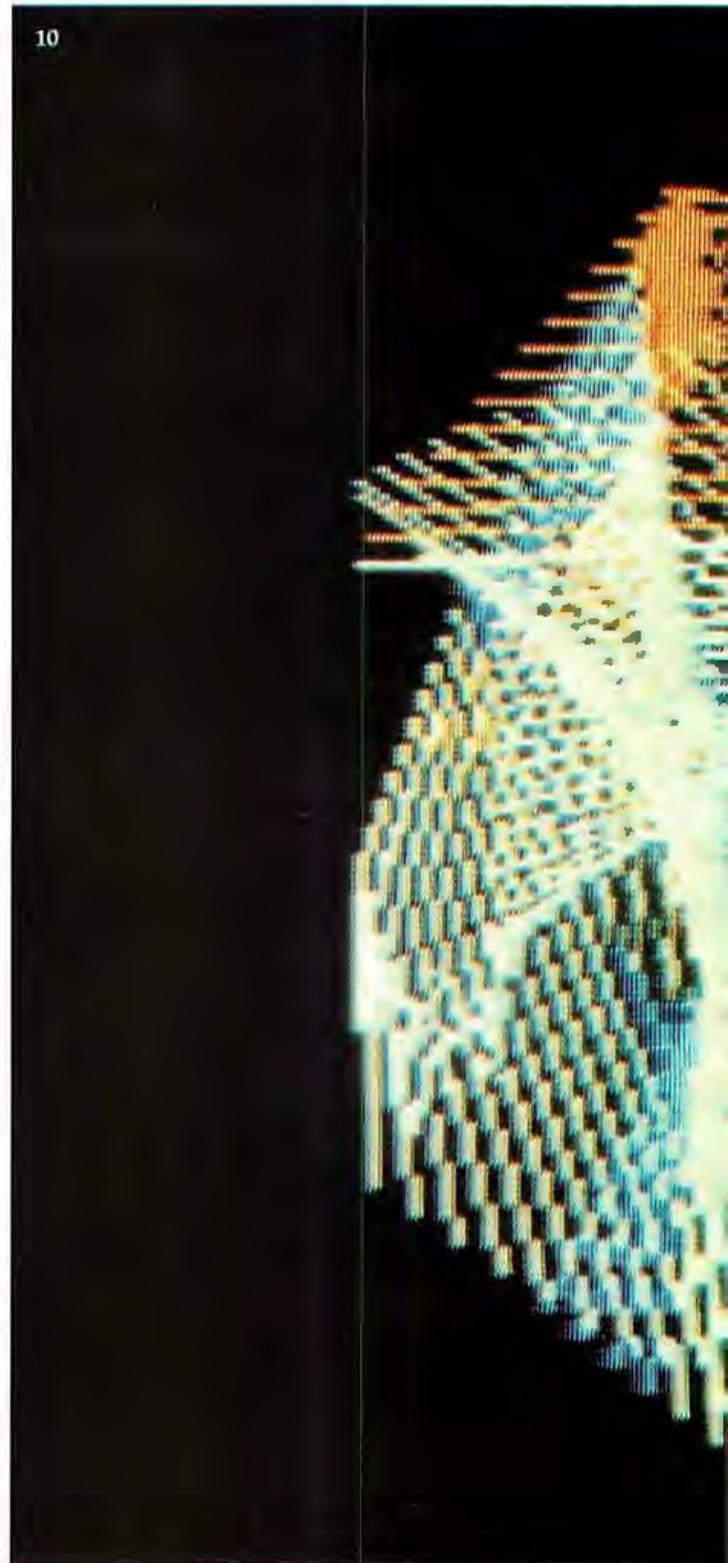
5. Compute new X1, Y1, X2, Y2 for next line and test for screen boundaries. For example,

```
470 PX1=X1+DX1
480 IF PX1>=0 AND PX1<=MX THEN 500
490 PX1=X1: DX1=-DX1
500 X1=PX1
```

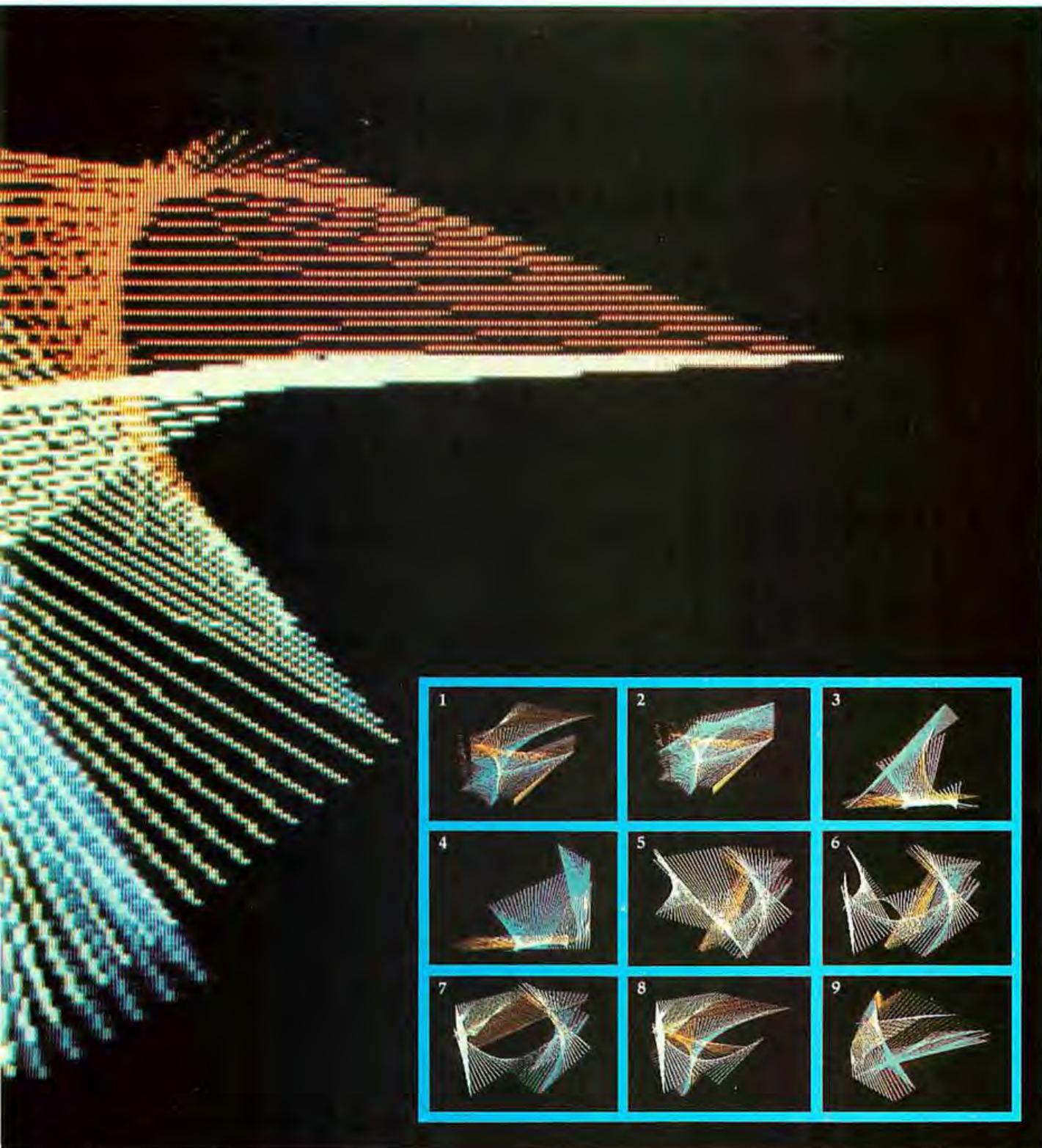
6. Draw the new line from X1, Y1 to X2, Y2.  
7. Store the coordinates and color of the new line in:  
C(AT), TX1(AT), TX2(AT), TY1(AT), TY2(AT)

8. Step AT to next position in table.  
AT=AT+1  
IF AT > 150 THEN AT=1

9. Go to step 2.



The algorithm used is quite simple. (See textbox. Contractual agreements preclude publishing a listing of the program.) The pictures are drawn by a line segment making a random walk on the screen. An initial pair of endpoints is chosen at random; also chosen at random are color, number of lines to be drawn with that color, step size for each endpoint (in the x and y directions), and number of times that the step sizes are to be used. Successive lines are drawn by advancing the endpoints of the line by the chosen step size in the x and y directions.



Whenever the number of times that an action was to be executed (such as number of lines to be drawn in a given color) is exhausted, new random values for that quantity and for the number of times that the quantity should be used, are chosen. If a point attempts to walk off the screen, it is reflected back.

The designs in the accompanying photographs are formed by 150 lines. The program was coded so that when the 151st line is added, the first line is deleted, and so on. This is done by a routine that keeps track of each

line segment currently on the screen. When the table contains 150 lines, this routine erases the oldest line segment before adding a new one. (This effect can be noted in photos 1 and 2.) Interesting effects can be obtained by using different algorithms to choose the new line to be added at each iteration. For example, an interesting effect is obtained with just 10 lines on the screen and choosing random endpoints for each new line (essentially a visual image of white noise). ■

# Micrograph

## Part 1: Developing an Instruction Set for a Raster-Scan Display

---

E Grady Booch  
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Colorado Springs CO 80907

---

Simply stated, computer graphics is the technique of visual communication from computer to man. (See reference 14.) Interactive computer graphics is an important subset of this broad field and relates to computer-generated displays that can interact with a user in real or near-real time. Interactive graphics started with attempts to use the CRT (cathode-ray tube) as a computer output device. (See reference 12.) The Whirlwind I in 1950 and Sketchpad in 1963 are examples of early attempts at interactive computer-graphics systems. Since that time, two distinct classes of CRT-based devices have been developed for use in interactive graphics: calligraphic (or vector) devices and raster-scan (as in a television receiver) devices.

The area of vector graphics "has for several years been sufficiently mature to justify efforts at standardization within it." (See reference 8.) A large body of information is available on the design of such systems. (See reference 13.) However, the same is

not necessarily true of raster-scan devices. Until recently, raster-scan technology has not been economically feasible. Decreasing hardware costs, especially for memory, have facilitated the trend toward raster-scan displays. (See reference 3.) The emergence of raster-scan displays has a side benefit, namely that "raster-scan technology is the only economical way to achieve color in full-sized displays." (See reference 4.)

For the microcomputer user, this means that he can add moderate-resolution color graphics to a system at an affordable price, using raster-scan technology. The benefits of color graphics for the personal computer are obvious: not only are color displays dazzling and eye-catching, but more important, they add a new dimension for communicating with a computer. Microcomputers with color-graphics capabilities have been available for some time, such as the Apple II and the Compucolor. Within the past year, however, Motorola and AMI (American

Microsystems Incorporated) have released a LSI (large-scale integration) chip, called a video-display generator, which performs all the video functions necessary to produce a color-graphics and alphanumeric display on a standard, unmodified color television. As a result, low-cost color-graphics displays are now possible for the personal computer user.

This three-part article presents the theory, design, and construction of a low-cost, color-graphics display processor called Micrograph, which is based on the Motorola MC6847 video-display generator. (See photo 1.) Essential characteristics of Micrograph are described in the text box. In the remainder of this article, I will review the characteristics of interactive computer-graphics systems, followed by an overview of the Micrograph design. Subsequent articles will concern the hardware construction details for Micrograph and the software necessary to control the system.

---

### About the Author

E Grady Booch is currently a computer systems design engineer with the Air Force Space and Missile Test Center. He is involved with the development of a high-resolution color-graphics system for tracking missile launches. Grady received his bachelor of science and master of science degrees in computer science from the United States Air Force Academy and the University of California, Santa Barbara, respectively.

### Micrograph Features:

- 64 by 64, 128 by 128, and 256 by 192 pixel resolutions are available.
- Up to eight different colors are displayed at one time.
- It contains a single-board processor, based on Zilog Z80 processor and Motorola MC6847 Video Display Generator.
- Construction cost: about \$275.

- High-level graphics primitives support.
- Both graphics and alphanumeric are supported.
- It interfaces to a host microcomputer via three 8-bit input/output ports (status, input, and output) and by radio-frequency or video entry to a standard, unmodified color television.

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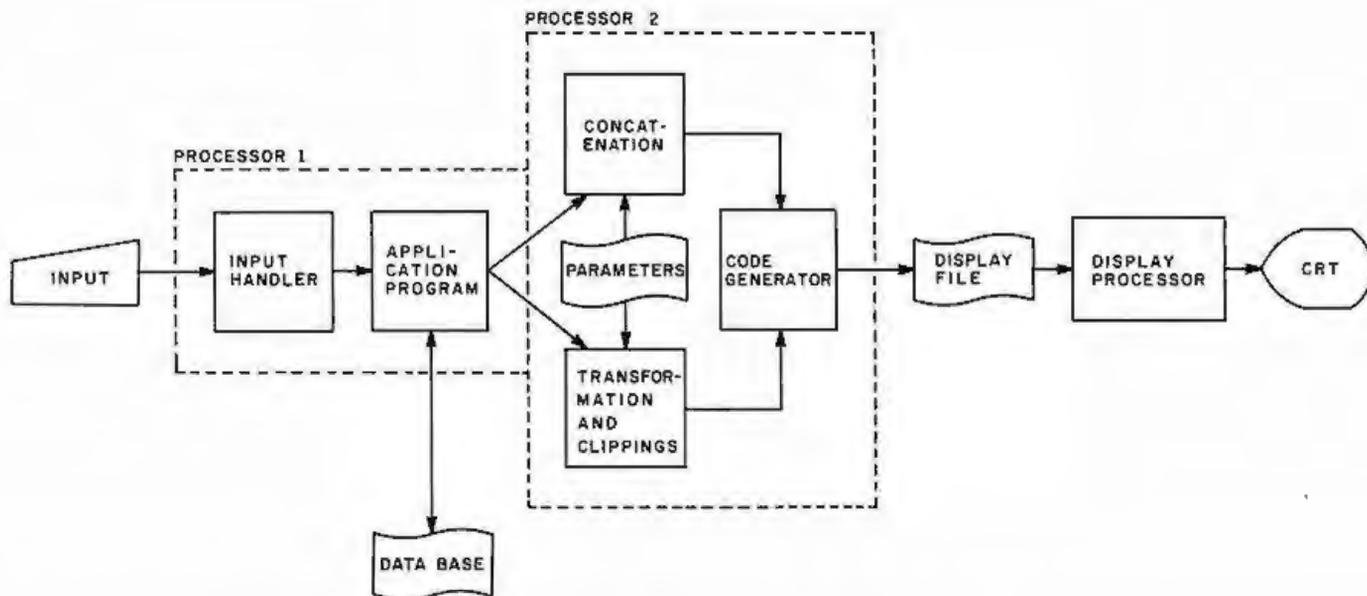


Figure 1: A general block diagram of an interactive graphics-display system. The functions of Processor 1 and Processor 2 may be performed by the same device; however, the output of Processor 1 must be a structured abstract of the image to be displayed, for the graphics package (Processor 2) to operate. (The figure is from *Principles of Interactive Computer Graphics*, by Newman and Sproull. Copyright 1973, used with permission of McGraw-Hill Book Company.)

### Background on Interactive Computer-Graphics Systems

Newman and Sproull, in their book *Principles of Interactive Computer*

*Graphics* (reference 12), present an excellent model of a generalized interactive graphics system, as reproduced in figure 1. Processor 1,

which is not necessarily a different physical processor than Processor 2, handles program-specific processing for a particular graphics application. The output of this processor is generally a structured, abstract representation of the set of images that will be displayed.

Processor 2 represents the processing that is to be handled by a graphics package, as it is commonly called. This processor manipulates the abstract representations, performing transformations (such as rotation, translation, and scaling) and clipping as needed. The output of this processor is generally a display file consisting of instructions that are meaningful to a physical display processor. The display processor uses these instructions to produce an image upon some type of display device. For interactive graphics, these processes must occur very rapidly.

Numerous graphics packages for commercial systems exist to handle the requirements of Processors 1 and 2. SIGGRAPH (Special Interest Group on Computer Graphics) of the ACM (Association for Computing Machinery) has proposed a standard for such systems. However, for our purposes, we must turn our attention to the display processor itself. Before examining the design for a color-

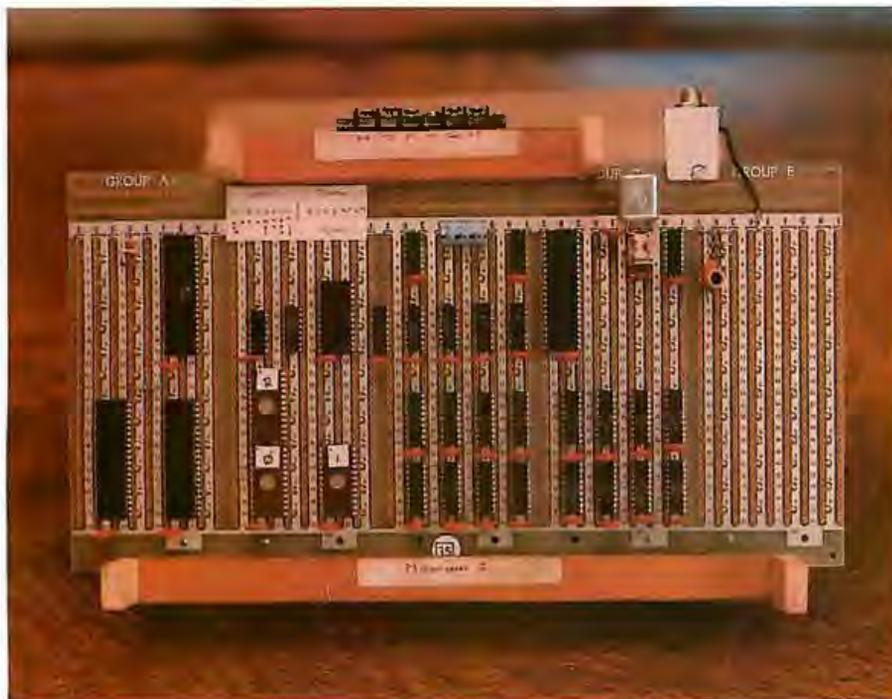


Photo 1: A view of the completed Micrograph prototype, based on the Motorola MC6847 video-display generator. Use of this integrated circuit greatly simplifies hardware design by eliminating the complex divider-chains usually found in homebrew video displays.

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UniFLEX is a true multi-tasking operating system. Not only may several users run different programs, but one user may run several programs at a time. For example, a compilation of one file could be initiated while simultaneously making changes to another file using the text editor. New tasks are generated in the system by the 'fork' operation. Tasks may be run in the background or 'locked' in main memory to assist critical response times. Inter-task communication is also supported through the 'pipe' mechanism.

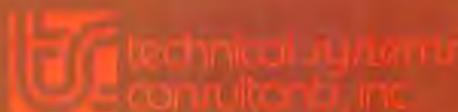


## Support

The design of UniFLEX, with its hierarchical file system and device independent I/O, allows the creation of a variety of complex support programs. There is currently a wide variety of software available and under development. Included in this list is a Text Processing System for word processing functions, BASIC interpreter and precompiler for general programming and educational use, native C and Pascal compilers for more advanced programming, sort/merge for business applications, and a variety of debug packages. The standard system includes a text editor, assembler, and about forty utility programs. UniFLEX for 6809 is sold with a single CPU license and one year maintenance for \$450.00. Additional yearly maintenance is available for \$100.00. OEM licenses are also available.

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graphics display processor, we must consider the characteristics of calligraphic and raster-scan displays.

### Comparison of Display Devices

Four basic technologies exist to support interactive graphics:

- calligraphic
- raster-scan
- storage-tube
- plasma

Three of these devices (calligraphic, raster-scan, and storage-tube) are CRT-based, but only two (calligraphic and raster-scan) are adaptable to interactive, rapidly

moving displays.

Calligraphic displays produce images by drawing vectors using end-point information. A relative or absolute position is presented to the display, and the electron beam is deflected from its current position. Analog methods of vector generation can produce high-resolution vectors. Symbols are usually generated as a collection of vectors. Special hardware may also exist to produce circles and arcs, but these features are generally not cost-effective.

Calligraphic displays can achieve resolutions of up to 4096 by 4096 pixels (ie: picture elements) which corresponds to 16,777,216 elements (which is why I don't consider 256 by 256 pixels or even 512 by 512 pixels as "high resolution"). (See reference 11.) Therefore, a 21-inch-diagonal rectangular CRT will typically have a spot size of 0.02 inches (0.5 mm). (See reference 9.) Vectors using these techniques will appear sharp rather than granular. Several thousand vectors may be displayed flicker-free.

Calligraphic displays can produce color images using beam-penetration tubes. This type of CRT has multiple layers of phosphor coating on the face of the tube. Individual colors (usually four different colors) are produced by varying the anode voltage

and hence the depth of beam penetration.

Raster-scan displays produce an image much like commercial television by generating a full screen of horizontal lines. This set of lines (the raster) is modulated in the Z axis (intensity and color) to produce an image. Vectors are drawn using digital scan-line-conversion techniques which compute every point along the vector. Symbols are usually generated using a character generator which directly plots each point of the symbol.

Raster-scan displays can achieve resolutions up to 2048 by 2048 in monochrome and 1024 by 1024 in color, which corresponds to roughly one million pixels (for color). (See reference 9.) The limited resolution for color displays results from the difficulty in producing shadow masks and the granularity of the phosphor-dot triples used in constructing the CRT. Because of the nature of the raster-scan CRT, the individual dots have insignificant overlap and therefore vectors appear coarse and stair-stepped. However, techniques such as *ordered-dithering* and *anti-aliasing* algorithms exist to reduce the effect of granularity. (See references 7, 10, and 12.) Stair-stepping (or aliasing) is most noticeable in near-

#### Glossary

**Aliasing:** As used here, a granular or stair-stepped appearance in an image caused by the display screen being divided into a finite number of elements. This effect is most noticeable on low-resolution displays and on high-resolution displays with near-horizontal or near-vertical lines.

**Calligraphic Display:** A display that produces an image from a collection of vectors and points, by directing the electron beam in the X and Y directions corresponding to the vector endpoints.

**Display Processor:** A special-purpose peripheral processor that is dedicated to producing a visual image on some type of display (usually a CRT) based on special graphics instructions in a display list.

**Instancing:** The technique of defining one image, then being able to perform transformations to reproduce the same image in several different places on the display.

**Pixel:** A picture element.

**Raster-Scan Display:** A display that produces images, just as in television, by amplitude modulation of the Z-axis beam along a full screen of horizontal lines (the raster).

**Scan-Line Conversion:** An algorithm used to calculate each individual point along a vector, given the starting and ending points.

**Transformation:** Modifications of an image, such as translation (movement in the X, Y, or Z axis), rotation (also in any axis), and scaling (also in any axis).

#### CALLIGRAPHIC DISPLAY

##### Advantages

- High resolution (4096 by 4096).
- Thousands of vectors can be displayed.

##### Disadvantages

- Analog circuitry often requires adjustment.
- Limited colors (usually four).
- Display has low brightness.
- Limited intensities are possible.
- Shading of large areas impossible.
- Flicker occurs when too many vectors are displayed.
- Ghosting occurs on rapidly moving displays.

#### RASTER-SCAN DISPLAY

##### Advantages

- Digital circuitry is quite reliable.
- Many colors possible (more than 2<sup>16</sup>).
- Display is high intensity.
- Many (gray scale) intensities exist.
- Shading areas is simple.
- Display does not flicker.
- Display has high contrast.

##### Disadvantages

- Moderate resolution (1024 by 1024 color).
- Digital scan-line conversion is slow.

Table 1: Comparison of calligraphic (ie: vector) and raster-scan displays.

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<b>Processor Type</b>	Motorola MC68000 Motorola MC6809 for I/O, Disk, and memory management.
<b>Processor Speed</b>	8 MHz.
<b>Bus Type</b>	Proprietary connector. Adapters available for S-100, Versabus, and others.
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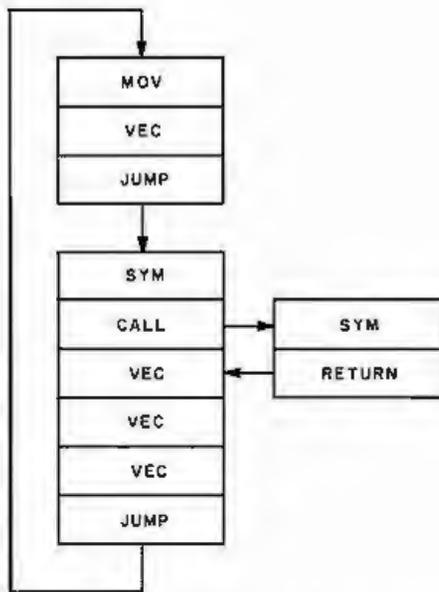


Figure 2: The display list of primitive instructions performed by the display processor of a calligraphic (ie: vector) display. The loop is performed repeatedly by the processor to guide the display electronics. A new or modified display is produced by altering the display list.

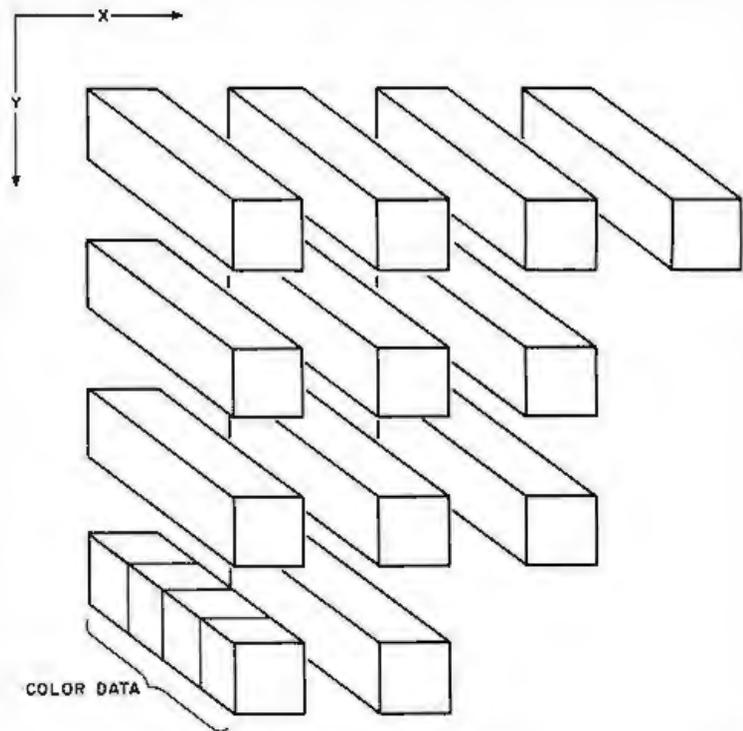


Figure 3: A color raster-scan frame buffer. Each pixel (ie: picture element) on the screen is represented by a unique set of X and Y coordinates. Every coordinate is associated with some amount of color information (in this case, 4 bits). This data may be used to specify an address in a color-look-up table such as figure 4.

vertical and near-horizontal lines. Any number of vectors, up to and including a full CRT screen, can be displayed without flicker.

Color raster-scan displays produce their images by exciting triads of dots or rectangles at each pixel. Each triad generally consists of one red, one blue, and one green element. Different colors (in excess of  $2^{16}$ ) can be produced by exciting each element at different levels of intensity.

Clearly, the use of each type of display is associated with certain advantages and disadvantages, as summarized in table 1.

### Controlling a Calligraphic Display

As mentioned previously, a calligraphic display draws vectors based upon endpoint information. Even the most complex images can be created as a collection of vectors. Because of the short persistence of the CRT phosphors required for a fast calligraphic display, once a vector is drawn, it will disappear very quickly, typically in just a few milliseconds. Thus, the entire display must be continuously refreshed to avoid flicker and a loss of portions of the image.

Refresh rates vary with the intensity of the display, but the image must be refreshed at least 30 times per second.

These requirements give rise to a structure called a *display list*. As figure 2 indicates, a display list is simply a collection of primitive instructions for the display processor. The display processor repeatedly scans this list to send vector-drawing information to the display electronics. To modify a display, Processor 2 (of figure 1) simply points the display processor to a new display list, or inserts or deletes a portion of the existing list. Generally, a display list is stored external to the display processor in the host-processor memory and is addressed via DMA (direct memory access).

Numerous instruction sets have been devised for calligraphic-display processors. Since displays at this primitive level are very difficult to control, the trend is toward higher-level graphics languages. However, all primitive instruction sets must contain certain basic features, including primitives to move the beam, draw a line, draw a character, call a subroutine, and change colors or intensity.

### Controlling a Raster-Scan Display

Unlike calligraphic displays, raster-scan displays generally employ what is known as a frame buffer. The frame buffer is essentially a block of memory that maintains a one-to-one correspondence with the set of pixels. In other words, there exists one memory location for every pixel. A pixel can be specified in one or more bits, as figure 3 indicates. Thus, color information for a pixel is stored at each memory location. In color raster-scan displays, this memory location does not necessarily hold physical color information, but often supplies a pointer to a color-look-up table, as figure 4 indicates. Thus, for example, a pixel may be specified by 4 bits, but the color information may be translated to any sixteen of a possible  $2^{16}$  colors. This technique allows the display of many different colors with a conservation of memory. The techniques of *contrast stretching* and *pseudocoloring* can be easily achieved with a color-look-up table.

A raster-scan display does require a large amount of memory to implement the frame buffer. For example, a display with a resolution of 512 by

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512 by 8 requires 256 K bytes of memory. This drawback is one of the primary reasons that raster-scan devices have only recently become cost-effective.

Using a frame buffer, an image is drawn by inserting color information into the memory location corresponding to the appropriate pixel. This architecture has the feature of producing flicker-free images; however, to draw vectors the display processor must calculate every point along the vector. Scan-line-conversion algorithms that calculate the points of a vector (given the endpoints) exist, but such algorithms are slow compared to analog techniques used in calligraphic displays. Once an image is written into the frame buffer, it will be continuously displayed. Refresh is not required by the host, but the image cannot be modified as a calligraphic display can.

Clearly, the characteristics of color raster-scan displays present control problems unlike those for calligraphic displays. We must therefore not only exploit the inherent color-display potential, but we must also deal with the problems of selectively updating a raster-scan display. As the next section indicates, we can adapt calligraphic control techniques to effectively control a color raster-scan display.

### Primitives for a Color Raster-Scan Display

To develop an instruction set for a color-graphics display processor, we must first establish our requirements. We assume as a minimum that these primitive instructions will be executed by an intelligent display processor having both a single-frame buffer and a color-look-up table. Therefore, we require that:

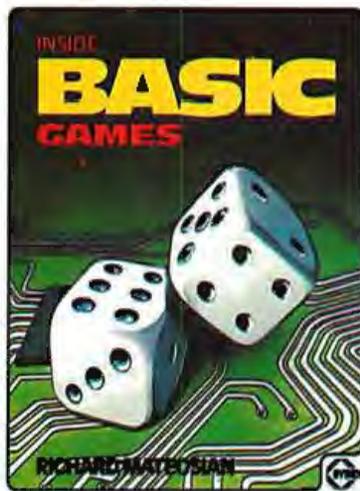
- The set of graphics primitives must permit the construction of any image within the physical limitations of the raster-scan display. The set doesn't need to be minimal; efficiency is a more important characteristic.
- The graphics primitives must be implementation-independent. The primitives must be applicable to any resolution and not be constrained by word size or any similar characteristic of the target processor.
- The graphics primitives must be



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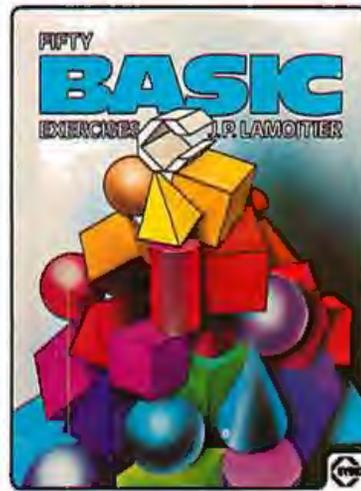


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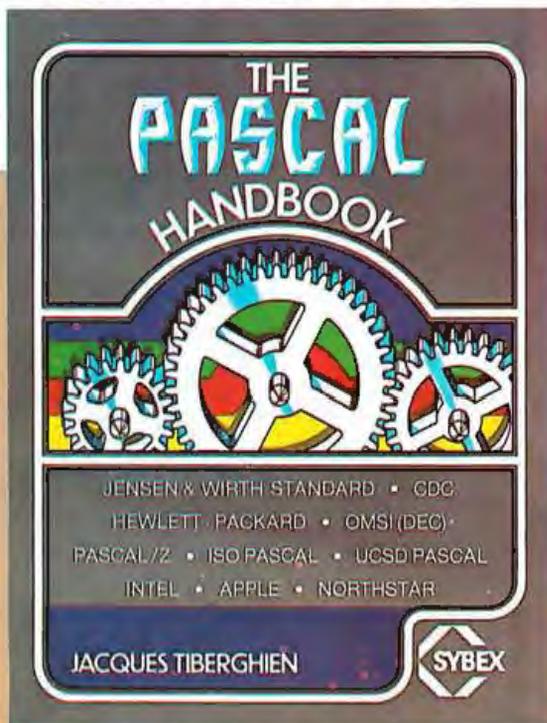
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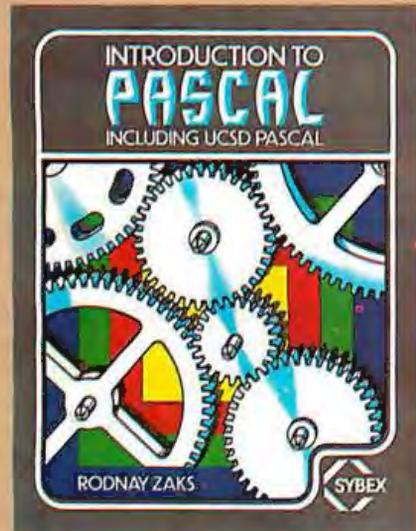
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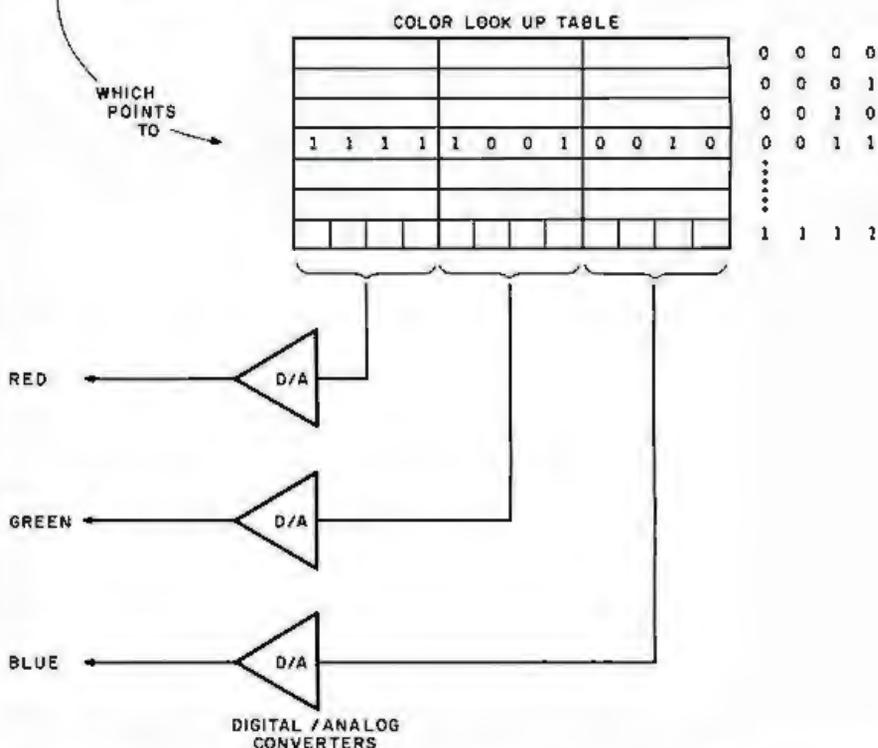
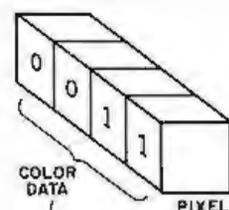


Figure 4: Color-look-up table. Using this scheme, a 4-bit value from the frame buffer (shown in figure 3) can select one of sixteen predefined colors. In this example, each color is composed of various intensities of red, green, and blue. Other systems may specify colors by indicating values for intensity, hue, and saturation.

adaptable to a display-list structure, since display lists are a well-established form of control for display processors and hence permit straightforward integration with generalized graphics-support software in the host processor.

**Graphics Primitives**

As explained previously, we know that raster-scan and calligraphic displays are architecturally different. However, our third requirement indicates that both classes of displays must at least appear identical to the user. Therefore, our graphics primitives become an abstraction for the control of a raster-scan display. We must design a set of primitives independent of the actual architecture of the display. Just as with the benefits of using a high-level programming language, the use of abstractions in controlling a graphics

display allows the user to concentrate upon producing images rather than concerning himself with the mechanics of the implementation.

Before examining the primitives for a color raster-scan display, it is important that you understand two very critical abstractions. First, it is necessary that the user visualize the display processor as manipulating a two-dimensional Cartesian surface, with the origin of the space at some predefined location (usually the center, or lower left-hand corner) on the display surface. There may or may not be a direct mapping of pixel data in the display-processor memory to this surface: the actual implementation should be invisible to the user.

From the previous section, we know that the display processor doesn't need to be concerned with identification of objects that are displayed in this space, but rather we

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need only to be able to manipulate the pixel data that forms these objects.

The second abstraction which we must develop concerns *graphics-display registers*. These registers are defined in the display processor and may be addressed by the user to set up global image parameters, such as current vector type, or to provide immediate processor-status information, such as the current X and Y position. Clearly, these registers may be implemented in diverse portions of the display hardware. Concerning the second requirement, it is important that the user sees these registers as an easily addressable set that may be referenced by the host processor. As we shall see, the use of graphics-display registers helps reduce the scope of some of the graphics primitives that are necessary to control a color raster-scan display.

It is evident, as with any graphics display, that the minimum set of instructions we need includes only a point-positioning and a vector-drawing primitive. But clearly, this set is by no means efficient. Thus, I will present and defend the set of graphics primitives for a color raster-scan display which will be implemented in Micrograph. Next I will present the primitive instructions in their mnemonic form in order to maintain their implementation independence.

As with a calligraphic display, one of the most fundamental operations we perform is point positioning. Since a raster-scan display does not produce an image by beam movement, but rather by Z-axis modulation, we must abstract current X and Y coordinates, which may also be addressed as graphics-display registers. To increase the utility of a move primitive (ie: primitive instruction specifying a movement), we must include several options. To begin, both absolute and relative point positioning are necessary. The need for absolute positioning is obvious; relative positioning permits an entire display to be defined relative to a single point in the image, which is an essential feature if subroutines and instancing are to be supported.

Furthermore, remember that the elements of an image are often closely spaced: thus, we need options for long and short movement. With a

long movement, we may express a point position in the full-screen coordinates (for either absolute or relative positioning). With a short movement, we may express a point position with a limited maximum value (such as 0 to 7, again either absolute or relative). Therefore, it's possible to decrease display-list memory requirements with the use of short movements, which take less storage than a long instruction. Finally, it is often necessary to simply plot a single point. To do so, we must include the option to illuminate or not. If we illuminate, we obviously must include a parameter for the color of the point. Mnemonically, our move primitive can be represented as:

MOV T,M,C,I,(±)X,(±)Y

where:

T = type (Short or Long movement)

M = mode (Absolute or Relative positioning)

C = color

I = illuminate (Yes or No)

X = X position or offset (with a sign on the relative mode)

Y = Y position or offset (with a sign on the relative mode)

For example, the primitive:

MOV S,R,4,Y,+3,-4

moves the current X,Y position by an offset of (3,-4) and illuminates that point in a color whose code is 4.

The next obvious primitive we need performs vector drawing. With the same justification as for the move primitive, we must permit the options of long and short vectors. We assume that the starting point of the vector is the current X,Y position, and the endpoints are determined by either absolute or relative positioning. Just as with a move primitive, we must also be able to specify the color of the vector. Finally, we must be able to define the current vector type, such as solid, dashed, or dotted vectors. Experience indicates that such line types are rarely used. Therefore, rather than specifying this parameter in the primitive itself, we assume that we have available a graphics-display register that defines the current line type. Mnemonically, our vector primitive

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can be represented as:

VEC T,M,C,(±)X,(±)Y

where:

T = type (Short or Long movement)

M = mode (Relative or Absolute endpoints)

C = color

X = X position or offset (with a sign in the relative mode)

Y = Y position or offset (with a sign in the relative mode)

For example, the primitive:

VEC L,A,15,255,180

draws a vector (with the color coded 15) from the current X,Y position to the pixel (255,180).

We must have an instruction that allows us to call a subroutine. Such a primitive is essential to support object instancing. Furthermore, since we assume the existence of an intelligent target display processor, we must expand our primitive to permit a call to a display-processor subroutine. Such

an option allows the user to execute his own predefined routines, which can possibly decrease the image-generation time and reduce some of the processing burden from the host for often-used routines. Clearly, this option is not essential, but it does allow the user to exploit the full capabilities of the display processor. Mnemonically, our call primitive (ie: primitive instruction to call a subroutine) can be represented as:

CALL T,N

where:

T = type of subroutine (Processor or Graphics)

N = name or number of subroutine

For example, the primitive:

CALL G7

calls the graphics subroutine number 7.

Along with the call primitive, we obviously must have a primitive which allows us to return from a subroutine. Our return primitive instruction can be represented as:

RET

Text is often an element of a display and therefore warrants its own primitive. It is important to realize that text usually occurs as a string of symbols rather than a single symbol. Therefore, we must include an option to display a number of contiguous symbols. Furthermore, in terms of the symbols themselves, we may wish to use either a standard alphanumeric font or a user-defined font. Therefore, we assume the availability of a programmable symbol generator. As will be explained, the user may define his own set of symbols and then display a string of symbols by using the symbol primitive, passing it the codes for the appropriate symbols. Mnemonically, our symbol primitive can be represented as:

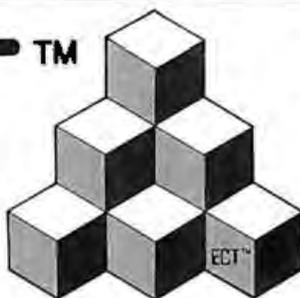
SYM N,S<sub>0</sub>..S<sub>n-1</sub>

where:

N = number of symbols in the string

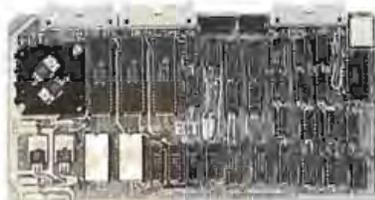
S<sub>i</sub> = symbol code

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For example, if we have defined a 128-character ASCII (American Standard Code for Information Interchange) set of symbols, the primitive:

SYM 5,68,80,77,80,83

displays the string "COLOR".

Also, as noted earlier, we may need to synchronize our display with the display frame rate, especially if we wish to perform animation with smooth movements. Therefore, we need a primitive that suspends display processing until the end of a frame or until after a certain number

of frames. Mnemonically, our wait primitive can be represented as:

WAIT N

where:

N = number of frames to wait

For example, the primitive:

WAIT 7

suspends processing for seven frames.

Since we have assumed the existence of a color-look-up table to facilitate pseudocoloring and contrast-stretching, we must provide

some method of controlling such a structure. There are two common methods for the organization of such tables. One method allows for the definition of a color by the proportions of red, green, and blue elements (the colors which physically make up a pixel). This method is easily performed in hardware, but it is not readily adaptable to common English color descriptions (such as hot pink or sea green). A preferred method, which we shall use, defines a color by its hue, intensity, and saturation. This classification refers to, respectively, the gradation of color (red, pink, purple), the brightness of the color, and the purity, or amount of black, in the color (dark red, fire-engine red).

We abstract the existence of a three-part table (which will actually be implemented in hardware) that is used as a color-look-up table. Since this table is user-alterable, we will refer to its parts as *color memories*. (They would usually be implemented as programmable-memory elements.) In order to generalize this primitive, we need to be able to update the entire table, one entire portion of the table (hue, intensity, or saturation), or all the parameters for a given color code. This table will allow selection of  $2^n$  colors out of a  $2^{i+h+s}$  color set where  $n$  is the pixel size in bits and  $i$ ,  $h$ , and  $s$  are, respectively, the word size of the intensity, hue, and saturation color memory. For example, if  $n = i = h = s = 4$ , we can select one of sixteen colors out of a  $2^{12}$  color set. Mnemonically, our load-color-memory primitive can be represented as:

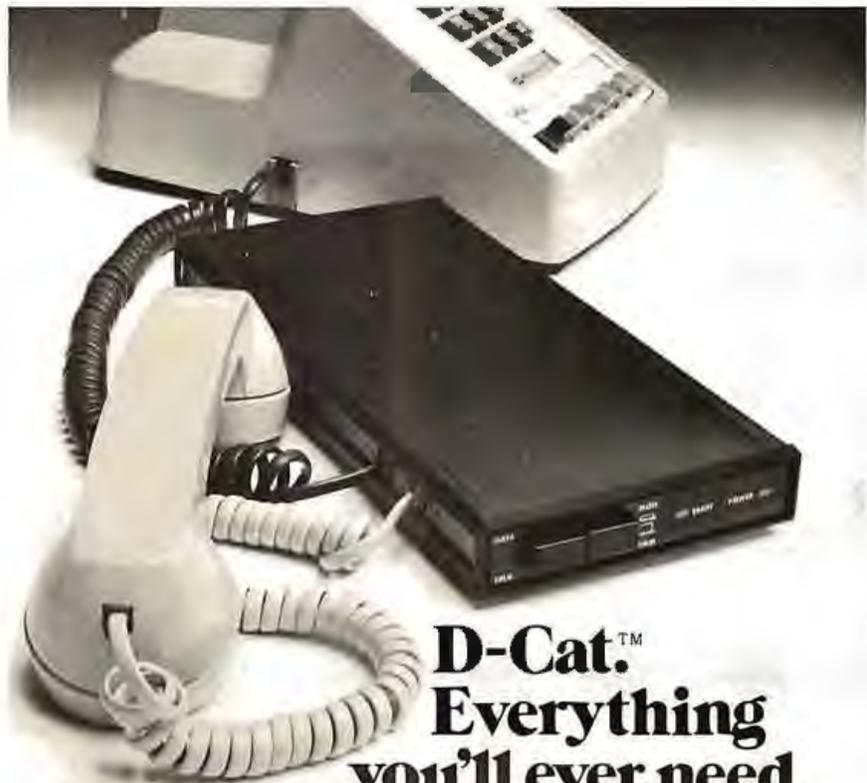
LCRAM R,M,(A),C,

where:

- R = reference (Intensity, Hue, or Saturation color memory, or All)
- M = mode (Single address or All addresses in table)
- A = address (optional)
- C = color data for the color memory

For example, the primitive:

LCRAM A,S,2,5,7,2



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loads all parameters for the color memories at the indexed color code of 2. The hue, intensity, and saturation are loaded at this address with the data 5, 7, and 2, respectively.

In order to exploit the full capabilities of the frame buffer, we must have some method to access individual elements of the buffer. And we must have the capability of loading all or portions of the frame buffer in order to support selective filling and erasing. If we do not provide this function, it becomes very difficult to produce solid colored or shaded images, which is one of the important advantages of a raster-scan display. Furthermore, if we allow the host to directly load individual elements of the frame buffer, we can produce a full frame that implements algorithms such as *depth queuing* and *shading* that cannot be performed otherwise by the display processor at the pixel level. Thus it is apparent that we do need some sort of load-pixel primitive. In order to increase the utility of this primitive, however, we must introduce the concept of the *viewport*.

Through the graphics-display registers, we can define a rectangular area on the display by a pair of X, Y coordinates (the left and right X boundary and the top and bottom Y boundary). Thus, rather than loading the full screen, we can reference the area bounded by a viewport. This feature permits us to load areas of the display or even to mask portions of the display. To further increase the generality of this primitive, we must also permit loading a single pixel. This feature allows us to change the color of the point we are currently at. We could do the same with the MOV primitive, but this instruction would be shorter. Finally, we can define our load-pixel primitive as:

LPIX R,C<sub>i</sub>,C<sub>i</sub>

where:

R = reference (Full frame, Viewport, or X, Y)  
C<sub>i</sub> = color data

Along with this primitive, we must add that a predefined order of filling the pixels must be maintained, such as left to right, bottom to top. For example, the primitive:

LPIX F,0,0,0,0...

loads the entire display with a single color 0.

The next primitives we need do not actually produce an image, but support the previous primitives. First, since we have assumed the existence of graphics-display registers, we must allow the host to load the registers with a value. In this work, we do not specify the types or numbers of graphics-display registers, since they may vary from system to system. However, certain registers will be consistent, such as vector type and current X and Y position. Mnemonically, our load-register primitive can be represented as:

LREG, N,V

where:

N = register name or number  
V = value to be loaded

For example, the primitive:

LREG X,4096

loads the X register with the value 4096.

Since some of these registers contain status information, it is important that the host be able to read back the value in the register. For example, if the display processor supports a light pen, it may be necessary for the host to read back the X and Y position coordinates. Mnemonically, our read-register-primitive can be represented as:

RREG N

where:

N = register name or number

For example, the primitive:

RREG Y

reads the contents of the Y register and returns the value to the host.

Since we have assumed the existence of subroutines, there must be some way of loading subroutines in the display-processor memory: thus we need a load-subroutine primitive. We obviously need the parameters of

Text continued on page 276

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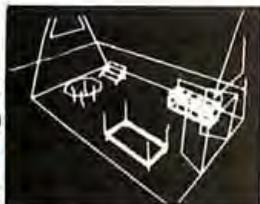
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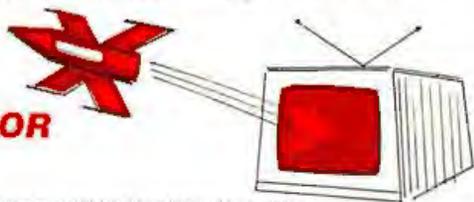
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## A Line-Failure Indicator

Hank Olson, POB 339, Menlo Park CA 94025

Have you ever come back from work looking forward to an evening of home computing, only to find that nothing works? The program that was almost debugged during previous evenings is gone?

While nothing short of nonvolatile memory will completely solve this problem, the simple line-failure indicator described here will alert you to problems that occurred while you were away. A simple glance at the three-color display of LEDs (light-emitting diodes) will at least let you know what you are in for. The indicators light as follows:

- green: power is on, no recent failures
- yellow: power has failed and returned
- red: power has been off for a short time
- none: power has been off for a long time

Having different colored LEDs seems best from a human-interface point of view, even though their voltage requirements differ somewhat.

The circuit of the line-status indicator is shown in figure 1. The basic power supply uses a common 6.3 V filament transformer and a bridge rectifier of four 1N4001 diodes. The primary is controlled by SW1, a double-pole switch which prevents the battery from discharging when the unit is off. This supply must provide the current to light one LED plus energize a small relay coil. This represents about 150 ohms, so the RC (resistor/capacitor) time constant of the power-supply filter is about 0.15 seconds. Therefore, if you return to find the yellow indicator on, you will know that there has been a line-voltage dropout of 0.3 seconds or longer.

Looking at figure 1, we see that the green LED is held on by SCR1. The SCR gate can only be triggered into conduction manually by means of SW2. Once this push-button switch (SW2) is (momentarily) closed, a pulse of current enters the gate of the SCR from the 0.1  $\mu$ F capacitor; and the SCR goes into conduction. Since this SCR operates on DC, it will stay in conduction until the DC supply fails (meaning that there is an AC line dropout).

When the DC supply fails, the relay K1 is de-energized, closing the "normally closed" contacts and lighting the

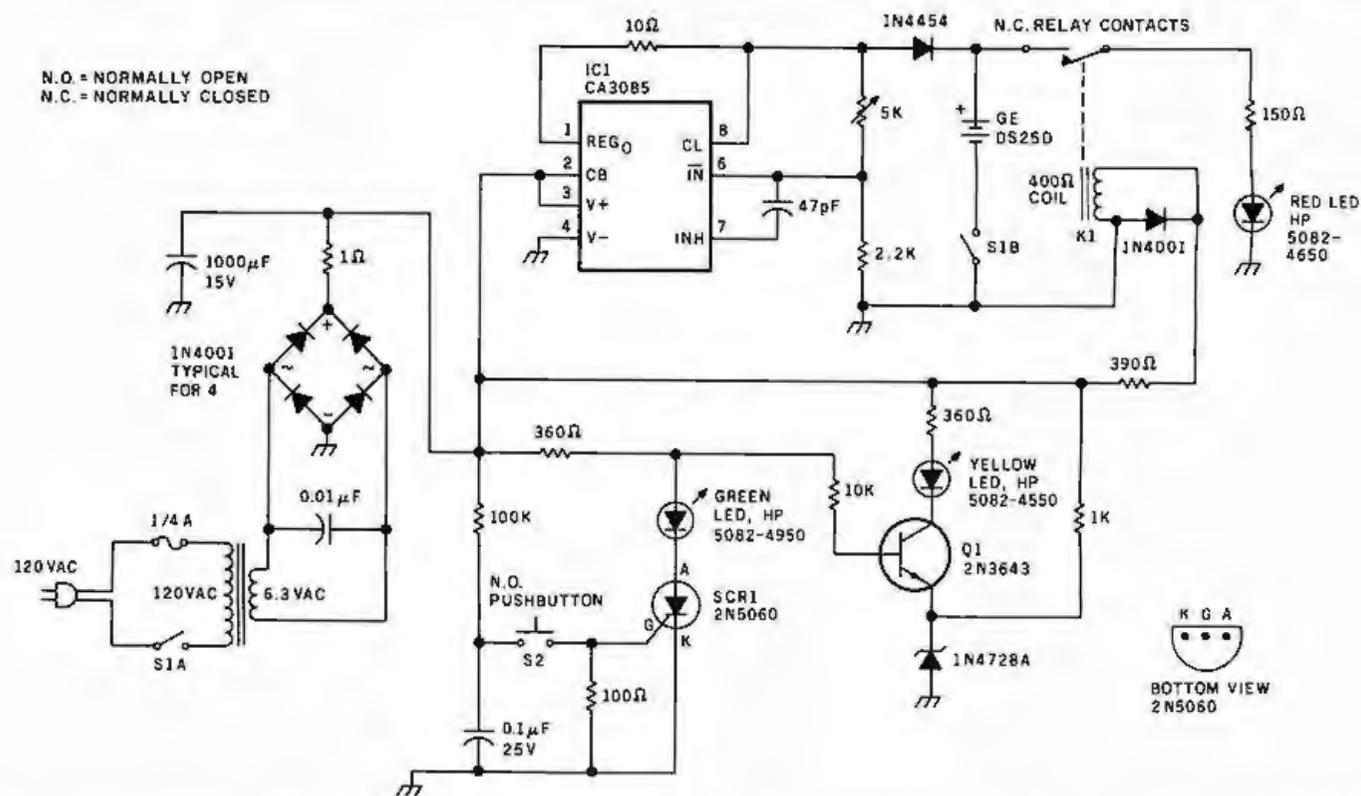


Figure 1: This power-line-failure indicator uses a silicon-controlled rectifier to detect voltage dropouts. If power should fail for more than 0.3 seconds, the SCR ceases to conduct and the green LED is extinguished, while the red LED lights. The red LED remains on as long as power is out; its power is drawn from a set of rechargeable batteries. Should power return, the red LED goes out and the yellow one is illuminated to indicate this sequence of events.



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red LED. The 1N4454 serves to disconnect the two-cell nickel-cadmium (nicad) battery from U1 during power outages, so that the *only* load on the battery is the LED. Use of a relay to actuate the battery-to-LED circuit is the best method, because it closes the circuit with nearly zero resistance, while consuming *no* power in the process. The two-cell nicad, a General Electric DS25D, is a rather small unit made for printed-circuit board mounting and thus fits in easily. This tiny battery will light the red LED for several hours when fully charged.

When AC power returns, DC is quickly restored to energize K1 and to charge the battery via IC1, the regulator. IC1 is a voltage regulator, but it also has current-limit capability. The 10-ohm resistor between pins 1 and 8 of the regulator causes charge current to be limited to 20 mA, even if the battery is nearly discharged. As the battery charges and its terminal voltage approaches the regulated voltage output to which IC1 is set, current drops below 20 mA and tapers off in the "constant-voltage" charge mode.

Meanwhile, the SCR remains nonconducting, which allows current to flow via the 360-ohm and 10 k-ohm resistors to the base of Q1, forward-biasing this transistor and lighting the yellow LED. Thus the yellow LED indicates that power has failed and returned. The red LED has, of course, been extinguished with the energizing of K1.

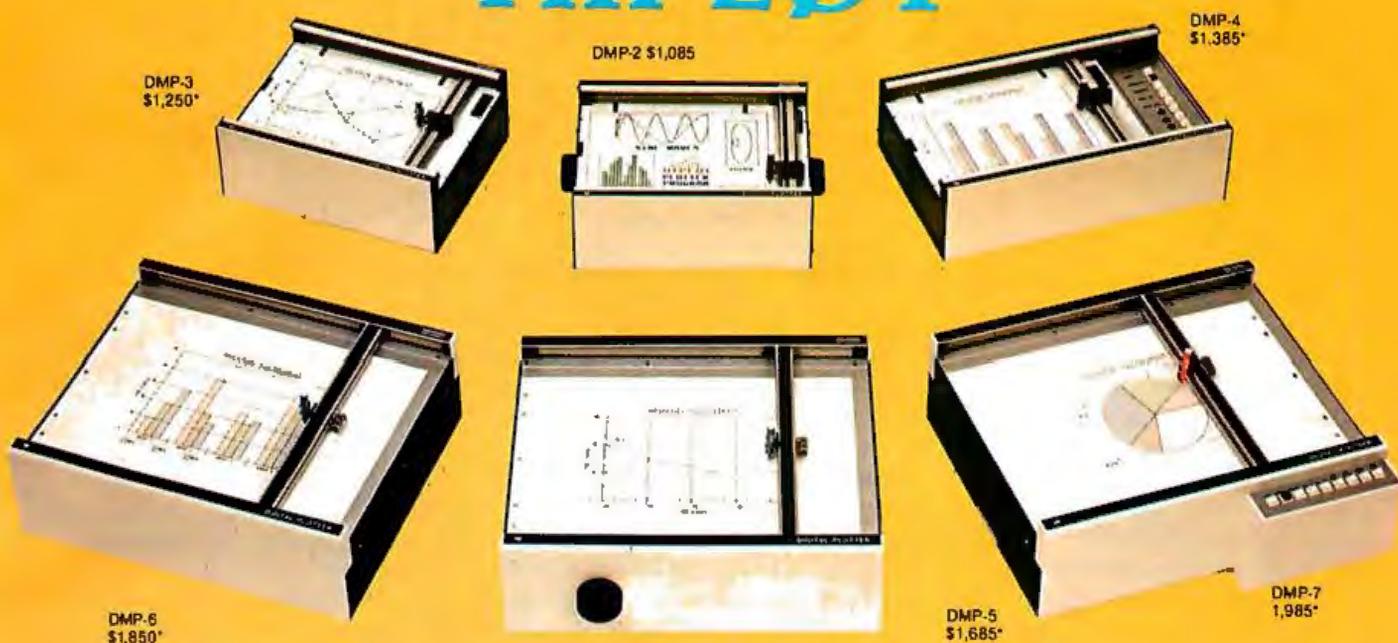
The final step in the sequence is when the person who uses this line-failure detector notices that the yellow LED is lit, and resets SW2. This act causes SCR1 to conduct, diverting current from the base of Q1, extinguishing the yellow LED and lighting the green LED.

Since it takes between 1.5 and 1.8 V to light an LED, I chose a battery consisting of two nicad cells in series. This gives a battery voltage of 2.4 V, which is adequate to light LEDs of all colors, using series dropping resistors. Since the battery is charged in series with a 1N4454, the voltage-regulator output should be set (by means of the 5 k-ohm variable resistor) to between +2.9 and +3.1 V. This accounts for the series forward-voltage drop in the 1N4454. Note that an RCA-CA3085 is used as a regulator. An LM305H (National Semiconductor) will not substitute for this integrated circuit since it's not made to regulate below +4.5 V. The older National LM300H would work, however.

K1 can be any small relay having a coil voltage from 4 to 8 V DC, with a set of normally closed contacts. The series resistor is adjusted to drop the unregulated +8 V of the DC supply to the desired voltage of the relay coil. In my own case, a small relay (from an old radiosonde transmitter) which had a 400-ohm coil and which closed reliably on +4 V was used. A 390-ohm resistor was then used to drop the +8 V supply to the coil voltage of +4 V. ■

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# Language Control Structures for Easy Electronic Visualization

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POB 4348  
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Control structures are the program-flow manipulation features of the language that you use to beat your computer into submission. BASIC's control structures are embodied in the RUN, GOTO, GOSUB, and RETURN keywords and a few functions, certainly an impoverished set. Highly structured languages like Pascal are rigidly limited to the control structure of subroutines. Lowly structured approaches like assembly language are necessary to implement

higher-level languages and real-time systems, because the lack of enforced structure allows an infinite variety of control structures to be used at a cost of great human effort. The execution-speed gain in using assembly language is more due to the efficient building of customized tables and linked lists than to efficiency in adding, subtracting, multiplying, and dividing numbers.

Assembler coding is by no means easy. Note the word "easy": it's

important because in one sense it means "accessible." In this case, it's your access to complex electronic visualizations.

Electronic visualizations are important because producing and manipulating images, especially animated ones, is a truly multidimensional task which reflects our real-world interactions much more than maintaining an accurate laundry list or printing payroll checks. Producing them demands a lot from software,

1a



1b



Photos 1a and 1b: Sample output from the GRASS/Image Processor. Photo 1a was made by Guenther Tetz, and photo 1b by Dan Sandin and the author.

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and making their access easy requires paying attention to the provision of rich control structures in a language.

*Electronic Visualization* is an intentionally broad term meant to conjure thoughts of computer graphics, animation, image processing, video synthesis, and even advanced word-processing. Anyone successfully producing images for communication is unlikely to reject a technique for reasons of algorithmic purity (as a computer scientist might feel forced to do). Computer hobbyists use the tools at hand, and electronic visualization is the means to the end and the end product of using these tools. Simultaneously, it can be both because we are seeing the vast increase of real-time imaging systems, even in microcomputer-based configurations; and controlling these real-time systems can be as feedback-intensive as playing a musical instrument or driving a racing car.

Just to unify the concepts so far, think about this question: what besides the cosmetic packaging governs our choice of a musical instrument or an automobile? It is a combination of capability and user

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The most successful approaches to date are basically highly developed, beautifully evolved kluges.

---

control, of course: having one without the other is useless. So why are the programming languages currently available so impoverished on the control-structure side?

Perhaps it is because computers were invented to process payrolls, not images. Television, on the other hand, is image-oriented and currently uses a host of presently emerging real-time digital techniques and increasingly flexible control structures. As a matter of fact, just about all the television you see these days is digitally processed for purposes of synchronization.

Television is a high-speed medium conducive to parallel and pipeline processing. You are driving television rather than generating it. TV cameras are on all the time and you, as direc-

tor, are fading, switching, adding titles and constantly throwing away images that you don't want. Control is the name of the game.

The television folk are not about to give up rich, real-time control structures and the computer folk won't give up language. How to get them together is the essence of the task at hand.

### Getting Computers and Television Technology Together

Looking at the history of control structures for computer graphics and for television, we see that most computer-graphics usage, with the obvious and exciting exception of video games, is some variety of non-real-time plotting. This is where the money is and where the language development for computer-aided design has been focused. No manufacturer of equipment for computer graphics (excepting the video-game people) now depends on animation for solvency. Plotting is slow and often merely the side output of a large FORTRAN finite-element analysis program. Visual aesthetics are rarely the primary concern, if any concern at all. People who use such systems are highly skilled and highly paid technicians who became that way by having to deal with plotting packages as a condition of employment. If the job were easy, they wouldn't get paid so much.

We are just reaching the point of electronically generating and manipulating images, in real time, under program control. How do we design languages to deal with real time? Or, more important, why do we want such a language, an alphanumeric string-oriented language, at all? Why not use picture-based languages with symbols for motions and timing?

### How Can You Control Images Easily?

After about ten years of living with this obvious and nagging question, some conclusions became clear. First, purist approaches to electronic visualization are hopeless. Image control employs a hybrid of languages, several input devices, picture-oriented commands, custom hardware, and a smattering of idiosyncrasies. The most successful approaches to date are basically

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highly developed, beautifully evolved kluges. We know what "purism" in coding FORTRAN and BASIC does to image production. Purism in television technique eliminates computer graphics as we know it. So how about using graphic symbols to save the day?

Using symbols in a menu and some sort of manual-selection mechanism is an approach taken by many FORTRAN graphics systems. This limits the number of symbols to those defined in the menu and there is no user-level extensibility in that you cannot create new symbols out of

sequences of old symbols, which eliminates the one truly unique feature of computers. To state it bluntly, you can't program with a menu.

What happens, however, if you do find a system that provides for the combination of nonalphanumeric symbols in meaningful ways? In an extremely advanced case, it should look something like Japanese, and you might note that the language used to program computers in Japan is a *phonetic alphanumeric transcription* of their language. They do not program in their extremely beautiful

and rich symbol set. Eliminating alphanumeric languages is not such a hot idea, except in turnkey systems.

The second conclusion gestating for the past ten years is that complete parallelism is necessary for controlling images in meaningful ways. You simply must be able to develop sequences independently and merge them in ways that do not necessitate rewriting the programs. Xerox's Smalltalk and certain other languages have this capability, as do television technology and everyday life: making this parallelism easily accessible takes real care.

The third conclusion is that a flexible priority scheme is needed. Some tasks are more important than others, just as in real life and computer operating systems. It is essential to give this capability to the user of an electronic visualization system.

Fourth, providing for user extensibility at several levels is the only way people will easily be able to use a system for applications not envisioned by the designer. I will discuss this later.

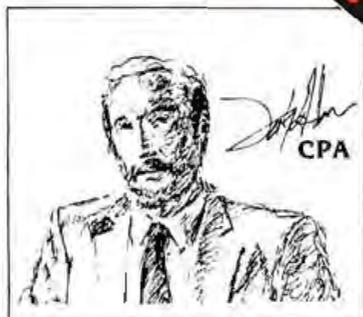
Fifth, the system must be software-fault tolerant. Fault-tolerant hardware has been a research area of great importance to real-time control systems, yet language purists still think people should solve problems in structured, orthodox, algorithmic ways. A computer language should provide as many paths to a given communication as possible, as natural languages do, and the kind of error handling that a friend would offer. Allowing nonstructured, non-procedural, "seat-of-the-pants" programming is often the only salvation when the final goal is aesthetically defined, and is, perhaps, not at all clear. It has been called "fuzzy programming," and it's easy to throw in the recursive, value-returning, clever structured-programming capabilities as well, but limiting yourself to these latter approaches stifles human creativity, problem-solving, and sideways thinking.

## Zgrass — A Language for Easy Electronic Visualization

Zgrass is a programming language and operating system written in assembly language for the Z80 microprocessor by Nola Donato, Jay Fenton, and me. Not surprisingly, it embodies all the control structures mentioned so far in this article and

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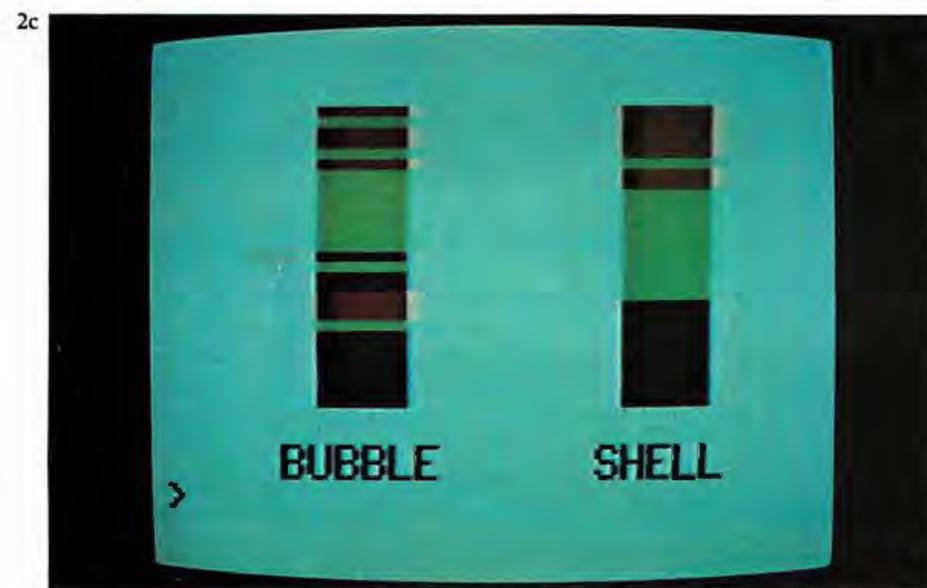
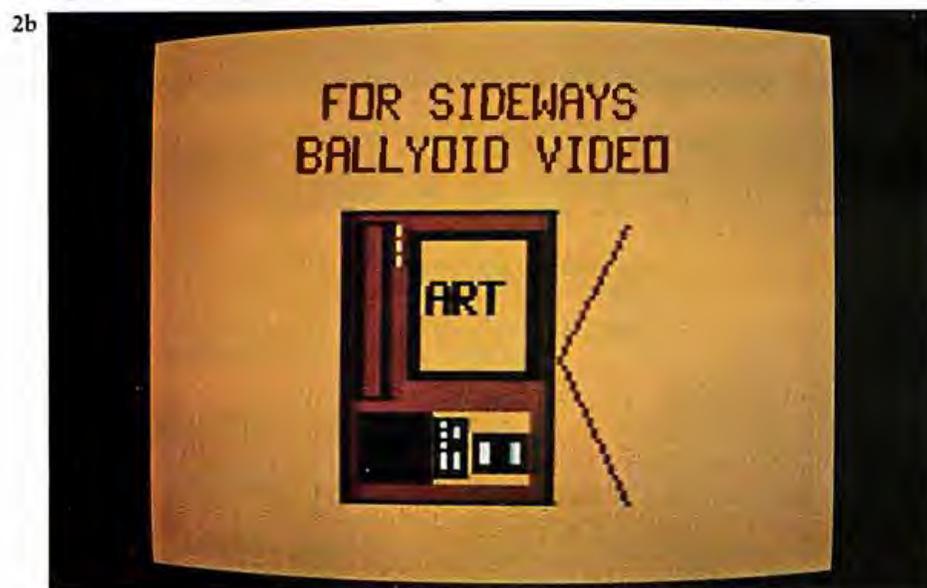
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Photos 2a, 2b, and 2c: Sample output from the first Zgrass system, with a resolution of 160 by 102 pixels, with 2 bits per pixel. Photo 2a was made by Copper Giloth, and photos 2b and 2c by Nola Donato.

has been in development for ten years.

Zgrass started out as GRASS (Graphics Symbiosis System), a language designed to bring the immense complexity of a Digital Equipment Corporation PDP-11/45 and as Vector General 3DR Display system within the grasp of artists and educators at Ohio State University. It has high levels of interaction, parallelism, priority, and tree-structured manipulations of vector-defined objects. Photos from this system can be seen in "About the Cover... And Some More of the Same," in the October 1977 *BYTE*, page 22.

GRASS depends on \$120,000 of equipment to run — rather expensive for a single-user system — but it is one of the first highly developed non-FORTRAN interactive graphics systems for use by artists.

In 1973, Dan Sandin, inventor of the Image Processor, brought color television usage to our computer graphics work at the University of Illinois at Chicago Circle. Dan and I developed most of the ideas about control structures presented here. Photos 1a and 1b show some output from the GRASS/Image Processor system.

Generating a complete programming language with parsers, compilers, and graphics takes a lot of human effort. More than ten person-years of programming were devoted to GRASS, aided by generous support from the National Science Foundation, National Endowment for the Arts, and others.

GRASS is totally oriented toward real-time generation and control of images for the simple reason that television cannot easily be slowed down for long and/or time-lapse exposures as can be done with film. The control structures for GRASS were developed ad hoc and became increasingly idiosyncratic. Nola Donato, a postgraduate student of mine, decided to teach me how to generalize many of the programming-language concepts. The result was GRASS3, which later became Zgrass.

In 1977, I was led to Jeff Frederiksen at Dave Nutting Associates, who was developing a deluxe home computer for Bally Corporation using the custom integrated circuits they had developed for the Bally Arcade video game. The pros-

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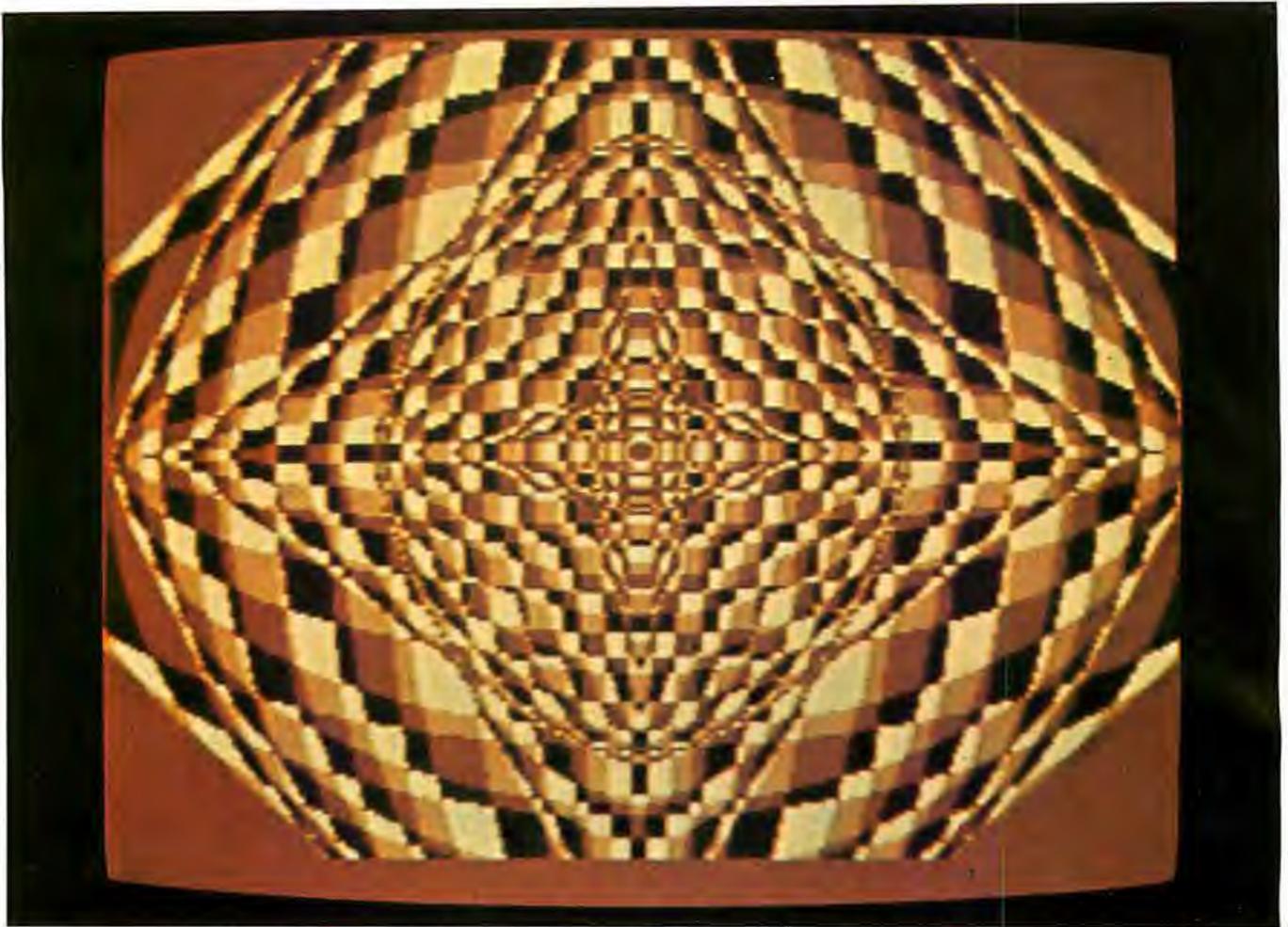


Photo 3: Sample output from a later version of Zgrass, with a resolution of 320 by 204 pixels with 2 bits per pixel. Photo 3 was made by Frank Dietrich.

pect of developing a language for fun, one that had user-orientation as the benchmark rather than how many FOR-NEXT loops you could execute per unit time was too good to pass up. I was contracted to produce Zgrass, and in a year, Nola Donato, Jay Fenton (a legendary wizard of video games and pinball-machine operating systems), and I had generated 9000 lines of code. (Much of the work was done not in a lab but in a cabin in the woods of Wisconsin!) Examples of output from this system are seen in photos 2a, 2b, and 2c. Note that the resolution of this first Zgrass machine is 160 by 102 pixels (ie: picture elements), with 2 bits per pixel.

Some confusion arose about whether we were producing a hobbyist machine or a home computer for consumers, so the project was suspended. Even now nobody really knows what a "consumer computer" is supposed to be.

From consulting with less enlightened would-be consumer computer manufacturers, I have perceived that they follow the rather negative view of consumerism. (Few people reading this article would be considered only consumers — I assume that BYTE readers are mostly hobbyists or professionals.) Consumerism is based on great market penetration, and the big question is: "How do you get 90% market penetration like color TV?"

It is also based on consuming, that is, wearing out or getting sick of hardware and software so you go buy more and consume it. The user is expected to supply no creativity, just assume a passive, susceptible-to-entertainment pose — this reminds you of television watching, doesn't it? Well, anything requiring creative energy is akin to hobbyism.

Consumer computers do exist in the form of video games that you can get bored with and buy more — even the advertisements invariably cite the

number of new games to be available each month. I don't know how to write a programming language that wears out, though. User-extensibility is planned "nonobsolescence." Zgrass is not a consumer language by current standards.

The project is on active status again, but this time with a hobbyist/professional orientation. We believe there are many people who want a recordable image-producing system for around \$3000. The current configuration includes:

- Z80 processor with 16 K bytes of EPROM and 48 K bytes of programmable memory
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Eight Zgrass units in this configuration have been alive and well and tied into the Bell-Laboratory-developed UNIX operating system since January 1980. Although I have only discussed software design, I must mention that the hardware to test the concepts really exists! See photo 3 and note that the resolution is now 320 by 204 pixels, with 2 bits used per pixel.

### Details of Zgrass Control Structures

Programs in Zgrass are called *macros*. Macros are stored as ASCII (American Standard Code for Information Interchange) character strings and normally contain executable Zgrass commands. The fundamental unit of execution in Zgrass is a command, which is either an assignment statement or a function call.

Zgrass does not require declaration of variable types (with the exception of array dimensioning). The software automatically does all conversions

that make sense based on the context. Any argument can be a function call whose returned value is converted to whatever is needed, if at all possible. Literals, indirect references, variables, built-in commands, user-defined commands, and user-defined macros are all handled by the same parser, so the syntax is very predictable. The fact that there are no restrictions on name length helps to produce easily read code.

### User-Level Extensibility

Extensibility in Zgrass is achieved in two major ways. First, you can write macros which return values, produce graphics, or ask questions; or, through string-manipulation primitives written by Barb Wilson, you can generate other macros. Macros use arguments in exactly the same way as system commands, and are even named and called like system commands.

To reiterate, macros are simply strings of ASCII characters. When a macro is called, an MIB (Macro Invocation Block) is automatically built. It gives information on the invoking function call, the passed-argument

list, and pointers to local variables, and provides room for the returned value. MIBs form a stack which implements the subroutines and block structuring of the language. When the macro returns, the MIB is deleted along with the local variables and unused literal arguments, if any, and control is passed back to the caller.

If arguments are to be passed to a macro, they are read by the normal input command, and print statements are suppressed as long as there are arguments left. If no arguments are present or an insufficient number are passed, the print statements function normally and the macro asks for input from the terminal. This allows macros to be used whether or not you know the arguments wanted, with no extra code by the author of the macro.

Macros can also be executed in parallel as background jobs. When called and suffixed by a ".B", the Macro Invocation Block is added to a background linked list. After that, the macro will run forever (it restarts at the beginning when it tries to return) until Control-C or the stop command selectively kills it. Photo 2c shows two sorting algorithms being compared for execution speed in real time, a tricky task in most languages, easy in Zgrass.

The background parallelism is achieved by interleaving execution of the macro statements. The MIB contains all relevant context for execution, including a pointer to the next command to execute, so switching MIBs after each line has been completed is simple and gives the functional parallelism. If there are five background macros, each one gets a line executed, in turn, round-robin fashion. This construct is simple and straightforward with no bizarre side-effects except that unusually time-consuming commands will make the parallelism temporally step somewhat. Background interleaving is easily understood and used even by the most naive users.

Meanwhile, the keyboard is still active. When the user types a command line, it is executed at a higher priority than the background macros. If the user initiates a macro at keyboard level, it will finish before the background macros continue. In any event, the keyboard overrides the background, again in an obvious, predictable way.

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The user may also specify programs to run as the result of a clock interrupt. When a macro call is suffixed by a ".F", the Macro Invocation Block is chained into a list that is polled every 1/60 second. The user sets the frequency of execution from 1 to 32,768 sixtieths of a second. These foreground macros execute on a higher priority level than the keyboard and background macros so they will start up just about on time (again, delayed only by a time-consuming graphics command). Foreground macros allow a keyboard command to be slipped in during context switching.

Zgrass, then, has three effective levels of priority with parallelism at two of the three levels. Since the Macro Invocation Block maintains all context information, even recursive programming is possible at any level.

One of the severe problems in interpretive, extensible languages like Zgrass is the overhead of parsing and looking up names in name tables. For this reason, Zgrass has a compiler which eliminates the overhead and dramatically increases speed. All the automatic conversions, priority, and

parallelism continue to work. Compiling does eliminate some of the interactive debugging features, so you usually debug on the noncompiled version first.

### Zgrass System Extensibility

Zgrass also allows extensibility at the system-command level. A system such as this should allow an experienced programmer to write new commands in assembler and interface them to the system easily, certainly without changing the EPROMs (erasable, programmable read-only memories). A transfer vector in low memory and a series of Z80 RST (special restart subroutine-call) instructions allow communication with about one hundred system routines which do parsing, type conversion, graphics primitives, and so on.

Documentation explains what these routines do, and anyone with a cross assembler (or patience for hand assembly) can write new commands of which the system has no prior knowledge. Such extensibility allows virtually infinite variety of specialty graphics commands, device drivers, and so forth to be written and

distributed to others on audio tape, disk, or over telephone lines. Terry Disz wrote a debugging program used as a disk-resident command for setting break-points, dumping memory and registers and so on. This capability is not for everyone, but it's there.

The maximum size of one of these user-written nonresident commands is 4 K bytes. Since the typical Zgrass machine has 30 K bytes of programmable memory, the amount of potential custom code is immense. All housekeeping for storage allocation and deletion, maintenance of temporary scratch-pad areas and general cleanup is done by system routines. You only concentrate on the details, obeying a few rules for writing position-independent code.

One further type of extensibility is easy to get. Zgrass has an extra UART which talks to other computers quite nicely. Larger computers can send graphics and character data to your Zgrass machine. Zgrass units can even talk to one another at up to 19.2 k bps!

### Error Handling, Debugging and Automated Instruction

Zgrass was designed from the beginning to be a language for writing CAI (computer-aided instruction) programs. In particular, it was designed to be self-teaching to a fairly high degree. When Zgrass is used as a CAI system, the result of providing parallelism, string manipulation, and good error handling is that the student always has the power of the whole language to explore while the author of the CAI programs is also in control.

Since macros are character strings, they can be built and executed. You can take student input, make it into a program (before the student even knows how to edit), let parameters be changed, show the results, and verify certain classes of results both during execution and after. The approaches we have taken to Zgrass CAI are beyond the scope of this article, so I will just mention the system features which make CAI possible.

Error-handling routines normally generate error-message numbers on the terminal. There are about sixty of them and they are quite specific. During regular programming, they are used in conjunction with single stepping, variable printing and other debugging techniques to identify

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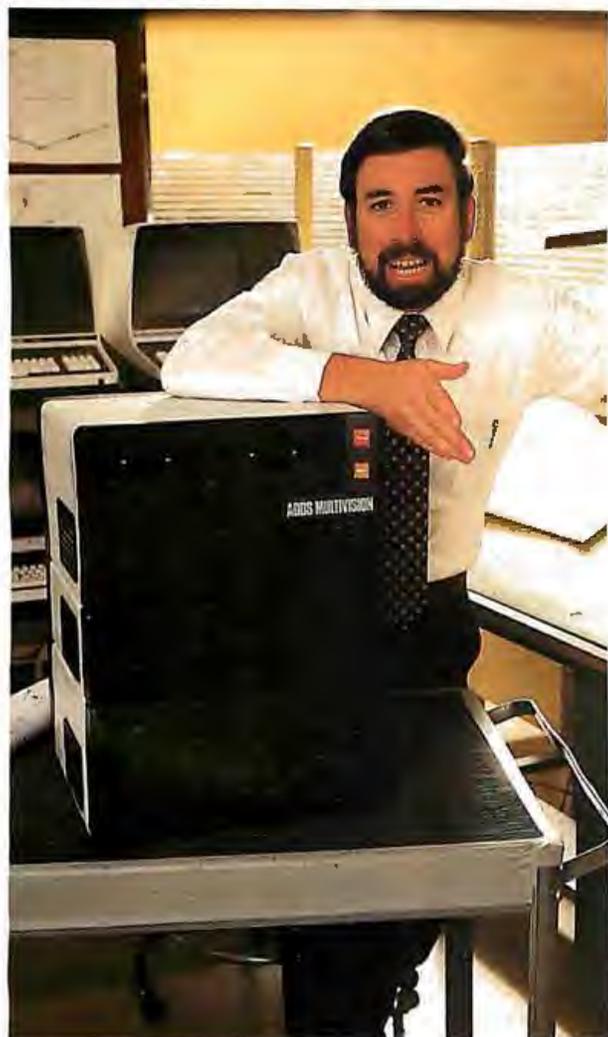
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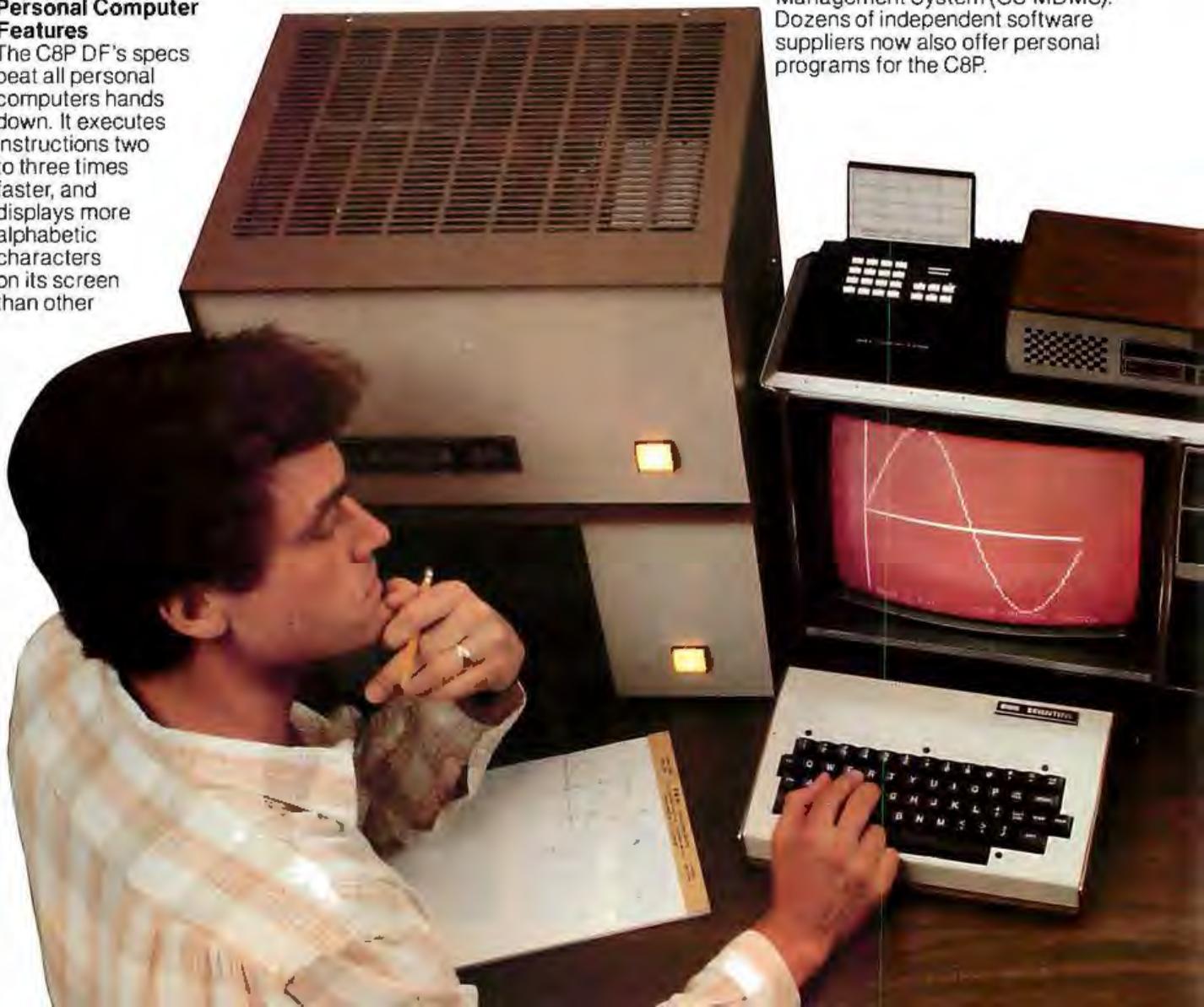
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Ohio Scientific offers a large library of personal applications programs, including exciting action games such as Invaders and Star Trek, sports simulations, games of logic

and educational games, personal applications such as biorhythms, calorie counter, home programs such as checking and savings account balancers and a home budgeter just to name a few. A new Plot BASIC makes elaborate animations easy, and music composition program allows you to play complex multi-part music through the computers DAC.

At the systems level the machine comes standard with OS-65D, an advanced disk operating system with Microsoft BASIC and an interactive Assembler Editor. Optional software includes UCSD PASCAL and FORTRAN and an Information Management System (OS-MDMS). Dozens of independent software suppliers now also offer personal programs for the C8P.



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The C8P DF has the most advanced home monitoring and control capabilities ever offered in a computer system. It incorporates a real time clock and a unique FOREGROUND/BACKGROUND operating system which allows the computer to function with normal BASIC programs, at the same time it is monitoring external devices. The C8P DF comes standard with an AC remote control interface, which

allows it to control a wide range of AC appliances and lights remotely, without wiring, and an interface for home security systems which monitors fire, intrusion, car theft, water levels and freezer temperature, all without messy wiring. In addition, the C8P DF can accept Ohio Scientific's Votrax voice I/O board and/or Ohio Scientific's new universal telephone interface (UTI). The telephone interface connects the computer to any telephone line. The computer system is able to answer calls, initiate calls and communicate via touch-tone signals, voice output or 300 baud modem signals. It can accept and decode touch-tone signals, 300 baud modem signals and record incoming voice messages. These features collectively give the C8P DF capabilities to monitor and control home functions with almost human-like capabilities.

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## Documentation

The C8P DF is not a beginner's computer and doesn't come with beginner's documentation. However, Ohio Scientific does offer detailed documentation on the computer which is meaningful for experts, including a Howard Sams produced hardware service manual that includes detailed block diagrams, schematics, parts placement diagrams and parts lists. Ohio Scientific is now also offering fully documented Source Code in machine readable form for OS-65D, the Challenger 8P's operating system allowing experimenters and industrial users to customize the system to their specific applications.

## What's Next?

Ohio Scientific is working on a speech recognizer to complement the UTI system, with a several hundred word vocabulary. The company is also developing an 8 megabyte low-cost, add-on hard disk for use in conjunction with natural language parsing to further advance the state-of-the-art in small computers. The modular bus architecture of the C8P assures system owners of being able to make use of these new developments as they become available just as the owner of a 1976 vintage Challenger can directly plug in voice output, the UTI and other current state-of-the-art OSI products.

The C8P DF with dual 8" floppies, BASIC and two operating systems costs about \$3000, only slightly more than you would pay for a dual mini-floppy equipped personal computer with only a fraction of the capabilities of the C8P.

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problems. When teaching, however, the CAI program must trap errors. These fall into three types: syntax, nontermination, and logic.

To trap syntax errors, you should use the ONERROR command which transfers the control to a diagnostic section of the program that you, as a CAI author, will have provided. There you can get the error number, the erroneous argument, and even the entire ASCII text of the line in error with the GETERROR command. You can then explain the problem to the user in whatever level of detail you wish.

Indefinite loops are caught with the LOOPMAX command which sets a limit to the number of control transfers (ie: skips and GOTOs). Once the limit is exceeded, an error is generated and trapped as explained

earlier. So, you can catch nonterminating programs or be very meticulous and require efficiency from advanced students by lowering the LOOPMAX appropriately.

Logic errors are trickier and the general case is impossible. However, if you choose suitable problems to solve, you can do some very nice verification. For graphic tasks, the CMPARA command can check a student's building of an image against a prototype. The CAI author can tell if the student's image is a proper subset of the prototype and let it continue. Once a stray pixel is written, CMPARA returns a value of -2 which means the image is "mixed up," and you inform the student immediately. This approach clearly falls short of genuine artificial intelligence, but it is nevertheless quite useful.

Several classes at the University of Illinois at Chicago Circle have been taught with great success using a GRASS-coded prototype (called GAIN, by Tom Towle).

## Conclusions

Zgrass is a language/system designed to provide easy access to computer graphics and, in general, to computing. It has sophisticated real-time structures and control capability, and it's friendly, extensible, and fun. The language is more efficient than BASIC, more user-oriented than FORTRAN or Pascal, and it has the kind of language-control structures that will help you create your mind's fantastic visualizations on your video screen with more ease than ever before. ■

## Glossary

**Color:** The 256 colors available in Zgrass form an abbreviated spectrum. You can get four colors on the screen at any one time. The default colors are white, red, green, and blue. They are also known as color 0, color 1, color 2, and color 3. The values are stored in \$L0, \$L1, \$L2, and \$L3 unless you modify \$HB to use the right-side colors \$R0, \$R1, \$R2, and \$R3.

**Color Map:** The color map is the way Zgrass translates color 0 thru color 3 to the 256 available colors. The hardware looks at the values of \$L0 thru \$L3 before it writes a pixel to the screen. If it is writing a 0, it uses the color stored in \$L0; if it is writing a 1, it uses the color stored in \$L1, and so on. To change the color map so 1 refers to yellow instead of red, set \$L1 to 127. There are actually two color maps, the \$Ls and the \$Rs. You get to the \$Rs by setting \$HB.

**Color Option:** The possible values for color option are 0 thru 15. You may need to study your truth tables for inclusive-OR and exclusive-OR (XOR) logical operations to really understand what's going on. The following is functionally true, however:

Color Option	Meaning
0	replace with color 0 (white)
1	replace with color 1 (red)
2	replace with color 2 (green)
3	replace with color 3 (blue)
4	don't draw (actually XOR with 00)
5	XOR screen with color 1 (01 binary)
6	XOR screen with color 2 (10 binary)
7	XOR screen with color 3 (11 binary)
8	change red to white, blue to green (clear bit 0)
9	change green to white, blue to red (clear bit 1)
10	OR with 01 (if red or white, stay red; if blue or green, stay blue)
11	OR with 10 (if green or white, stay green; if red or blue, stay blue)
12	replace with red only if white were there
13	replace with green only if white or red were there
14	increment the color there by 1 (white to red, red to green, green to blue, and blue to white)
15	decrement the color there by 1 (white to blue, red to white, green to red, and blue to green)

**Macro:** A string that is supposed to contain legal Zgrass commands. Most programming languages call such things "programs" or "subroutines," but we call them macros. Macros are effectively user-defined commands. Macros can behave just like commands in the sense that you can pass arguments to macros with the INPUT command and return values with the RETURN command. You define a macro just like you define a string, with an assignment to a name or by using EDIT.

**String:** A collection of characters (ie: numbers, letters, punctuation) delimited (ie: enclosed) by single or double quotes or balanced (ie: enclosed) by brackets or braces. If you have to use a string delimiter in a string, make sure that it is delimited by a different string delimiter or things will get very confused. Most likely it will consider the rest of your macro as part of the string. Examples:

```
"THIS IS A LONGER STRING"
"PRINT A*B*C
SKIP -1 ;THIS STRING
COULD BE A MACRO TOO"
[THIS IS HOW TO PUT A
QUOTE IN A STRING: " "]
[1234]
[ ]
```

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# Book Reviews

## Applied Mathematical Physics With Programmable Pocket Calculators

by Robert M Eisberg  
McGraw-Hill Book Company,  
New York NY,  
1976

176 pages, softcover  
\$9.95

This book by Professor Eisberg of the University of California, Santa Barbara is interesting on three counts. First, it introduces the reader to numerical methods for differentiation, integration, and solution of differential equations. Second, these methods are applied to the general problems of mathematical physics, starting with the motion of an oscillator and finishing with Schrödinger's equation. Third, the programs for the solution of the equations in these fields are given for the Hewlett-Packard HP-25 and the Texas Instruments SR-56 calculators.

A reader's first reaction might be that the programs apply only to the solution of the problems of mathematical physics. However, the mathematical procedures that were aimed at these calculators may also be applied to any computer. Furthermore, the problems are in the field of physics, but the methods of solution of these problems should be of interest to the general reader.

This book discusses the derivative and methods of obtaining it, followed by programs and examples. Problems for testing the program are also given. Procedures for integration and summation are introduced with the appropriate programs and examples for solution.

The numerical procedure for the solution of second-

order differential equations is developed without the great depth required for mathematical development. These equations are given for both undamped and damped motion, as well as the driven oscillator. The program development and the results obtained are interesting.

The harmonic oscillator section is followed by the coupled oscillator. The examples for the coupled oscillators and their motion are interesting not only for the study of the motion of such systems, but also for the solution of the simultaneous equations involved.

The concept of central force motion is introduced, including orbital path determination. This section concludes with alpha particle scatter due to repulsive forces. A "random" number generator program is introduced and applied to problems of entropy, or run-down evaluation.

Finally, Schrödinger's time-independent equation is introduced and evaluated, and programs are given for the harmonic oscillator and the potential well.

This is an admirable little book on mathematics applied to physics and the programming of such material for the HP-25 and SR-56 programmable calculators. It is also of great interest to the computer programmer because of the procedures discussed, which are adaptable to the computer.

WB Agocs  
Department of Physical  
Sciences  
Kutztown State College  
Kutztown PA 19530

## The Little LISPer

by Daniel P Friedman  
Science Research  
Associates Inc  
Palo Alto CA, 1974

# WHY CIS COBOL LETS YOUR MICROCOMPUTER PERFORM LIKE A MAINFRAME.



**N**ow, you can use a microcomputer for sophisticated business applications ... because now there's CIS COBOL. Micro Focus developed this COBOL so your microcomputer can run the same programs as a minicomputer or a mainframe.

CIS COBOL is Micro Focus' Compact, Interactive, Standard COBOL which offers the advantages of COBOL... powerful data structure features, English-like language, existing programmer expertise... to provide you with a full commercial language. You won't be restricted by size either: a 64K byte microcomputer will compile up to 8000 lines of COBOL, more if the program's split into dynamically loaded modules.

## **Choose a Compact Compiler.**

The Compact compiler runs on 32K byte microcomputer systems. Its powerful subset includes full support for random, indexed and sequential files.

## **Or choose the Standard Compiler.**

The Standard CIS COBOL compiler requires a minimum 48K of user RAM. A super-set of the Compact compiler, implementing ANSI '74 COBOL to Federal Low-intermediate Level.

The same CIS COBOL extensions for conversational working, screen control, interactive debugging, and special peripheral support are in both compilers. And there are more reasons to consider CIS COBOL:

- It conforms fully to the ANSI '74 standard, so programs are portable upwards and downwards to minis or mainframes.
- Its interactive features enable mainframe programmers to get results fast... working on inexpensive microcomputers.

## **Forms**

The FORMS utility lets you build a screen layout online at the CRT. Then it automatically generates COBOL record descriptions for inclusion in your program.

## **Forms-2**

A superset of FORMS, it eliminates the need to write simple data entry and inquiry programs, because the programs can be automatically generated from screen definitions.

## **Environment**

CIS COBOL products run on the 8080 or Z80 microprocessors under the CP/M\* operating system, and on the LSI-11 or PDP-11 processors under RT-11.

They are distributed in a variety of disk formats and come with a utility that enables you to use any make of CRT.

## **OEMs**

Intel has adopted CIS COBOL and offers it (as iCIS-COBOL) for their Intellec and

Intellec II systems. Ideal for OEM's or private label, CIS COBOL was developed entirely by Micro Focus. Send inquiries for CIS COBOL object packs and application vendor terms to MICRO FOCUS or its licensed distributors. Distributor terms also available from MICRO FOCUS.

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It might seem a little odd to review a six-year-old book, but there is a good reason for it in this case: LISP has only recently become available for microcomputers. John Allen (guest editor of the August 1979 BYTE special issue on LISP) has promised that his LISP Company will unveil a full line of LISP systems. It will start with a Z80 version and proceed to much more capable LISP's for the new 16-bit microprocessors. Also, LISP interpreters from other sources exist for Z80, 6800, and AM-100 processors.

The next question is how does one learn LISP? Reference manuals give too much detail and not enough feel for the language. Most introductory material gives too little detail and not enough feel for the language, and nearly all books on LISP make the mistake of telling the student what LISP functions are and

what they do instead of how to use them. There is an alternative to all this. One can obtain *The Little LISPer*, study it for a short time, and come away with a firm grasp of the essentials of LISP. This grasp is sufficient to make sense out of the rest of the material concerning LISP and LISP-based systems that one might encounter.

*The Little LISPer* was originally written to provide a two-week course for non-programmers. It is one of the best introductions to any language that I have ever read. I went straight through it the day I got it. The sequence of topics (interleaving functions, data structures, programming principles, recursive programming techniques) is laid out with a deft touch that has the student progressing much faster than he realizes. This organization of the material allows the reader to build up a sophisticated sense of the patterns inherent in LISP structures

almost without noticing.

Other features that contribute to the relaxed, but speedy, progress of the student are the organization of the entire text into carefully constructed sets of questions and answers and the light humorous touch of the examples.

LISP operates on list structures, and most of the data used in the book are lists of foods. One of the problems for the reader is to determine the list that results from inserting the atom ROAST after the atom CHUCK in a list beginning:

(HOW (MUCH WOOD) . . .

Unfortunately the text breaks off too soon, leaving the reader with a clear sense of things he was just about ready to do, but will have to find out about elsewhere. In any case, the author says the reader is "better prepared than he realizes" to learn the details of a full LISP system and many more advanced programming techniques. It is only necessary to become familiar with the full range of features of a complete LISP system before diving into the world of artificial intelligence and numerous other fields.

LISP is a realization and extension (in notation, not computing power) of Church's lambda calculus, one of the most powerful mathematical tools in existence. It is generally considered a remarkable achievement to teach a powerful mathematical technique to nonmathematicians. As far as I am concerned, though, this kind of teaching should be normal, and the usual "math is hard and you're too dumb to learn it" approach should be thrown away. The fact is that most people are not too dumb to learn mathematics of whatever sort, but few people are clever enough to learn improperly presented mathematics. It seems that even fewer are clever enough to present it well. I am delighted to have an opportunity to point out an in-

stance of top-quality textbook writing and to offer my congratulations to Daniel Friedman.

Mokurai Cherlin  
APL Business Consultants Inc  
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## Mathematical Elements for Computer Graphics

by David Rogers and  
J Alan Adams  
McGraw-Hill Book  
Company, New York  
NY, 1976  
Softcover, 239 pages  
\$12.95

One of the ironies of computer graphics is that it is the aspect of computer use that most attracts people who do not like mathematics, while it is one of the few fields of computing (contrary to popular belief) that require mathematics. *Mathematical Elements for Computer Graphics* is a good sourcebook of the mathematics, the formulae, and the algorithms required to implement graphics packages and applications on computers of any size. It is especially well suited to personal-computer use, since all of the algorithms are presented in BASIC.

Rogers and Adams assume several things about the reader. First, they assume that the reader is writing, or wants to write, software for a line-drawing display (such as those produced by Tektronix). If you have a television-technology display (like most small-computer users), you will need to devise the software to make it draw lines. They also assume that the reader has a substantial background in mathematics. Unfortunately for this subject, a substantial mathematical background means three terms of college-level calculus plus matrix algebra. Also, the algorithms are presented in Dartmouth BASIC, which requires a fair amount of conversion before it will

## the electric pencil II™

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The Electric Pencil is a Character Oriented Word Processing System. This means that text is entered as a continuous string of characters and is manipulated as such. This allows the user maximum freedom and ease in the movement and handling of text. Since lines are not delimited, any number of characters, words, lines or paragraphs may be inserted or deleted anywhere in the text. The entirety of the text shifts and opens up or closes as needed in full view of the user. Page range returns, as well as word hyphenation, are set required since each line of text is formatted automatically.

As text is typed and the end of a screen line is reached, a partially completed word is shifted to the beginning of the following line. Whenever text is inserted or deleted, existing text is pushed down or pulled up in a wrap-around fashion. Everything appears on the video display screen as it occurs, thereby eliminating any guesswork. Text may be zoomed at will by variable speed or step-on-line scrolling both in the forward and reverse directions. By using the search or the search and replace function, any string of characters may be located and/or replaced with any other string of characters as desired. Specific sets of characters within marked strings may also be located.

When text is printed, The Electric Pencil automatically inserts carriage returns where they are needed. Numerous combinations of Line Length, Page Length, Character Spacing, Line Spacing and Page Spacing allow for any form to be handled. Right justification gives right-hand margins that are even. Pages may be numbered as well as listed.

### the electric pencil

A Fusion Word Processing System

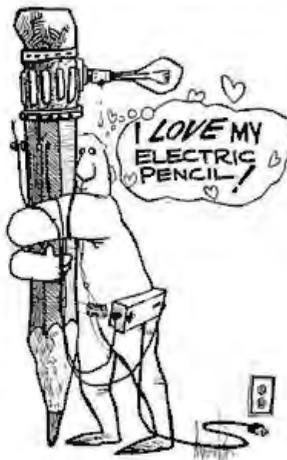
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The Electric Pencil II is still available for TRS-80 Model I users. Although not as sophisticated as Electric Pencil II, it is still an extremely easy to use and powerful word processing system. The software has been designed to be used with both Level I (ASIC system) and Level II models of the TRS-80. Two versions, one for use with cassette, and one for use with disk, are available on cassette. The TRS-80 disk version is easily transferred to disk and is fully interactive with the READ, WRITE, DIR, and KILL routines of TRS80S.

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\*TRS80 is a registered trade name of Radio Shack, a division of Tandy Corp.

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work in Microsoft BASIC or BASIC-E.

For those of you who have not yet been scared off, you will learn algorithms and techniques for: scaling, rotation, curve representation, three-dimensional displays, three-dimensional transformation, and surface description and display. Of course, I am only summarizing; Rogers and Adams break these topics down into 65 sections, plus algorithms.

So why buy (or borrow) this book? If you want a text to teach yourself computer graphics, this is the wrong book. It will not really tell you how to put all of the algorithms together into a usable package or application. But, if you already know something about computer graphics and need a reference to give or compare formulae and algorithms, then this is definitely the right book. A caveat is in order: I have not checked any of the algorithms or programs for typographical accuracy. Which is to say, it's a good reference, but not a good text. ■

John A Lehman  
716 Hutchins #2  
Ann Arbor MI 48103

## BYTE's Bugs

### Duplicated NAND Gate

A drafting error marred Steve Ciarcia's article "A Build-It-Yourself Modem for Under \$50" (August 1980 BYTE, page 22). The pin numbers for a section of an integrated circuit were incorrectly marked, duplicating the numbers for a different section.

In figure 1b on page 28, the NAND gate of IC4c should have had its input indicated as being on pins 8 and 9, with output on pin 10. The pin numbers for IC4d are correct as shown. ■

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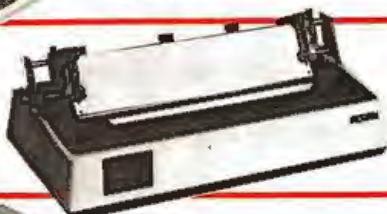
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## Books Received

The following 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 acknowledgement of these books and the publishers who sent them.

**Bit-Slice Microprocessor Design**, Jim Brick and John Mick; McGraw-Hill Book Company, New York NY 1980; 7¼ by 9½ inches (20 by 24.5 cm), 398 pages, hardcover, ISBN 0-07-041781-4, \$18.50.

**Computer Peripherals for Minicomputers, Microprocessors, and Personal Computers**, C Louis Hohenstein; McGraw-Hill Book Company, New York NY 1980; 6 by 9 inches (15.5 by 23 cm), 312 pages, hardcover, ISBN 0-07-029451-8, \$19.50.

**Early British Computers**, Simon Lavington; Digital Press, Bedford MA 1980; 5¼ by 8¼ inches (15 by 21 cm), 130 pages, softcover, ISBN 0-932376-08-8, \$8.

**A Guide to Structured COBOL with Efficiency Techniques and Special Algorithms**, Pacifico A Lim; Van Nostrand Reinhold, New York NY 1980; 6 by 9 inches (15.5 by 23 cm); 272 pages, hardcover, ISBN 0-442-24585-8, \$18.95.

**Master Handbook of Electronic Tables & Formulas**, third edition, Martin Clifford; Tab Books, Blue Ridge Summit PA 1980; 6 by 8¼ inches (15.5 by 21 cm), 313 pages, softcover, ISBN 0-8306-1225-4, \$8.95.

**More Chess and Computers: The Microcomputer Revolution, The Challenging Match**, David Levy, Monroe Newborn; Computer Science Press, Potomac MD 1980; 5¼ by 8¼ inches (13.5 by 20.5 cm), 117 pages; softcover, ISBN 0-914894-07-2, \$12.95.

**Practical Area Navigation**, Paul Garrison; Tab Books, Blue Ridge Summit PA 1980; 6 by 9¼ inches (15.5 by 23 cm), 224 pages; soft-

cover, ISBN 0-8306-2286-1, \$5.95.

**Practical BASIC Programs**, Lon Poole; Osborne/McGraw-Hill, Berkeley CA 1980; 8½ by 10½ inches (20.5 by 26.6 cm), 171 pages, softcover, ISBN 0-931988-38-1, \$15.

**Project Whirlwind: The History of a Pioneer Computer**, Kent C Redmond and Thomas M Smith; Digital Press, Bedford MA 1980; 7½ by 9½ inches (18.6 by 24.5 cm), 280 pages, hardcover, ISBN 0-932376-09-6, \$21.

**Some Common BASIC Programs**, third edition, Mary Borchers and Lon Poole; Osborne/McGraw-Hill, Berkeley CA 1980; 8½ by 10½ inches (20.5 by 27.5 cm), 195 pages; softcover, ISBN 0-931988-06-3.

**Structured BASIC and Beyond**, Wayne Amsbury; Computer Science Press, Potomac MD 1980; 6 by 9 inches (15.5 by 23 cm), 310 pages, softcover, ISBN 0-914894-16-1, \$10.95. ■

## BYTE's Bugs

### The First Shall Be Last

The Washington Area Computer Society (WACS) meets on the *last* Friday of the month (not the first) on the campus of the Catholic University of America in Washington, DC, in the first-floor lecture room in Keane Hall, starting at 7:30 PM. Incorrect information about the meeting time had been published in a past issue of BYTE. ■



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## Complex Number Subroutines

William R Harlow, Department of Mechanical and Industrial Engineering, 836 Rhodes Hall, University of Cincinnati, Cincinnati OH 45221

I teach numerical methods to engineering students at the University of Cincinnati, where we have an Amdahl computer. Also, various departments have purchased Heath, IMSAI, Radio Shack, and Wang systems. Although the big system has built-in hardware to perform complex operations, the smaller systems must have them implemented as subroutines.

Besides the four fundamental operations of addition, subtraction, multiplication, and division, there are several important functions of a complex variable. These include  $\log(z)$ ,  $e^z$ ,  $\sin(z)$ ,  $\cos(z)$ ,  $z^n$ , and others. Since addition and subtraction are so easy to handle, they are not included in the routines listed here.

Listing 1 gives a set of BASIC routines to do the complex operations listed in table 1. Other functions not

**Listing 1:** Subroutines for manipulation of complex numbers. See table 1 for a description of the functions calculated. Note that some of the routines use the constant #PI, which should be set to 3.1415926535.

```

1000 REM
1010 M1=A1*A2-B1*B2:M2=A1*B2+A2*B1:RETURN
2000 REM
2010 D=A2+2+B2+2
2020 B1=(A1*A2+B1*B2)/D:Q2=(A2*B1-A1*B2)/D:RETURN
3000 REM
3010 R=SQR(A1+2+B1+2):I=SGN(A1)+3*SGN(B1)+4
3020 ON I GOTO 3050,3060,3070,3110,3080,3090,3100,3060
3030 B=ARCTAN(B1/A1)-#PI:GOTO 3120
3050 B=(-#PI/2):GOTO 3120
3060 B=ARCTAN(B1/A1):GOTO 3120
3070 B=#PI:GOTO 3120
3080 B=0:GOTO 3120
3090 B=#PI+ARCTAN(B1/A1):GOTO 3120
3100 B=#PI/2:GOTO 3120
3110 P1,P2=0:GOTO 3120
3120 R0=P*LOG(R):R=EXP(R0)
3130 F1=R*COS(P#B):F2=R*SIN(P#B):RETURN
4000 REM
4010 I=SGN(A1)+3*SGN(B1)+4
4020 IF I=4 THEN 4120
4030 L=.5*LOG(A1+2+B1+2)
4040 ON I GOTO 4060,4070,4080,4120,4090,4100,4110,4070
4050 L2=ARCTAN(B1/A1)-#PI:GOTO 4130
4060 L2=(-#PI/2):GOTO 4130
4070 L2=ARCTAN(B1/A1):GOTO 4130
4080 L2=#PI:GOTO 4130
4090 L2=0:GOTO 4130
4100 L2=#PI+ARCTAN(B1/A1):GOTO 4130
4110 L2=#PI/2:GOTO 4130
4120 PRINT "LOG(Z) IS UNDEFINED":STOP:RETURN
4130 L1=L:RETURN
5000 REM
5010 E1=EXP(A1)*COS(B1):E2=EXP(A1)*SIN(B1):RETURN
6000 REM
6010 U1=(EXP(B1)-EXP(-B1))/2:U2=(EXP(B1)+EXP(-B1))/2
6020 S1=SIN(A1)*U2:S2=COS(A1)*U1:RETURN
7000 REM
7010 U1=(EXP(B1)-EXP(-B1))/2:U2=(EXP(B1)+EXP(-B1))/2
7020 C1=COS(A1)*U2:C2=SIN(A1)*(-U1):RETURN
8000 REM
8010 IF B1<>0 THEN B050
8020 IF A1<0 THEN B040
8030 R1=SQR(A1):R2=0:RETURN
8040 R1=0:R2=SQR(-A1):RETURN
8050 R=SQR(A1+2+B1+2)
8060 R1=SQR((R+A1)/2):R2=SGN(B1)*SQR((R-A1)/2):RETURN
    
```

Line Number	Operation type	Input; Use	Other Variables Used	Output
1000	product $z_1 \times z_2$	A1,B1;A2,B2		M1,M2
2000	quotient $z_1 / z_2$	A1,B1;A2,B2	D	Q1,Q2
3000	power $z^n$	A1,B1	P,R,I,B	P1,P2
4000	natural logarithm $\ln z$	A1,B1	I,L	L1,L2
5000	exponential $e^z$	A1,B1		E1,E2
6000	sine $\sin z$	A1,B1	U1,U2	S1,S2
7000	cosine $\cos z$	A1,B1	U1,U2	C1,C2
8000	square root $z^{1/2}$	A1,B1	R	R1,R2

**Table 1:** Table of complex number operations performed by subroutines in listing 1. In the "Input" column (A1, B1) refers to the complex number  $A1 + Bi$ , where  $i$  is the square root of  $-1$ . In the "Output" column, the two numbers listed are the real and imaginary parts of the answer; eg: the output variables M1 and M2 of the multiplication routine mean that the result of the multiplication is the complex number  $M1 + Mi$ .

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included could be the hyperbolic and inverse trigonometric functions. The square root of a complex number was included even though it is a special case of  $z^p$ . The only complicated ones are the power and the logarithm. This is due to the angle utilized.

The subroutines have been given large line numbers so that they may be put at the end of a program. Users can certainly renumber these lines or use only those needed for a particular problem.

Two rather simple problems (see listings 2 and 3) are included to demonstrate the use of the functions. Both make use of Newton's method to solve for the roots of a function. This is done using the following iterative formula to obtain a better approximation of  $z$ ,  $z_{k+1}$ , from the current approximation,  $z_k$ :

$$z_{k+1} = z_k - f(z_k)/f'(z_k) \text{ where } k=1,2,\dots$$

An initial or starting value of  $z$  is selected ( $z=x+iy$ ). Thus  $z_1 = x_1 + iy_1$  is used in  $f(z_1)$  and  $f'(z_1)$ . This will generate a  $z_2$  which is fed back into the right-hand side of the equation to give a  $z_3$ , and so on.

The method is rapid in convergence and quite stable. If a certain  $z_k$  should make  $f'(z_k)$  very small or zero, however, it is best to restart with a new  $z_1$ . In the programs shown, a test to stop cycling is made on the  $f(z)$ :

IF SQR(F1I2+F2I2) < 1E-6 THEN . . .

This statement stops the iteration when the complex error has a magnitude of less than  $10^{-6}$ . ■

**Listing 2:** Example program using the subroutines of listing 1. The program given in listing 2a attempts to find a root of the function  $f(z)=e^z - z^2$ . Note that its derivative  $f'(z)=g(z)=e^z - 2z$ . Listing 2b shows two separate runs of the program with starting points of (1,1) and (-1,0); the final results are underlined. Due to the cyclic nature of  $e^z$ , there are an infinite number of solutions to this problem.

(2a)

```

10 INPUT " KEY IN X,Y ",X,Y
12 PRINT
15 PRINT TAB(14):X,Y
20 A1=X:G1=Y
30 GOSUB 5000
40 F=2
50 GOSUB 3000
60 F1=E1-P1:F2=E2-P2
65 IF SQR(F1I2+F2I2)<1E-6 THEN 120
70 G1=E1-2*A1:G2=E2-2*B1
80 A1=F1:G1=F2:A2=G1:B2=G2
90 GOSUB 2000
100 X=X-G1:Y=Y-G2
110 GOTO 15
120 STOP " ROOT DETERMINED. KEY RUN FOR A NEW SET"

```

(2b)

X <sub>1</sub> = 1	Y <sub>1</sub> = 1
<u>2.912389622375</u>	<u>2.575157181739</u>
2.187132232955	2.174648763578
1.760811047732	1.808824533853
1.603663701734	1.596954184978
1.58722527908	1.54253028231
1.588042823737	1.540223443863
<u>1.588042264669</u>	<u>1.540223501065</u>

X <sub>1</sub> = -1	Y <sub>1</sub> = 0
<u>-1.733043605249</u>	<u>0</u>
-1.7038077863239	0
<u>-1.7034674683272</u>	<u>0</u>

**Listing 3:** Example program using the subroutines of listing 1. The program given in listing 3a attempts to find a root of the function  $f(z)=2z^2 + (-6-i)z + (20-i)=(2z+4-i)(z-5)$ . (Its roots are  $(-2+0.5i)$  and  $5$ .) The derivative  $f'(z)=g(z)=4z + (-6-i)$ . Two runs of the program are shown in listing 3b, with the final results underlined.

(3a)

```

10 INPUT " KEY IN X,Y ",X,Y
12 PRINT
15 PRINT TAB(14):X,Y
20 A1=X:G1=Y
40 F=2
50 GOSUB 3000
60 F1=2*A1:F2=2*B1
70 A2=-6:G2=-1
80 GOSUB 1000
90 F1=F1+A1-20:F2=F2+A2+5
95 IF SQR(F1I2+F2I2)<1E-6 THEN 200
100 G1=4*A1-6:G2=4*B1-1
110 A1=F1:G1=F2:A2=G1:B2=G2
120 GOSUB 2000
130 X=X-G1:Y=Y-G2
140 GOTO 15
200 STOP " ROOT DETERMINED. KEY RUN FOR A NEW SET"

```

(3b)

X <sub>1</sub> = 1	Y <sub>1</sub> = 1
<u>-3.307692307727</u>	<u>-4.461538461518</u>
-1.45941644561	-1.379310344755
-1.434942737807	-1.532192367931
-2.053130882705	-4.886935917174
-2.00036624035	-4.998063289297
<u>-2.00000001228</u>	<u>-4.999999788528</u>

X <sub>1</sub> = 2	Y <sub>1</sub> = 2
<u>2.207547169882</u>	<u>-2.226415094319</u>
2.830440251643	1.193459119487
4.902563504007	-1.877088064073
4.604544248345	-1.193451338577
5.015324400454	2.68292464E-02
4.999923902019	1.12126002E-04
<u>4.999999999177</u>	<u>-2.49665620E-09</u>

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A free catalog will be provided to each individual or organization with listings in the catalog. Catalogs will be available to others for \$10.

The first catalog containing listings of software and all information necessary to order or submit programs will be published in January, 1981. Catalog entries dealing with administrative or business applications should be mailed to Howard R Baldwin, Registrar, University of Akron, 3220 Miles NW, Canton OH 44718. Catalog entries concerning educational or professional

applications should be sent to Swen A Larsen, Dean of Science and Technology, World University, Barbosa esq Guayama, Hato Rey, Puerto Rico 00917. For a copy of the catalog or for more information, contact John Earle Associates Inc, POB 12213, Loiza Station, Santurce, Puerto Rico 00914.

## Pass the Salt and the Computer, Please

Eleven of the nation's newspapers affiliated with the AP (Associated Press) are experimenting with electronic delivery of news to the home. Through the joint efforts of the newspapers, the AP, and CompuServe Inc, an information networking firm, a daily electronic edition will be published for at least six months. The results of this test will be shared with the 1300 daily newspapers and 3500 radio and television stations that are a part of the AP news cooperative.

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The experimenters hope that the test will provide substantial information on marketing the service, promotion, design of the data base, and new sources of advertising revenue. For more information, contact CompuServe Inc, 5000 Arlington Centre Blvd, Columbus OH 43220, (614) 457-8600.

## Tuition-Free Program for Women in Electrical Engineering

A brochure from the University of Dayton outlines a National Science Foundation-sponsored Fast-Track program for women interested in electrical engineering. To qualify, an applicant must hold a bachelor's degree in mathematics, physics, or a related science. Participants earn a certificate that serves to advance them to an

academic level equivalent to that of an electrical engineering graduate. Credits earned can be applied toward a bachelor's degree in electrical engineering. A Fast-Track staff at the university offers counseling and guidance, assists in part-time work placement, arranges for partial living expense stipends and placement in engineering jobs at program conclusion. The program commences January 5, 1981, and lasts thru December 19, 1981. Copies of the brochure, entitled *Women Interested in Engineering*, can be obtained by writing or calling Carol M Shaw, Assistant Dean, School of Engineering, University of Dayton, Dayton OH 45469, (513) 229-2736. ■

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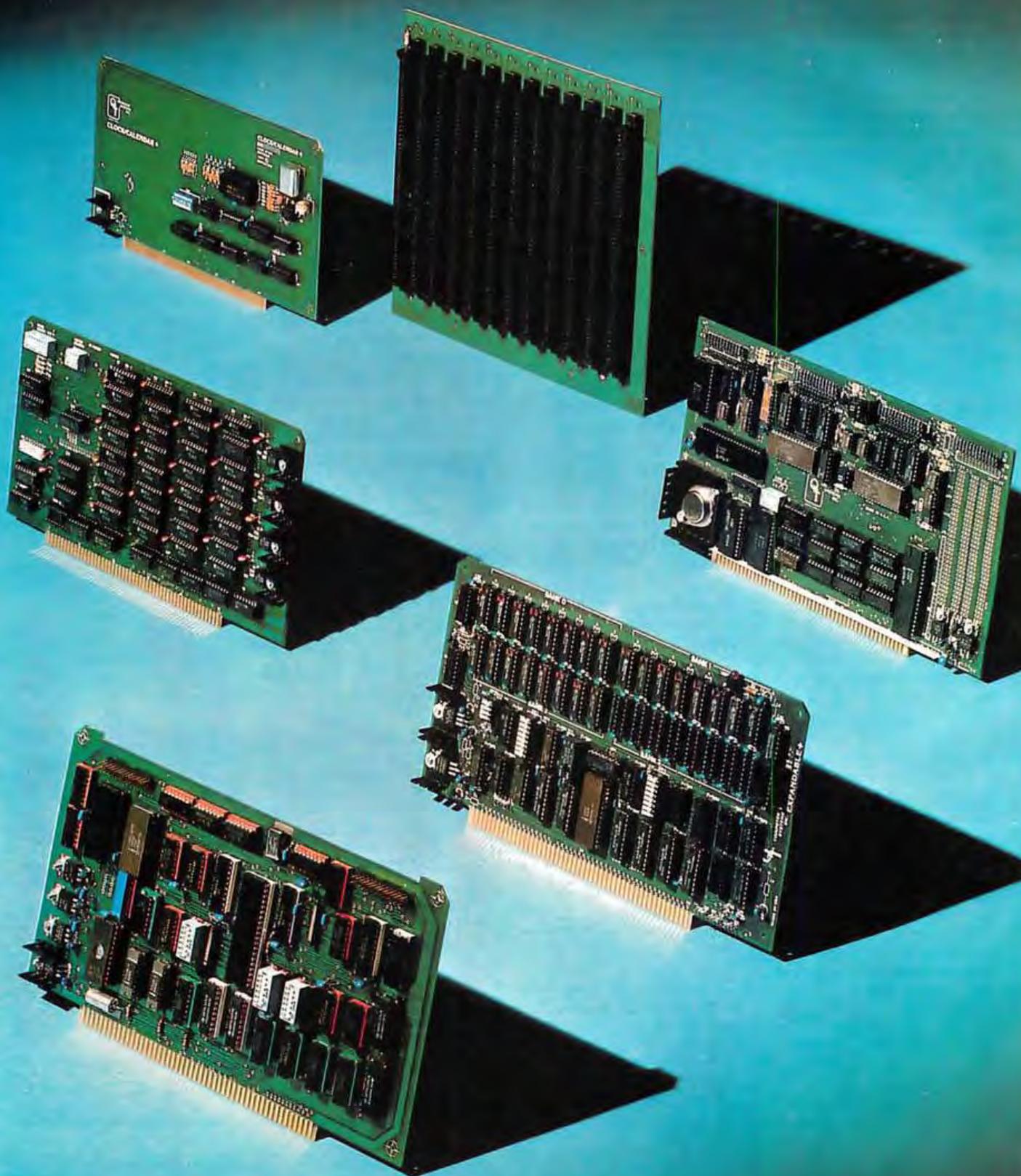
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```
?SIN(2*Y)*(4*COS(X)^3  
-COS(3*X)+SIN(Y)*COS  
(X+Y+#P1)-COS(X-Y));  
Then instantly muMath  
returns:  
@4*SIN(Y)*COS(X)*COS(Y).  
Adding fractions? Need  
you ask?  
?1/3+5/6+2/5+3/7;  
@419/210.
```

muMath is written in muSIMP, which is included in the muMath package.

muSIMP is an applicative, recursive language, ideal for describing complex mathematical concepts.

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## BYTE's BOMB Cards

From the first year of BYTE to the present we have put great stock in your monthly comments that accompany BOMB (BYTE's Ongoing Monitor Box) cards. We really do read every one of them, and we are often influenced by your comments. What follows is a representative sampling from the cards over the past few issues. By the way, if you'd like to add your votes on this month's articles to our tally, simply fill out the BOMB card at the back of the magazine, using the article table on the second-to-last page as a guide....CM

### Pournelle:

- The User's Column is a very good idea—keep on!
- Pournelle is great!
- More Pournelle please. I'm subscribing.
- Very interesting theme. No more Pournelle, please.
- [Pournelle wrote the] best article on TRS-80 since BYTE began.
- Are Pournelle's articles only to be semiregular? I vote for more.
- Pournelle alone will get me to subscribe.
- Pournelle has no finesse.
- Pournelle helped me decide between Radio Shack, Apple, and Atari... TRS-80 and Omikron here I come.
- Jerry Pournelle's column told me far more about TRS-80 add-ons than I have managed to learn in many weeks of searching.

### Ciarcia:

- Mr Ciarcia has done it again.
- Don't lose Steve, he's worth his weight in gold!
- You should put two or three more

Steve Ciarcia on the payroll.

- Ciarcia's article was excellent, but only Bo Derek gets a 10.

### CAI:

- [I was] glad to have some really good info on CAI!
- There were too many articles on CAI.
- CAI makes as much sense as substituting computer-game playing for physical education. Education is achieved through dint of personal dedication and mental application of effort. Chrome-plated push-button gee-gaws cannot substitute for same.

### Others:

- Excellent editorial.
- The editorial by Dr Braun rated a ten.
- Editorials should be rated.
- Your product description of the Apple III was terrific—and they say regular magazines can't get new products published quickly.
- I found the product description of the Apple III outstanding.
- Not being so good at hardware and "systems stuff," I found the July issue more readable than usual.
- Surprisingly, the standard of the July issue was exceptionally low.
- After I finish this BOMB card, I'm going to fill out the subscription form.
- The quality of articles in BYTE is slowly going downhill.
- [July was the] best overall issue of BYTE in a while!
- [July was] a rather dull issue—let's keep it on a professional level.
- Indeed you *are* starting to speak English instead of "highbrow."

### How About...

- More hardware!
- More language-oriented articles!
- More homebrew articles!
- More on 16-bit processors!

- Emphasis on personal applications?
  - Less educational material—more technical articles?
  - Publishing "Favorite Benchmarks" as they come in.
  - Publishing information about the Signetics 2650 microprocessor?
- Coming up:**
- I would like to see articles on homebrew graphics terminals.
  - I would appreciate more articles on the new 16- and 32-bit microprocessors.
  - I would very much like to see in-depth articles on speech recognition.
  - When will you publish more articles on artificial intelligence?
  - It would be nice if more articles could appear on fantasy games....

## CP/M Vendors?

As the developers of CP/M and MP/M, we at Digital Research are preparing a list of vendors of CP/M-compatible software. We would appreciate the help of BYTE readers in compiling this list for distribution to all interested persons who contact us.

If you are currently marketing CP/M-compatible software, please send us any or all literature pertaining to your software. If you have any questions, please contact Curt Geske, at Digital Research, POB 579, Pacific Grove CA 93950, or (408) 649-3896.

Thank you.

Marilyn Darling  
Digital Research ■

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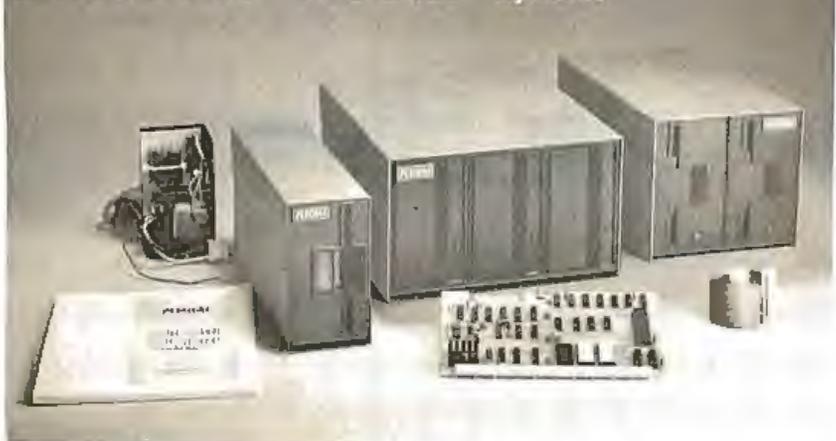
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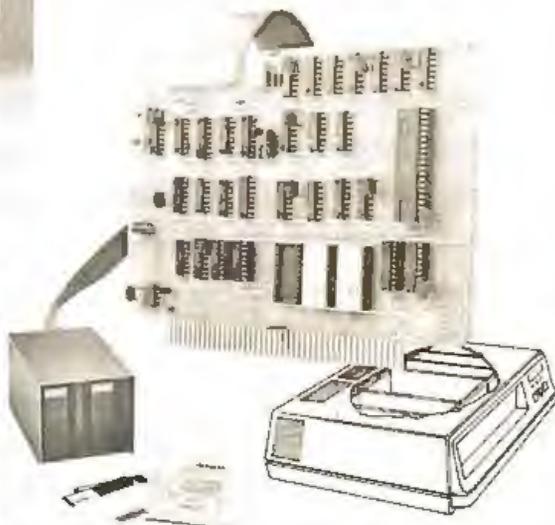


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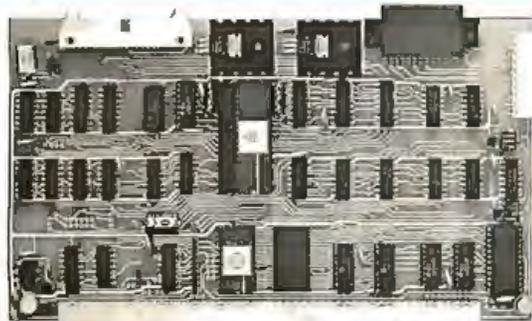
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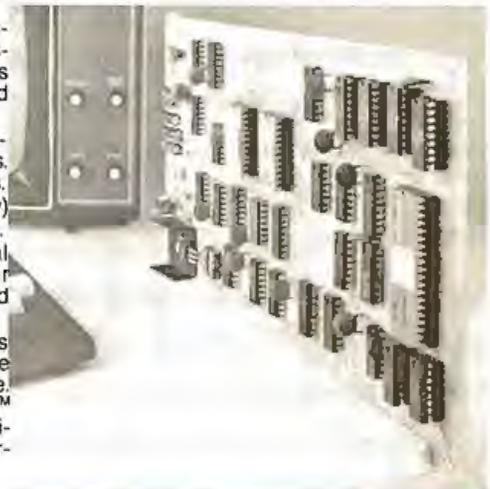
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# Graphic Color Slides

## Part 1

---

Alan W Grogono  
Associate Professor  
Department of Anesthesiology  
Upstate Medical Center  
State University of New York  
750 E Adams St  
Syracuse NY 13210

---

Color slides of graphs, bar charts, and other visual aids are a valuable addition to various public presentations. When made using conventional methods, the slides are expensive to produce and difficult to modify. But when the slide is produced by photographing a computer-generated color image (as described in my article, "Making Color Slides with an Intecolor Microcomputer," January 1980 BYTE, page 20), the slide can be produced inexpensively and the image can be modified easily. Points, lines, bars, and curves can be drawn to represent numeric data.

Unfortunately, writing the program that creates the screen image can be tedious and time-consuming. Many aspects of the program design, such as the selection of suitable scales and the conversion from user-units to screen-units, can be done by the computer. The subroutines given here in listing 1 have been written to provide a common set of routines that can be used to generate different kinds of graphs on a CompuColor II computer with a minimum of effort.

### Design Considerations

Ergonomic texts (ie: those that analyze human engineering factors) suggest that scales are most convenient for the user if they are subdivided in steps that are powers of ten—1, 10, 100, 0.1, 0.001, etc. Double- and half-size steps (2 and 0.5) are also acceptable for intermediate ranges, although other scale intervals (such as 0.75, 1.5, 3, 4) should be avoided. Based on this, I have written

---

Writing the program that creates the screen image can be tedious and time-consuming.

---

subroutines to select a suitable step size from the series: 0.1, 0.2, 0.5, 1, 2, 5, 10, 20, 50....

The ideal number of steps depends upon the application. On graph paper, where fine measurements may be made, a large number of smaller steps is useful. On a video monitor or in a color slide, however, a smaller number of large steps is preferable because it is less confusing; around four to eight steps seem to be appropriate. The scale should start and end at a multiple of the step size.

A program that satisfies these criteria should be easy to write; some readers might want to stop at this point and write their own. Unfortunately, there are several pitfalls for the unwary. At several stages of the calculation and graph preparation, it is necessary to avoid calculation errors (for example, producing 2.99999 or 3.00001 instead of 3). Similarly, scale zero might be calculated as 1.000E-06, which looks odd if printed on a graph scale.

The first step of the scaling process is to calculate the range of the data, R, and make an initial guess for the value of the step size, JUMP. This value can be obtained from table 1, or it can be calculated from the follow-

ing equation:

$$\text{JUMP} = 4 * 10^{\text{INT}(0.434295 * \text{LOG}(R/1.21))}$$

(This is essentially line 10315 of the BASIC program in listing 1; the constant 0.434295 is used to obtain the base-10 logarithm from the CompuColor BASIC LOG function, which returns the natural or base-e logarithm.)

Once the initial value of JUMP has been calculated, it is repeatedly divided by 2 until the resulting value for JUMP is less than or equal to one-fourth the value of the range R; this assures that the graph will have at least four steps in the range. The constant 1.21 is chosen to give the relationship between R and JUMP shown in table 1.

### Implementation Notes

The program has been written, tested, and employed to illustrate this article on a CompuColor II. The BASIC interpreter recognizes two-letter variable names but tolerates longer names (ie: AXIS, AXES and AX are all equivalent). Names were chosen to avoid BASIC reserved words such as INT, OR, ON, STEP. Thus the variable COLOR has been spelled COLOUR, and JUMP has been used in place of STEP. For graphics work this version of the language employs the word PLOT followed by one or more arguments. Table 2 lists the more important plotting codes.

*Text continued on page 138*

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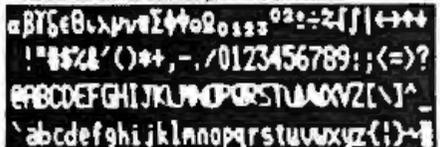
The Computer Terminal requires no I/O mapping and includes 1k of memory, character generator, 2 key rollover, processor controlled cursor control, parallel ASCII/BAUDOT to serial conversion and serial to video processing—fully crystal controlled for superb accuracy. PC boards are the highest quality glass epoxy for the ultimate in reliability and long life.

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Video Output: 1.5 P/P into 75 ohm (EIA RS-170) • Baud Rate: 110 and 300 ASCII • Outputs: RS232-C or 20 ma. current loop • ASCII Character Set: 128 printable characters—



BAUDOT Character Set: A B C D E F G H I J K L M N O P Q R S T U V W X Y Z - ? : \* 3 8 ( ) . , 9 0 ! @ # % ^ & \* ( ) \_ + , - / 0 1 2 3 4 5 6 7 8 9 : ; = < > ?  
Cursor Modes: Home, Backspace, Horizontal Tab, Line Feed, Vertical Tab, Carriage Return. Two special cursor sequences are provided for absolute and relative X-Y cursor addressing • Cursor Control: Erase, End of Line, Erase of Screen, Form Feed, Delete • Monitor Operation: 50 or 60Hz (Jumper selectable).

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Listing 1: Collection of plotting subroutines and driver program for the CompuColor II. See text and listing remarks for further description of the subroutines.

```

5 REM KY 5 REM      GRAPHS. (C) A.W.GROGONO.  AUG. 1979
6 REM      SUBROUTINES V1
40 RESTORE :CLEAR 200:DIM I$(12)
50 DATA 1,2,6,4:FOR I= 1TO 4:READ COLOUR(I):NEXT I
60 REM WRITE:  60 DIM(ARRAY(25,1)) TO USE EQUATION SUB
90 PLOT 29, 27, 24, 15, 14, 2, 255, 6, 1, 12, 3, 16, 3:REM CLEAR PAGE
100 REM
101 REM
110 REM  SUBROUTINES  7000 ERASE/REVIEW IMAGES
120 REM      9000 COMPLETE GRAPH OUTLINE
130 REM      10000 DATA ENTRY
140 REM      10100 EQUATION PLOTTING
150 REM      10200 FIND LITTLE AND BIG
160 REM      10300 CALCULATE DATA FOR BORDERS
170 REM      10500 DRAW BORDERS
180 REM      10700 CONVERT USER UNITS TO GRAPH
190 REM      10800 GRAPH UNITS TO TEXT POSITION
200 REM      11000 PLOT POINTS
210 REM      11100 PLOT VECTORS
220 REM      11200 PLOT Y-BARS
230 REM      11300 PLOT X-BARS
235 REM      11500 SAVE ON DISK
240 REM      11800 SELECT COLORS
250 REM      11900 PAUSE
260 REM
270 END

490 REM WRITE EQUATION AT 500, EG: 500 Y= X^2 - 3* X
510 RETURN
6900 REM
6901 REM
6902 REM  ERASE/REVIEW IMAGES
6903 REM
7000 PLOT 2, 255, 27, 24, 6, 11, 14, 12, 3, 11, 7:REM IMAGE ERASE/REVIEW
7005 FOR I= 1TO 12:I$(I)= CHR$(48+ I- 7*(I 9)):NEXT I
7010 PRINT "E R A S E / R E V I E W  I M A G E S":PRINT
7020 PRINT ,, "1.  REVIEW IMAGES. ":PRINT
7030 PRINT ,, :INPUT "2.  ERASE IMAGES.  ENTER NUMBER: "; I
7040 IF I= 2THEN 7100
7050 I$= "REVIEWED":GOSUB 7200
7060 FOR I= LOWTO HIGH:PLOT 3, 64, 29, 27, 4:REM LOSE CURSOR
7070 PRINT "LOAD SCREEN. DIS; "+ I$(I):PLOT 27, 27:REM IMAGE
7080 INPUT " "; I$:NEXT I:RETURN
7100 I$= "ERASED":GOSUB 7200
7110 PLOT 27, 4:FOR I= HIGHTO LOWSTEP - 1
7120 PRINT "DEL SCREEN. DIS; "+ I$(I):NEXT I
7130 PLOT 27, 27:PRINT "IGNORE FCS ERROR - EFN";
7140 PRINT " DURING RENAMING":PLOT 17, 10, 27, 4
7150 J= HIGH- LOW+ 1:FOR I= LOWTO 12- J:REM CLOSE GAP
7160 PRINT "REN SCREEN. DIS; "+ I$(I+ J)+ " TO SCREEN. DIS; "+ I$(I)
7180 NEXT I:PLOT 27, 27:RETURN
7200 PLOT 6, 5* I- 4, 12, 27, 4:PRINT "DIR":REM DIRECTORY
7210 PLOT 27, 27:PRINT ,, "IMAGES ARE LISTED  SCREEN. DIS; N  ";
7220 PRINT "WHERE N IS THE NUMBER. ":PRINT
7230 PRINT ,, "ENTER #S OF FIRST AND LAST IMAGES TO BE "; I$; " : "
7235 PRINT :PRINT ,, "FOR A ENTER 10, FOR B ENTER 11 ETC. "
7240 PRINT :PRINT ,, :INPUT "FIRST "; LOW:REM
7250 PRINT :PRINT ,, :INPUT " LAST "; HIGH:REM
7260 PRINT :PRINT ,, :INPUT "PUSH RETURN TO ADVANCE"; I$:RETURN

```

Listing 1 continued on page 130

# Major Impact.



## Meet IMP 2, the stylish impact printer with three way paper handling.

Designed for desk top use, this sleek unit combines an ultra-low profile with a unique fan-cooled printing system that can knock out 80, 96, or 132 columns of crisp hardcopy with continuous throughput of one line per second.

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for just about any system — high speed serial, Apple, Pet, TRS-80, IEEE 488... you name it.

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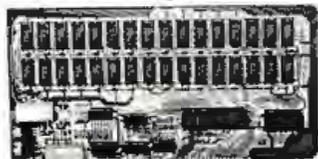
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Please send the items checked below:

- JAWS 16K RAM kit, No. 6416, \$199.95.\*
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- JAWS 32K RAM kit, No. 6432, (reg. price \$329.95), SPECIAL PRICE \$299.95.\*
- JAWS 32K RAM fully assembled, tested, burned in, No. 6432W, (reg. price \$369.95), SPECIAL PRICE \$339.95.\*
- JAWS 48K RAM kit, No. 6448, (reg. price \$459.95), SPECIAL PRICE \$399.95.\*
- JAWS 48K fully assembled, tested, burned in, No. 6448W, (reg. price \$509.95), SPECIAL PRICE \$449.95.\*
- JAWS 64K RAM kit, No. 6464, (reg. price \$589.95), SPECIAL PRICE \$499.95.\*
- JAWS 64K RAM fully assembled, tested, burned in, No. 6464W, (reg. price \$649.95), SPECIAL PRICE \$559.95.\*
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\*All prices plus \$2 postage and handling. Connecticut residents add sales tax.

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Send me more information

Listing 1 continued:

```

8988 REM
8989 REM
8990 REM   PREPARE COMPLETE GRAPH OUTLINE
8991 REM
8992 REM           CALCULATES LIMITS, SCALE VALUES AND
8993 REM           DRAWS OUTLINE WITH TIC MARKS, SCALES,
8994 REM           TITLE AND AXES LABELS
8995 REM
9000 REM GRAPH OUTLINE
9010 GOSUB 10200:REM DATA RANGE
9020 GOSUB 10300:REM AUTOSCALE
9030 GOSUB 10500:RETURN :REM FRAME
9980 REM
9981 REM
9982 REM   ENTER:
9983 REM
9984 REM           TITLE#
9985 REM           NUMBER OF DATA POINTS
9986 REM           LABEL$(0) FOR X-AXIS
9987 REM           LABEL$(1) FOR Y-AXIS
9988 REM           ARRAY(NUMBER,2) OF DATA POINTS
9989 REM
9990 REM   NOTE: IF CHOICE = 1 THEN ONLY 1 AXIS IS ENTERED
9991 REM
10000 PLOT 6,1,12,14,3,18,13:REM DATA ENTRY
10010 PRINT "D A T A   E N T R Y"
10015 PLOT 10,9,9:INPUT "GRAPH TITLE: ";TITLE#
10020 PLOT 10,9,9:INPUT "NUMBER OF DATA POINTS: ";NUMBER
10021 DIM ARRAY(NUMBER+ 2,2)
10024 PLOT 10,9,9:INPUT "X-AXIS UNITS, INDEPENDANT: ";LABEL$(0)
10025 IF CHOICE= 1THEN LABEL$(1)="NUMBER":GOTO 10030
10026 PLOT 10,9,9:INPUT "Y-AXIS UNITS, DEPENDANT: ";LABEL$(1)
10028 LABEL$(2)= LABEL$(1)
10030 FOR ITEM= 1TO NUMBER:REM ENTER POINTS
10040 IF ITEM- 1< > 10* INT ((ITEM- 1)/ 10)THEN 10060:REM PAGE
10050 PLOT 12,10,10:PRINT "POINT",,LABEL$(0):REM
10055 IF CHOICE< > 1THEN PLOT 28:PRINT ,,, " ";LABEL$(1)
10060 IF ITEM- 1= 5* INT ((ITEM- 1)/ 5)THEN PLOT 10:REM SPACE
10070 PRINT :PRINT " "; ITEM, :INPUT " "; ARRAY(ITEM, 0):REM
10075 IF CHOICE= 1THEN NEXT ITEM:RETURN
10080 PLOT 28,18,9,9,9,9:INPUT " "; ARRAY(ITEM, 1)
10085 ARRAY(ITEM, 2)= ARRAY(ITEM, 1):NEXT ITEM:RETURN
10090 REM
10091 REM
10092 REM   WRITE EQUATION
10093 REM
10094 REM           TESTS IS THE EQUATION WRITTEN
10095 REM           INPUT LITTLE(0)
10096 REM           INPUT BIG(0)
10097 REM           CALCULATES ARRAY(25,2) FROM EQUATION
10098 REM
10100 PLOT 6,5,14,12,3,12,7:REM EQUATION PLOTTING
10110 PRINT "E Q U A T I O N   P L O T T I N G":PRINT :REM
10120 NUMBER= 25:X= 1:Y= .9999:GOSUB 490
10130 IF Y< > .9999THEN 10140:REM JUMP IF EQUATION AT LINE 500
10132 PLOT 3,16,11:PRINT "TYPE EQUATION AT LINE 500":PRINT
10133 PRINT ,, "USING THE RULES OF BASIC. ":PRINT :PRINT
10134 PRINT ,, "EXAMPLE: 500 Y=X^2-3*X":PRINT :REM
10135 PRINT ,, "NOW TYPE 500 ..... ":PRINT
10136 PRINT ,, "THEN TYPE RUN AND PRESS RETURN":END

```

Listing 1 continued on page 132



# EVERYONE WINS

*Selecting software for your Ohio Scientific computer is a chancy task at best. There are few trustworthy vendors with a national reputation. There are no consistent quality standards and the documentation is often cryptic and inaccurate. If you are lucky enough to find a good package, there's no guarantee of ongoing support. A wrong choice results in months of wasted time, effort, and money.*

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*tributors to select and market quality software through reputable dealers nationwide.*

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*The Software Federation solves the dealer's problems by providing low cost access to high quality software with the sort of demonstration packages, documentation, and support that the dealer needs to successfully sell machines.*

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*The Software Federation solves the independent vendor's problems by providing a proprietary method of software protection, aggressive enforcement of software licenses, a strong dealer base, primary support, and national advertising.*

## END USERS

*The Software Federation solves the user's problems by providing quality software, exceptional documentation, after-the-sale support, and optional software maintenance services.*

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- BUS-1 Original of popular series, sold "as is" \$99
- BUS-11 Unlicensed version of BUS-1 \$150
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- MEMTEST/2 New edition of popular memory test \$50
- WP-INT Interface between WP-2 and OSI-DMS for form letters \$80
- Amway Distributors Package \$995
- DATA DIRECTOR Complete rewrite of OSI-DMS Nucleus by BBS, command oriented, very interactive \$995
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- WP6502 65U word processor from DQFLS \$125
- USUS Software Exchange Library 6 disk set of UCSD Pascal programs, includes USUS membership \$80
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- Payroll Very thorough package for floppy or hard disk, DMS compatible \$495
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Listing 1 continued:

```

10140 IF TITLE<< > "" THEN 10145
10142 PRINT :PRINT .. "ENTER TITLE (E.G. EQUATION): "
10143 PRINT :PRINT .. :INPUT "":TITLE$
10145 PRINT :PRINT .. :INPUT "ENTER LOWEST X VALUE: ";LITTLE(0)
10150 PRINT :PRINT .. :INPUT "   HIGHEST X VALUE: ";BIG(0)
10160 X= LITTLE(0):FOR ITEM= 1TO 25:GOSUB 490:REM Y FROM EQUAN
10170 ARRAY(ITEM,0)= X:ARRAY(ITEM,1)= Y
10180 X= X+ (BIG(0)- LITTLE(0))/ 24:NEXT ITEM:RETURN :REM INC X
10190 REM
10191 REM
10192 REM   FIND LITTLE(AXIS) AND BIG(AXIS)
10193 REM           FROM ARRAY(NUMBER,1) IN BOTH AXES
10194 REM
10200 FOR AXIS= 0TO 1:GOSUB 10210:NEXT AXIS:RETURN :REM LO, HI
10210 LITTLE(AXIS)= ARRAY(1,AXIS):BIG(AXIS)= ARRAY(1,AXIS)
10215 FOR ITEM= 1TO NUMBER
10220 IF ARRAY(ITEM,AXIS)> LITTLE(AXIS) THEN 10230
10225 LITTLE(AXIS)= ARRAY(ITEM,AXIS)
10230 IF ARRAY(ITEM,AXIS)< BIG(AXIS) THEN 10240
10235 BIG(AXIS)= ARRAY(ITEM,AXIS)
10240 NEXT ITEM:RETURN
10288 REM
10289 REM
10290 REM   CALCULATE FRAME FROM LITTLE(AXIS) AND BIG(AXIS)
10291 REM
10292 REM           JUMP(AXIS)   IS STEP LENGTH
10293 REM           LOW(AXIS)    IS SCALE LOW
10294 REM           HIGH(AXIS)   IS SCALE HIGH
10295 REM           SCALE(AXIS)  IS SCALE LENGTH
10296 REM           GAPS(AXIS)   IS NUMBER OF STEPS
10297 REM
10300 FOR AXIS= 0TO 1:GOSUB 10310:NEXT AXIS:RETURN :REM SCALE
10310 RANGE= (BIG(AXIS)- LITTLE(AXIS))/ 1.21
10315 JUMP(AXIS)= 4* 10^ (INT (.434295* LOG (RANGE)))
10320 DEF FN I(I)= JUMP(AXIS)* INT (I/ JUMP(AXIS)+ .0001)
10325 FOR I= 1TO 3:JUMP(AXIS)= JUMP(AXIS)/ 2
10330 HIGH(AXIS)= - FN I(- BIG(AXIS))
10340 LOW(AXIS)= FN I(LITTLE(AXIS))
10350 SCALE(AXIS)= HIGH(AXIS)- LOW(AXIS)
10360 GAPS(AXIS)= INT (1.0001* SCALE(AXIS)/ JUMP(AXIS))
10370 IF GAPS(AXIS)< 4 THEN NEXT I
10380 EVEN= 2* JUMP(AXIS)* INT (- SCALE(AXIS)/ JUMP(AXIS)/ 2.1)
10390 HIGH(AXIS)= LOW(AXIS)- EVEN
10395 SCALE(AXIS)= HIGH(AXIS)- LOW(AXIS):RETURN
10480 REM
10481 REM
10482 REM   DRAW BORDERS WITH SCALES AND TITLES
10483 REM
10484 REM           USER MAY ALTER
10485 REM           MINSCREEN(AXIS) AND MAXSCREEN(AXIS) BUT
10486 REM           SELECT VALUES TO MAKE
10487 REM           RANGE A MULTIPLE OF 24.  ALSO:
10489 REM
10490 REM           IN 0 AXIS VALUES MUST BE MULTIPLES OF 2
10491 REM           IN 1 AXIS VALUES MUST BE MULTIPLES OF 4
10492 REM
10493 REM           RATIO(AXIS) IS CALCULATED FROM
10494 REM           RANGE AND SCALE(AXIS)
10495 REM

```

Listing 1 continued on page 134

# The best news since CP/M... customizable full screen editing

North Star  
Heath H8/H89  
Super Brain

Sorcerer  
TRS-80 Model I  
TRS-80 Model II

Most other CP/M Systems with  
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## Changes You Make On the Screen Become The Changes to the File.

Full screen editing is the fastest and easiest method of editing all types of text files. Straight forward enough for novices, yet also the choice of professionals. VEDIT is a proven full screen editor with unequalled features. You will appreciate that you can easily edit 10 times faster than with a command editor. Since VEDIT is customizable, it adapts to your applications and preferences, instead of requiring you to adapt to it.

VEDIT is ideally suited to program development and it's special features make it the most valuable development tool a programmer can have. VEDIT appeals to word processing users too. Many simple text editing tasks, such as mailing lists, are faster and easier to do with VEDIT than with more complex word processors.

### Features of VEDIT:

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

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Text movement is very easy using a text register.

Flexible command mode allows global search and substitute, repetitive editing operations.

File handling allows files to be merged on input, split on output, drive selection and more. Blocks of text are readily copied from one file to another.

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Listing 1 continued:

```

10496 REM           PLACE IS CALCULATED FOR
10497 REM           TIC MARKS AND SCALE NUMBERS
10498 REM
10500 PLOT 2, 255, 27, 24, 29, 15, 6, COLOUR(1), 12:REM DRAW FRAME
10505 MINSCREEN(0)= 18:MAXSCREEN(0)= 114
10510 MINSCREEN(1)= 16:MAXSCREEN(1)= 112
10515 FOR AXIS= 0 TO 1:RANGE= MAXSCREEN(AXIS)- MINSCREEN(AXIS)
10520 RATIO(AXIS)= RANGE/ SCALE(AXIS):NEXT AXIS
10522 PLOT 3, (MAXSCREEN(0)+ MINSCREEN(0))/ 4- LEN (TITLE#)/ 2
10523 PLOT 29- MAXSCREEN(1)/ 4:PRINT TITLE#
10525 FOR AXIS= 0 TO 1
10530 PLOT 6, COLOUR(1), 2, 250- 4* AXIS, MINSCREEN(AXIS)- 1
10540 PLOT MINSCREEN(1- AXIS)- 1
10545 PLOT MAXSCREEN(AXIS)+ 2- 2* (AXIS= 1)
10550 PLOT MAXSCREEN(1- AXIS)+ 2- 2* (AXIS= 0)
10555 PLOT MAXSCREEN(AXIS)+ 2- 2* (AXIS= 1), 255
10560 J= JUMP(AXIS)/ 2
10565 FOR PLACE= LOW(AXIS) TO HIGH(AXIS)+ JSTEP JUMP(AXIS)
10570 GOSUB 10700:REM TIC MARKS
10580 GRAPH(1- AXIS)= MINSCREEN(1- AXIS)- 2:REM OUTSIDE FRAME
10590 PLOT 6, COLOUR(1):GOSUB 11010
10600 PLOT 6, COLOUR(2):REM NUMBERS
10620 IF ABS (PLACE)< JUMP(AXIS)/ 2 THEN PLACE= 0:REM NO EXPON
10630 GRAPH(1- AXIS)= MINSCREEN(1- AXIS)- 8+ 4* AXIS
10640 GOSUB 10800:PLACE#= STR# (PLACE)
10650 PLOT 3, TEXT(0)- LEN (PLACE#)/ (2- AXIS), TEXT(1)
10660 PRINT PLACE#:NEXT PLACE:NEXT AXIS
10662 PLOT 3, MAXSCREEN(0)/ 2- 4- LEN (LABEL#(0))
10664 PLOT 34- MINSCREEN(1)/ 4:PRINT LABEL#(0)
10666 PLOT 3, MINSCREEN(0)/ 2- 6, 29- MAXSCREEN(1)/ 4
10670 PRINT LABEL#(1):RETURN
10688 REM
10689 REM
10690 REM   CALCULATE SCREEN GRAPH POSITION
10691 REM
10692 REM           CONVERTS PLACE IN USER UNITS
10693 REM           TO GRAPH(AXIS) FROM
10694 REM           RATIO(AXIS), LOW(AXIS), MINSCREEN(AXIS)
10695 REM
10700 J= RATIO(AXIS)* (PLACE- LOW(AXIS)):REM CONVERT USER UNITS
10710 GRAPH(AXIS)= MINSCREEN(AXIS)+ J+ .0001:RETURN
10790 REM
10791 REM
10792 REM   CALCULATE SCREEN TEXT POSITION
10793 REM
10794 REM           CONVERTS GRAPH(AXIS) PLOTTING UNITS
10795 REM           TO TEXT(AXIS) FOR CURSOR POSITION
10796 REM
10800 TEXT(0)= GRAPH(0)/ 2:REM GRAPH UNITS TO CURSOR POS
10810 TEXT(1)= INT (31.75- GRAPH(1)/ 4):RETURN
10988 REM
10989 REM
10990 REM   PLOT POINTS OR LINES
10991 REM
10992 REM           ARRAY(NUMBER, 1) IS PLOTTED EITHER
10993 REM           AS POINTS OR AS CONTINUOUS LINE
10994 REM
11000 FLAG= 1:GOSUB 11150:RETURN :REM POINTS
11010 PLOT 2, GRAPH(0), GRAPH(1), 255:RETURN :REM POINT

```

Listing 1 continued on page 138

# The Perfect Fit

The Micromodem II data communications system and the Apple II\* computer. What better combination to maximize the capabilities of your personal computer!

This popular direct connect modem can transmit data between an Apple II and another Apple II, a terminal, another microcomputer, minicomputer or even a large time-sharing computer anywhere in North America. The Micromodem II has unique automatic dialing and answer capabilities which further increases the communications possibilities between the Apple II and another computer or terminal.

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The Micromodem II consists of two parts. One part includes the printed circuit board which holds the Micromodem II, ROM firmware and the serial interface. The board plugs directly into the Apple II providing all the functions of a serial interface card plus programmable auto dialing and auto answer capabilities. The on-board ROM firmware enables the Micromodem II to operate in any of three modes to perform different tasks-terminal mode, remote console and program control mode.

The other part of the Micromodem II datacomm system is a Microcoupler which connects the Micromodem board and Apple II to a telephone line. The Microcoupler gets a dial tone, dials numbers, answers the phone and hangs up when a transmission is over. There are none of the losses or distortions associated with acoustic couplers. The Microcoupler is compatible with any North American standard telephone lines and is FCC-approved for direct connection in the U.S. It works with standard dial phone service or Touch-tone service.

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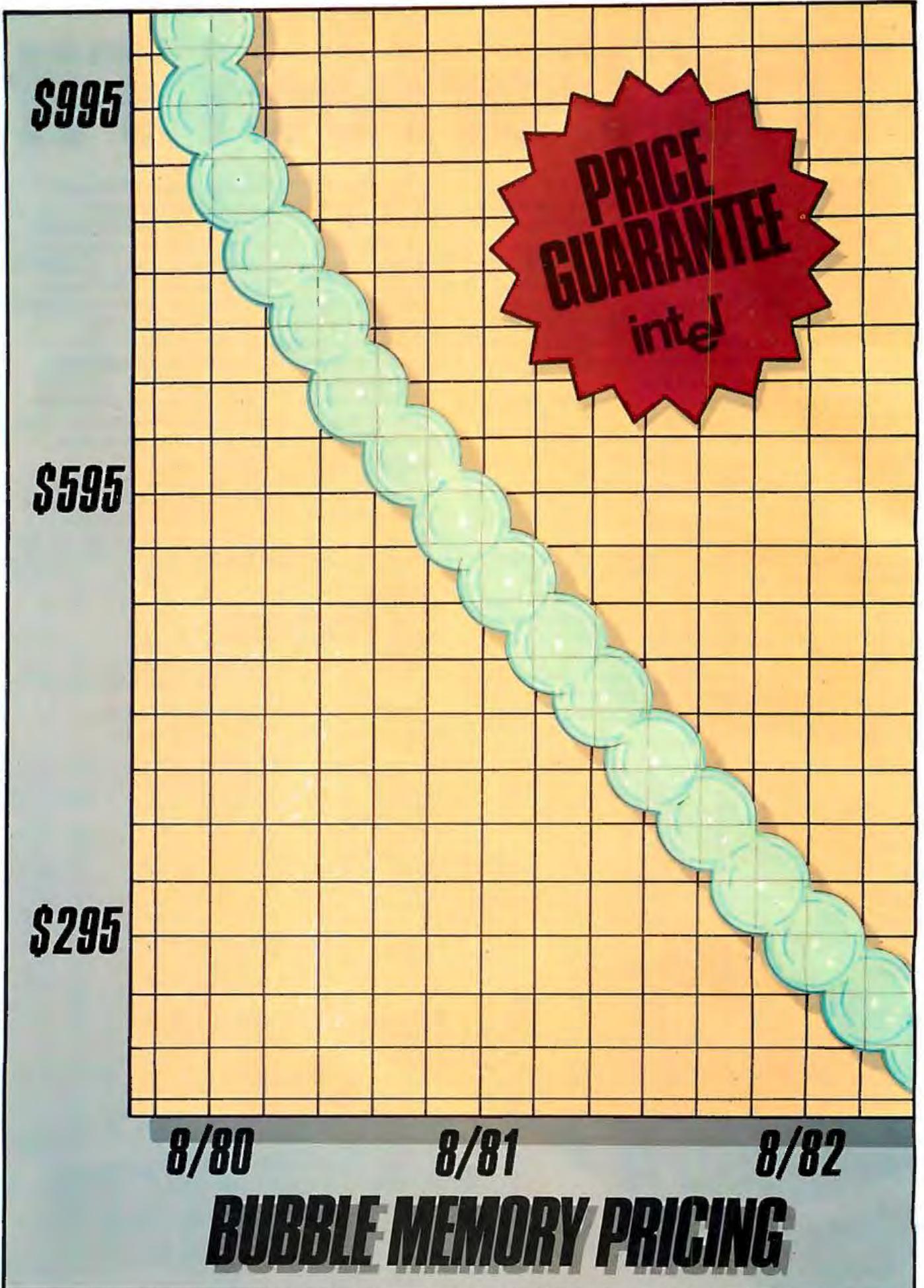
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Listing 1 continued:

```
11020 PLOT 2, 242, GRAPH(0), GRAPH(1), 255:RETURN :REM VECTOR
11100 FLAG= 0:GOSUB 11150:RETURN :REM VECTORS
11150 PLOT 6, COLOUR(3):FOR ITEM= 1TO NUMBER:FOR AXIS= 0TO 1
11160 PLACE= ARRAY(ITEM, AXIS):GOSUB 10700:NEXT AXIS
11170 ON 2+ (ITEM= 1OR FLAG= 1)GOSUB 11010, 11020
11180 NEXT ITEM:RETURN
11188 REM
11189 REM
11190 REM PLOT BAR GRAPHS
11191 REM
11192 REM ARRAY(NUMBER, 1) IS PLOTTED EITHER
11193 REM AS VERTICAL OR AS HORIZONTAL BARS
11194 REM
11200 FLAG= 1:GOSUB 11310:RETURN :REM Y-BAR
11300 FLAG= 0:GOSUB 11310:RETURN :REM X-BAR
11310 COLOUR= 2:FOR ITEM= 1TO NUMBER
11320 COLOUR= COLOUR+ 1+ 2* (COLOUR= 4):PLOT 6, COLOUR(COLOUR)
11330 FOR AXIS= 0TO 1:PLACE= ARRAY(ITEM, AXIS)
11340 GOSUB 10700:NEXT AXIS
11350 PLOT 2, 250- FLAG* 4, MINSCREEN(FLAG):REM X OR Y BAR
11360 FOR I= GRAPH(1- FLAG)TO GRAPH(1- FLAG)+ 1
11370 PLOT I, GRAPH(FLAG):NEXT I:PLOT 255:NEXT ITEM:RETURN
11490 REM
11491 REM
11492 REM SAVE IMAGES ON DISK
11493 REM
11494 REM IMAGES SAVED AS SCREEN.DIS
11495 REM
```

Listing 1 continued on page 140

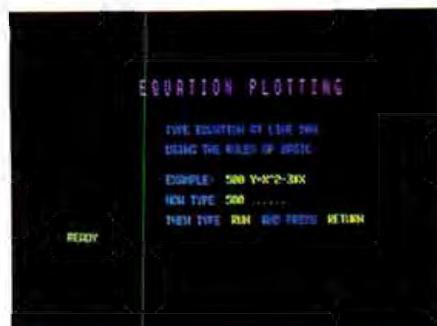


Photo 1: Variation of text height and color. Both text height and color can be changed under program control.

Text continued from page 126:

Subscripts for array variables commence at 0. In consequence, if NUMBER = 25 and AXES = 1, then the BASIC statement DIM ARRAY (NUMBER, AXES) will define an array with dimensions 26 and 2.

Values of 0 or -1 are assigned to results of logical operations: 0 for false and -1 for true. This property is used in line 11170 of listing 1.

It is also possible to change the height and color of displayed text (as shown in photo 1); this is done occasionally within the body of the program in listing 1.

## The Subroutines

Listing 1 contains the subroutines that together can be used to produce a graph on the color video-display screen. Subscripted variables, when used with a subscript of 0, refer to some horizontal component of the graph; a subscript of 1 refers to some vertical component of the graph. Certain calculation subroutines (for example, 10200 and 10300) can be accessed at a line ending in "00" to perform calculations for both the X and Y axes, or they can be accessed at the corresponding line ending in "10" to calculate for only one axis.

Some of the more important subroutines are described briefly in the paragraphs that follow:

- 7000—Review or erase images; this subroutine enables graphs stored on disk to be reviewed (displayed) or erased from the disk.
- 9000—Prepare complete graph outline; this subroutine consists of three subroutines that examine the data and draw the appropriate graph frame (see also subroutines 10200, 10300, and 10500).
- 10000—Data entry; the title of the graph, the axes' labels, and data

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Listing 1 continued:

```

11500 PLOT 6, COLOUR(2), 3, 0, 31, 11, 3, 13, 31:REM SAVE ON DISK
11510 INPUT "ENTER S TO SAVE, OR PRESS RETURN: "; I$:PLOT 28, 11
11520 IF I$ < "S" THEN 11540
11530 PLOT 27, 4:PRINT "SAVE SCREEN. DIS 0000-6FFF":PLOT 27, 27
11540 RETURN
11780 REM
11781 REM
11782 REM SELECT COLORS
11783 REM
11784 REM COLOUR(1) FRAME
11785 REM COLOUR(2) SCALE
11786 REM COLOUR(3) GRAPH 1
11787 REM COLOUR(4) GRAPH 2
11788 REM
11800 PLOT 6, 4, 3, 0, 31, 11, 3, 16, 31:REM COLOR SELECTION
11802 INPUT "ENTER C TO CHANGE COLOR: "; K$
11804 PLOT 6, COLOUR(2), 3, 0, 31, 11: IF K$ < "C" THEN RETURN
11806 PLOT 6, 38, 12, 3, 23, 7, 14:PRINT "COLOR SELECTION"
11810 PRINT :PRINT :INPUT "TOUCH COLOR FOR BACKGROUND: "; I$
11820 I= (ASC (I$)- 16)* 8:PLOT 6, I, 12, 3, 16, 11:REM BKD
11830 PLOT 6, I/ 8* 9+ 2+ 4* (I> 40)
11840 DATA "FRAME", "SCALES", "GRAPH1", "GRAPH2":RESTORE 11840
11850 FOR J= 1 TO 4:READ I$:PLOT 3, 16, 9+ 2* J:PRINT "FOR "; I$
11860 INPUT " "; J$:COLOUR(J)= I+ ASC (J$)- 16
11870 PLOT 6, COLOUR(J), 3, 32, 9+ 2* J:PRINT I$:NEXT J:RETURN
11890 REM
11891 REM
11892 REM PAUSE
11893 REM
11894 REM "PRESS RETURN TO CONTINUE"
11895 REM BLINKS BRIEFLY AT BOTTOM OF GRAPH
11896 REM
11900 PLOT 6, COLOUR(1), 31, 3, 18, 31:REM PAUSE
11910 PRINT "PRESS RETURN TO CONTINUE":FOR I= 1 TO 1000:NEXT I
11920 PLOT 15, 3, 0, 31, 11:INPUT " "; I$:RETURN

```

Range of Values, R, to Be Plotted	Initial Value for JUMP
$0.121 \leq R < 1.21$	0.4
$1.21 \leq R < 12.1$	4.0
$12.1 \leq R < 121$	40.0
$121 \leq R < 1210$	400.0
$1210 \leq R < 12100$	4000.0

Table 1: Initial value for step size (JUMP) given the range (R) of the variable to be plotted. The table can be continued in both directions by either multiplying or dividing all the numbers in a line by 10. Once the initial value for JUMP is found, it is repeatedly divided by 2 until the step size used subdivides the range into at least four intervals—that is, until  $JUMP \leq (R/4)$ .

are entered in this subroutine. Certain applications (eg: histograms) require only one set of data to be entered. If CHOICE=1, then the subroutine fills only ARRAY (n,1), that is, the data entries are placed in ARRAY (0,0), ARRAY (1,0), ARRAY (2,0), and so on. If CHOICE is not equal to 1, then this subroutine expects two sets of data to be entered, filling both ARRAY (n,0) and ARRAY (n,1). The Y-axis data is duplicated in a third column, ARRAY (n,2), thus allowing this data to be manipulated later without being destroyed.

- 10100—Equation plotting; this subroutine tests to see that no equation exists, then invites the user to write an equation at line 500. The equation takes the form  $Y =$  (some arithmetic expression using X). Once the equation exists, the subroutine asks for a title and the X-axis limits. The program then uses the equation to calculate twenty-five equidistant data points to fill ARRAY (n,1).
- 10200—Find big and little; this subroutine determines the largest and smallest values for the data and stores them in arrays BIG (n) and LITTLE (n).
- 10300—Prepare values for frame; the step size (JUMP) is calculated in accordance with the constraints described above. This value is used to determine the HIGH and LOW values for the scale. GAPS is the number of JUMPS in the length of the axis (variable SCALE).
- 10500—Draw borders with scales and titles; this subroutine draws

PLOT 2	Enter graph-plotting mode
PLOT 2, X, Y	Point at X,Y
PLOT 2, 242, X, Y	Vector to X,Y
PLOT 2, 250, X0, Y, XM	Horizontal bar at Y from X0 to XM
PLOT 2, 246, Y0, X, YM	Vertical bar at X from Y0 to YM
PLOT 3, T, L	Cursor to tab T at line L
PLOT 6, C	Defines the color of both the foreground and background
PLOT 8	Cursor to home
PLOT 9	Tab 8 spaces
PLOT 10	Line feed (move cursor down one line)
PLOT 11	Erase line
PLOT 12	Erase page
PLOT 14	Double-height text
PLOT 15	Normal-height text, with blink mode off
PLOT 16 thru PLOT 23	Changes color of foreground or background (whichever is active)
PLOT 27, 4: PRINT "[disk commands]":	
PLOT 27, 27	Execute floppy-disk command
PLOT 27, 10	Write text vertically
PLOT 27, 24	Write text horizontally
PLOT 28	Cursor up
PLOT 29	Enable background color
PLOT 31	Blink on
PLOT 255	Cancel graph-plotting mode

Table 2: Table of plot codes in Compucolor BASIC. Many functions associated with the color video-display screen are achieved by the use of the PLOT command. The table of PLOT commands here includes all those used in listings 1 and 2.

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**Listing 2: Demonstration program for the subroutines of listing 1. This short program, when added to the program in listing 1, allows the user to make a graph of a collection of points, an equation, or a series of vertical bars.**

```

5 REM KY 5 REM      GRAPHS. (C) A.W.GROGONO.  AUG. 1979
6 REM      DEMONSTRATION PROGRAM FOR USE WITH SUBROUTINES
40 RESTORE :CLEAR 200:DIM I$(12)
50 DATA 1,2,6,4:FOR I= 1TO 4:READ COLOUR(I):NEXT I
90 PLOT 29,27,24,15,14,2,255,6,1,12,3,16,3:REM CLEAR PAGE
280 REM
290 REM
300 PRINT "S E L E C T   G R A P H   T Y P E.":PRINT
310 PRINT :PRINT ,, "1.  X/Y SCATTER"
320 PRINT :PRINT ,, "2.  PLOT EQUATION"
330 PRINT :PRINT ,, "3.  Y-BAR GRAPH"
340 PRINT :PRINT ,,, :INPUT "ENTER 1 ~ 3: ";K:PLOT 28,11
350 IF KK 1OR K> 3THEN 340
360 IF KK > 2THEN 390
370 RESTORE :CLEAR 200:FOR I= 1TO 4:READ COLOUR(I):NEXT I
380 K= 2:DIM ARRAY(25,1):REM DIMENSIONS FOR EQUATION
390 ON KGOSUB 10000,10100,10000:REM PREPARE DATA ARRAY
400 GOSUB 9000:REM FRAME
410 ON KGOSUB 11000,11100,11200:REM SCATTER, LINE, Y-BARS
420 GOSUB 11900:REM PAUSE
430 GOSUB 11500:REM SAVE
440 GOSUB 11800:REM SELECT COLORS
450 IF K#="C"THEN 400
460 GOTO 5

```

the borders for the graph with its scales, labels, and title. The length of each number or word is employed to ensure appropriate positioning. The value of **RATIO**, calculated here, is used in the subroutine at line 10700.

- 10700—Convert units to screen; a value on one of the axes (in variable **PLACE**) is converted to its corresponding screen position (stored in variable **GRAPH**).
- 10800—Converts units for text position; a screen position variable, **GRAPH**, is converted to its corresponding cursor position and stored in variable **TEXT**.
- 11000 and 11100—Plot points or lines; the data points in **ARRAY** are plotted as separate points (11000) or as points joined by lines (11100).
- 11200 and 11300—Plot Y-bars or X-bars; the quantities in **ARRAY** are plotted as vertical (11200) or as horizontal bars (11300).
- 11500—Save image on disk; this subroutine transfers the finished graph to disk for recall later.
- 11800—Select colors; the colors for the background, frame, scales, and graphs are selected with this routine.
- 11900—Pause; this subroutine causes the words "PRESS RETURN TO CONTINUE" to flash briefly beneath the graph.

**A Demonstration Program**

The program in listing 2 was written to demonstrate the color-graphics subroutines. Graph type 1 allows data to be entered and displayed as separate points. The program initially selects the colors shown in photo 2a, but the user can select his own colors, as shown in photo 2b.

Photos 3a and 3b illustrate the use of the equation-plotting subroutine, graph type 2. Photo 3a shows the program colors for the first range selected (-2 to +2); photo 3b shows a different set of colors selected by the user for the longer range (-4 to +4). Photo 4a shows how a variable, such as income, can be displayed as a Y-bar, as an example of graph type 3. Photos 4b and 4c show the same data using different colors selected by the user.

The brevity of listing 2 shows that minimal program writing is required to produce these graphs. In fact, if only one type of graph is required

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A simulation



(eg: points joined by lines), then the total program would be:

```

300 GOSUB 10000 : REM DATA
    ENTRY
310 GOSUB 9000 : REM FRAME
320 GOSUB 11100 : REM PLOT
    LINES
330 GOSUB 11900 : REM PAUSE
340 END
  
```

Of course, this assumes the presence of the subroutines given in listing 1.

2a



2b

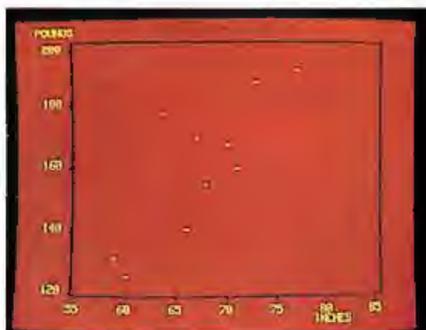
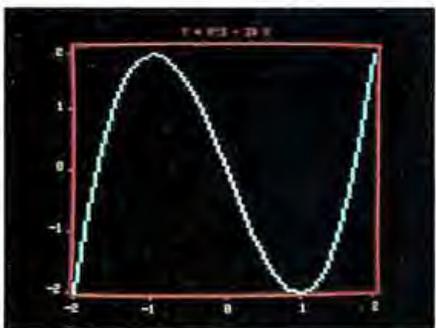


Photo 2: Examples of point-plotting mode. The computer automatically chooses the colors of photo 2a, but the user can override this to select any other color combination, as in photo 2b. The slight "pincushion" effect can be eliminated by the addition of a corrective kit supplied by Compucolor.

3a



3b

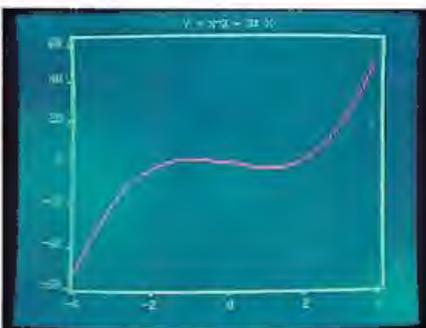
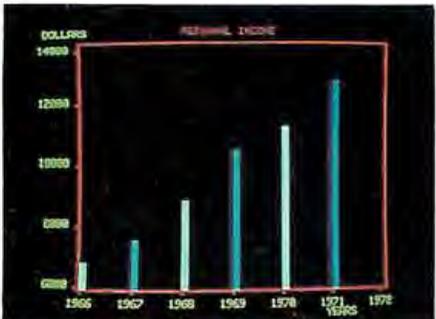
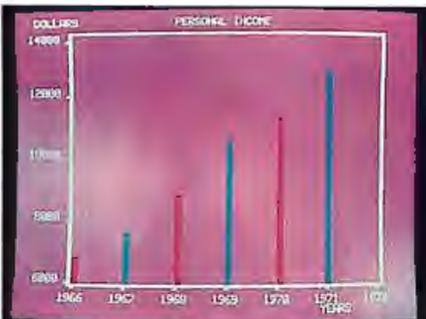


Photo 3: Examples of equation-plotting mode. The range of both the X and Y axes can be changed, as can the choice of colors. Photo 3a illustrates the standard colors as selected by the computer; photo 3b shows another graph with colors of the user's choice.

4a



4b



4c

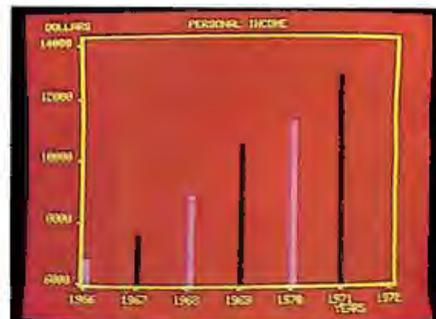


Photo 4: Examples of bar-graph-plotting mode. Here, the same data is displayed in the standard colors (photo 4a) and two sets of user-selected colors (photos 4b and 4c). Horizontal bar graphs can also be displayed.

In such a program and in the demonstration program, the X-axis and Y-axis graph scales are determined automatically by the program except where the user selects the X-axis limits for the equation.

### Summary

The subroutines in listing 1 were written to illustrate the principles used in determining neat graph scales, and emphasis has been placed on these calculations. The frame is

drawn just outside the area in which points will be graphed. This avoids the problem of graphing points that lie directly on the frame; it also avoids the possibility of the color for a nearby graph point spilling onto the frame. The program generates an even number of scale increments for each axis; this ensures uniform spacing of both tick marks and numbers. Colors are critical when the screen is being photographed; light colors on dark backgrounds show up best (this is discussed in detail in my previous article in the January 1980 BYTE).

These subroutines can be used in many graphics applications. As written, they employ two-letter names as well as the variables X, Y, I, J, K, I\$, J\$, and K\$. This allows the user all the remaining single letters. If the user's program defines NUMBER (number of points) and fills ARRAY with the appropriate data, then the subroutines in listing 1 can be used to generate a graph. The graph will be labeled as well if the user defines the variables TITLE\$, LABEL\$(0), and LABEL\$(1).

The photographs used to illustrate this article have been created using a Compucolor II with 16 K bytes of user memory but without the Pincushion Correction Kit. The barrel distortion on the top and bottom can be reduced by using a telephoto lens, but the pincushion effect on each side will then be worse unless the correction kit is installed.

Next month, Part 2 of this article will use the subroutines given here to construct several other kinds of graphs: a different kind of equation-plotting routine, a histogram with the equivalent Gaussian (bell-shaped) curve superimposed, linear and other kinds of regression plotting, and a monthly analysis graph of more than one variable. ■

## Simple Base Conversions for the TRS-80

James M Curran, 24 Greendale Rd, Cedar Grove NJ 07009

I have noticed that decimal-to-hexadecimal and decimal-to-octal conversions are usually accomplished by means of subroutines, most of which require three to four statements. This is efficient enough for users of a low-level BASIC; however, computer enthusiasts with a BASIC interpreter containing the DEF FN (define function) command long for a simple one-statement conversion. Here are such conversion statements. For those of you who need to convert hexadecimal or octal to decimal, these conversions are also included. I have even thrown in a decimal-to-binary function.

**Listing 1: Definitions for five base-conversion functions.** The first statement defines the function for converting decimal to binary numbers. The second and third definitions give the functions for converting from decimal to hexadecimal and from hexadecimal to decimal numbers. Notice that the variable HXS must be initialized for both of these. The last two statements define the functions for converting from decimal to-octal and from octal to decimal numbers.

```

1. DEF FN DB#(D)=(D AND 1)+(D AND 2)*5+(D AND 4)*25+
  (D AND 8)*125+(D AND 16)*625+
  (D AND 32)*3125+(D AND 64)*15625+
  (D AND 128)*78125

2. HXS="0123456789ABCDEF"
  DEF FN DH$(D)=MIDS$(HXS,(D AND -4096)/4096+1-
  (D>32767)*16,1)+
  MIDS$(HXS,(D AND 3840)/255+1,1)+
  MIDS$(HXS,(D AND 240)/16+1,1)+
  MIDS$(HXS,(D AND 15)+1,1)

3. HXS="0123456789ABCDEF"
  DEF FN HSD(HS)=(INSTR(HXS,MIDS$(HS,1,1))-1)*4096+
  (INSTR(HXS,MIDS$(HS,2,1))-1)*256+
  (INSTR(HXS,MIDS$(HS,3,1))-1)*16+
  (INSTR(HXS,MIDS$(HS,4,1))-1)

4. DEF FN DO#(D)=(D AND 7)+(D AND 56)*1.25+
  (D AND 448)*1.5625+
  (D AND 3584)*1.953125+
  (D AND 28672)*2.44140625

5. DEF FN OSD(OS)=VAL(MIDS$(OS,1,1))*3276+
  VAL(MIDS$(OS,2,1))*4096+
  VAL(MIDS$(OS,3,1))*512+
  VAL(MIDS$(OS,4,1))*64+
  VAL(MIDS$(OS,5,1))*8+
  VAL(MIDS$(OS,6,1))
  
```

These functions can also be used as subroutines by those without the DEF FN command. An AND-statement is necessary, because it performs a logical-AND operation which is used in all three routines to convert decimal to the various other bases.

The first function, which I call FNDB#, returns the binary equivalent of the argument as an eight-digit integer.

The hexadecimal equivalent of the argument is returned by the second function, FNDH\$, as a four-character string with leading zeros. Arguments greater than 32767 (7FFF hexadecimal) must be signed; ie: reduced by 65536. For a 1-byte conversion, only the second half of the function is necessary.

My third function, called FNHSD, converts the argument, which must be a four-character string, into its decimal equivalent. In this function, the INSTR command is employed; if your BASIC does not have it, it is easily replaced with a BASIC subroutine. Its function is to return the position in the first string at which the second string begins. FNHSD can also be made into a 1-byte routine by using its second half. Both FNHSD and FNDH\$ require HXS to be initialized.

The final two functions for decimal-to-octal conversions (FNDO# and FNO\$D) work similarly to their hexadecimal counterparts. ■

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## TRS-80 Group in Manchester

The Manchester TRS-80 Users Group meets the first Sunday of each month at Raytheon Company, Island Pond Rd, in Manchester, New Hampshire. For information, contact Scott Mitchell, 346 S Taylor St, Manchester NH 03103, (603) 624-0089.

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# Three-Dimensional Graphics for the Apple II

---

Dan Sokol  
John Shepard  
211 Fall Creek Dr  
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---

Many articles have been written regarding three-dimensional graphics on home computers. Some involve highly complex hardware such as spinning mirrors, while others rely upon computation-intensive software to project three-dimensional objects on a two-dimensional plane.

Taking an innovative step backwards and rediscovering an old technique, I have been able to create three-dimensional pictures using my Apple II computer. I have generated a number of visually stimulating displays in this manner and would like to share with you the methods used, with the hope that you too will discover new ways to use your computer.

The method is simple. Just take a piece of cardboard, and with a pair of scissors, cut out a pair of eyeglass frames. Next, put a red filter over the left eye opening in the frame and a green filter over the right opening (I did say it was an old idea!). When viewing the screen with the glasses on, anything colored red will not be visible to your right eye, and anything green will not be visible to your left eye (you may have to adjust the tint on your television to optimize this). Anything white will be visible to both eyes.

The image that falls on the retina of your right eye will be the green image on the video monitor, but it will appear to be white! (It's all done in your brain.) The same is true of the red image in relation to your left eye. (We will refer to the red image in our software as violet. This is because the Apple HI-RES graphics cannot generate red.) [However, see "More Colors for Your Apple," by Allen Watson III, June 1979 BYTE, page 60...RSS]

## Creating an Image

As you can see by figures 1a and 1b, an image that seems to appear in front of the screen can be made by drawing the green image to the left of the red one. An image that appears behind the screen is simulated by placing the green image to the right of the red one. The apparent depth is determined by the distance between the two colored images.

It should be mentioned that the brain requires a frame of reference to judge distance "properly." An efficient way to provide this reference is to put a white border around the screen. This will define the *neutral plane*. Naturally, any objects on this plane need be drawn only once in white.

The program in listing 1 generates a set of lines which appear to disappear into the distance.

Another simple program is presented in listing 2. This one generates a three-dimensional box.

Using the shape-generator programs provided by Apple, the user can make objects appear to be various sizes and depths. This effect can be seen by running the program in listing 3.

You can place as many objects in space as you have room for. There are, however, some guidelines.

- You should draw your images from *back to front*. This way any overwriting will look natural.
- As you approach the neutral plane, the two images get closer together. Any place that they are coincident should be white. This can be handled with software. (I didn't say easily.)
- Using other colors generates an unbalanced image in the neutral plane—you experiment.
- You will have to adjust your color television set to match the color of the filters that are being used. The best way to do this is to draw a small green square and a small red square on the screen. Then place a

*Text continued on page 154*

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**Listing 1:** *This Apple integer BASIC program generates three-dimensional lines disappearing into infinity.*

```
0 XO=YO=COLR=SHAPE=ROT=SCALE
5 INIT=2048: CLEAR=2062: PLOT=2830: LINE=2836: DRAW=2871: XDRAW=2884
10 BLACK=0: WHITE=127: VIOLET=85: LET GREEN=42
100 CALL INIT: POKE -16302,0:
150 REM BUILD THE BORDER
200 COLR=WHITE:XO=0:YO=0: CALL PLOT:XO=279: CALL LINE:YO=191: CALL LINE:XO=0: CALL LINE:YO=0: CALL LINE
205 XO=1:YO=1: CALL PLOT:XO=278: CALL LINE:YO=190: CALL LINE:XO=1: CALL LINE:YO=1: CALL LINE
250 REM
251 REM
252 REM
500 REM LINES TO INFINITY
510 COLR=VIOLET:XO=25:YO=180: CALL PLOT:XO=260:YO=20: CALL LINE:XO=70:YO=180: CALL LINE
520 COLR=GREEN:XO=60: CALL PLOT:XO=270:YO=20: CALL LINE:XO=10:YO=180: CALL LINE
550 END
```

**Listing 2:** *An Apple integer BASIC program for generating a three-dimensional box.*

```
0 XO=YO=COLR=SHAPE=ROT=SCALE
5 INIT=2048: CLEAR=2062: PLOT=2830: LINE=2836: DRAW=2871: XDRAW=2884
10 BLACK=0: WHITE=127: VIOLET=85: LET GREEN=42
100 CALL INIT: POKE -16302,0:
150 REM BUILD THE BORDER
200 COLR=WHITE:XO=0:YO=0: CALL PLOT:XO=279: CALL LINE:YO=191: CALL LINE:XO=0: CALL LINE:YO=0: CALL LINE
205 XO=1:YO=1: CALL PLOT:XO=278: CALL LINE:YO=190: CALL LINE:XO=1: CALL LINE:YO=1: CALL LINE
600 REM
601 REM
602 REM
603 REM A BOX...
610 COLR=WHITE:XO=150:YO=50: CALL PLOT:XO=250: CALL LINE:YO=150: CALL LINE:XO=150: CALL LINE:YO=50: CALL LINE
615 COLR=GREEN:YO=75:XO=40: CALL LINE
620 XO=140: CALL LINE:XO=250:YO=50: CALL LINE
622 XO=250:YO=150: CALL PLOT
625 XO=140:YO=175: CALL LINE:XO=40: CALL LINE:XO=150:YO=150: CALL LINE:XO=40:YO=175: CALL PLOT
630 YO=75: CALL LINE:XO=140: CALL PLOT:YO=175: CALL LINE
635 XO=41:YO=75: CALL PLOT:YO=175: CALL LINE:XO=141: CALL PLOT:YO=75: CALL LINE
637 COLR=VIOLET
640 XO=30:YO=185: CALL PLOT:YO=85: CALL LINE:XO=130: CALL LINE:YO=185: CALL LINE
642 XO=250:YO=150: CALL LINE
645 XO=130:YO=185: CALL PLOT:XO=30: CALL LINE
650 XO=150:YO=150: CALL LINE:XO=30:YO=85: CALL PLOT:XO=150:YO=50: CALL LINE
660 XO=130:YO=85: CALL PLOT:XO=250:YO=50: CALL LINE
680 END
```

**Listing 3:** *This program uses the shape stored in the Apple II shape table and transforms it into three-dimensional form.*

```
0 XO=YO=COLR=SHAPE=ROT=SCALE
5 INIT=2048: CLEAR=2062: PLOT=2830: LINE=2836: DRAW=2871: XDRAW=2884
10 BLACK=0: WHITE=127: VIOLET=85: LET GREEN=42
100 CALL INIT: POKE -16302,0:
150 REM BUILD THE BORDER
200 COLR=WHITE:XO=0:YO=0: CALL PLOT:XO=279: CALL LINE:YO=191: CALL LINE:XO=0: CALL LINE:YO=0: CALL LINE
205 XO=1:YO=1: CALL PLOT:XO=278: CALL LINE:YO=190: CALL LINE:XO=1: CALL LINE:YO=1: CALL LINE
250 REM
700 REM
701 REM
710 REM
800 REM 3-D SQUARES
801 REM USE SHAPE #1
802 REM SHAPE #1 = 01 01 24 3F 3F 36 36 2D 2D 24 00
805 ROT=0: SCALE=1: SHAPE=1: XO=5: YO=5
810 FOR I=1 TO 7: SCALE=I: COLR=GREEN: XO=XO+(I*4): YO=YO+(I*4)
820 CALL XDRAW: COLR=VIOLET: XO=XO+1: YO=YO+1: CALL XDRAW: NEXT I
830 XO=XO+32: YO=90: COLR=GREEN: SCALE=SCALE+2: CALL XDRAW: COLR=VIOLET: YO=YO+8: XO=XO+8: CALL XDRAW
840 XO=XO+42: YO=YO-42: COLR=GREEN: SCALE=SCALE+2: CALL XDRAW: COLR=VIOLET: YO=YO+9: XO=XO+9: CALL XDRAW
999 END
```

#### **Editor's Note:**

#### **Some Comments on the Programs**

The three programs in this article assume that the high-resolution graphics routines have been loaded into the Apple II starting at hexadecimal location C00. The instruction LOMEM:4096 should be executed before loading the programs to protect these routines.

When I was typing these pro-

grams into the Apple, I noticed that line 10 of each listing has the statement LET GREEN = 42. At the time I could not understand why the LET keyword was used, so I deleted it. Several syntax errors later I realized the answer.

When "GREEN = 42" is parsed by the BASIC interpreter, the token GR (for graphics mode) is recognized. The rest of the line (EEN = 42) is then unrecognizable

to the parser. When "LET GREEN = 42" is analyzed, the keyword LET tells the parser that the next token will be a variable. Therefore, GREEN is not broken into two tokens (GR and EEN).

This little trick could prove very useful when you wish to use a variable name which contains a keyword.



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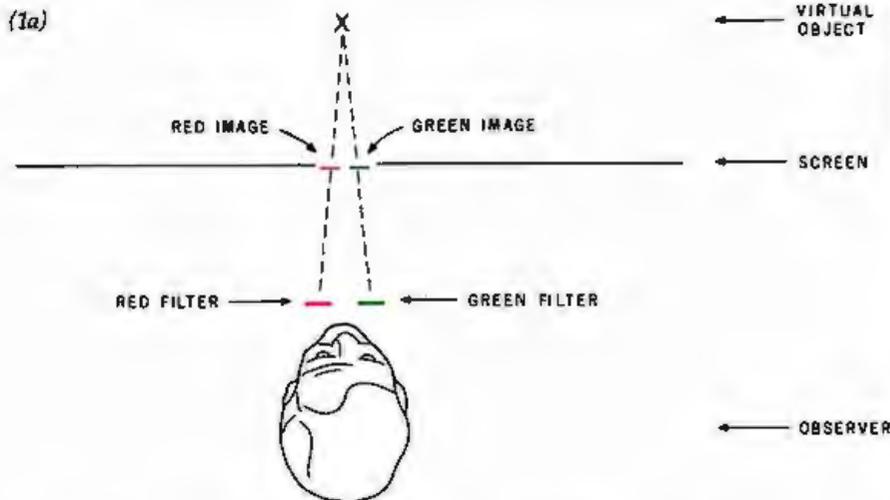
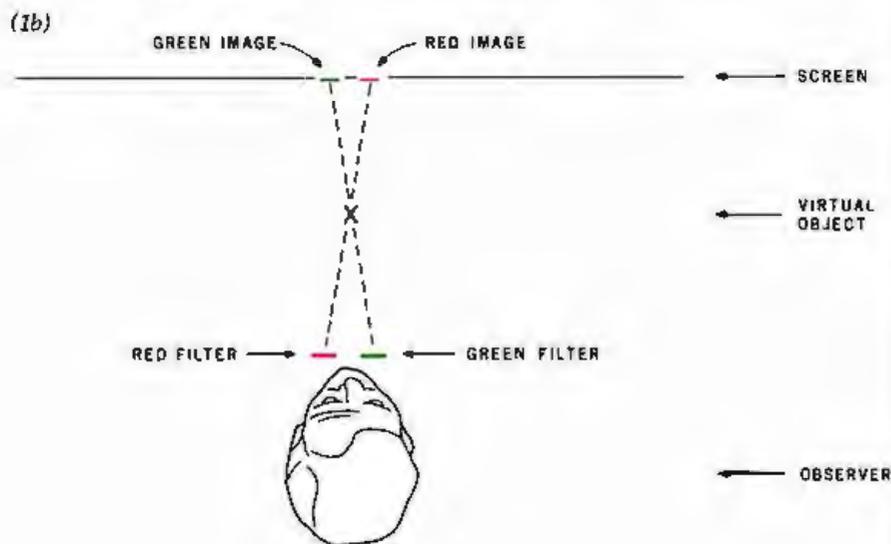


Figure 1: A figure which appears to be behind the video screen can be produced by drawing the red image on the left side of the screen and the green image on the right side (see figure 1a). By reversing these two images, the image will appear to be in front of the video screen (see figure 1b).



Text continued from page 148:

piece of the green filter over the red square and a piece of the red filter over the green square. Adjust the tint, chrominance (if you have one), and color knobs so that both squares disappear (as much as possible...you may have to double up the filters).

- If you aren't worried about using your color television for other entertainment, you can make the following adjustments to it. On the back of the set are three controls that are (usually) labeled red, green, and blue (or R, G, B; or red screen, blue screen, green screen). These adjust the relative intensity of the three electron guns. If you first mark the initial positions of the three controls with a pencil,

you will be able to reset them when you are finished. The adjustment is simple. Turn the blue screen off! This removes all the blue dots from the screen, only red and green remain. After adjusting the television as described in the previous step, reverse the positions of the filters (red over red, green over green) and adjust the red screen so that the intensity of the two squares through the filters appears the same.

- We used colored cellophane, available at most art supply stores, for filters.

There are a number of games that can be adapted to three-dimensional displays with this technique. Have fun! ■

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**KBASIC**—Microsoft Disk Extended BASIC version 4.51 integrated with KISS Multi-Keyed Index Sequential and Direct Access file management as 5 additional BASIC commands. KISS included as relocatable modules linkable to FORTRAN-80, COBOL-80, and BASIC COMPILER. Specify CP/M version 1.4 or 2.x when ordering. Requires 48K CP/M. **\$585/\$45** to licensed users of Microsoft BASIC-80 (MBASIC). **\$435/\$45**

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**STRING/80**—Character string handling plus routines for direct CP/M BIOS calls from FORTRAN and other compatible Microsoft languages. The utility library contains routines that enable programs to chain to a COM file, retrieve command line parameters and search file directories with full wild card facilities. Supplied as linkable modules in Microsoft format. **\$95/\$20**

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## The Altos ACS8000 Single-Board Computer

Mark Dahmke  
1515 Superior St, Apt 15  
Lincoln NE 68521

Altos Computer Systems of San Jose, California, manufactures a series of powerful Z80-based computers aimed mainly at the small-business and scientific-laboratory markets. The company offers a wide variety of models — from one 8-inch, single-density, Shugart floppy-disk drive with 32 K bytes of main memory to four double-density, 8-inch floppy-disk drives, and a hard-disk subsystem with as much as 58 megabytes of on-line storage.

### Hardware Design

The ACS8000 series are all single-circuit-card computers based on a Z80A microprocessor running at 4 MHz. All systems come with at least 32 K bytes of 4116 dynamic memory devices. This is expandable to 64 K bytes on two versions of the ACS8000, and to 208 K bytes on the third version.

The system also comes with a 2708 EPROM (erasable programmable read-only memory) that contains the ALTOS-E monitor program. The 2708 is active until CP/M is boot-loaded: it is then disabled and disappears so the entire memory-address space is available as programmable memory. This technique is widely used and is referred to as "phantom read-only memory."

### About the Author

Mark Dahmke is a consulting editor for BYTE Publications and also operates a computer consulting business. He has been involved with computers since 1974 and does a great deal of systems hardware and software design. His interests include writing, photography, voice synthesis, and computer graphics.

### Serial Ports

Even the smallest Altos system comes with a dual-channel, serial I/O (input/output) device. One channel is used for the system console, and the other is set up to drive a printer or another device, such as a modem. The console channel is preset by the ALTOS-E monitor firmware to 9600 bps, with 1 start bit, 1 stop bit, 8 data bits, and no parity. It runs in full-duplex (ie: simultaneous-bidirectional) mode. The 9600 bps data rate of the console is not alterable, but the printer characteristics can be changed after the system is booted up.

### Parallel Ports

All Altos computers come with at least two user-defined parallel ports. There are actually two Z80 PIO (parallel input/output) devices, each with two ports, but one is used to

control disk operations. The user-definable ports are accessible through an external connector that may be connected to a printer, an EPROM programmer, or a parallel-input keyboard. Both ports are fully programmable.

### The Counter-Timer Circuit

The Z80 CTC (counter-timer circuit) is a programmable counter-timer that has four independent channels. Three of the channels (addresses 0 thru 2) are used by the system to set console and printer data rates and disk-head load-delay times. The fourth channel is available to the user and can be programmed as an interval timer or real-time clock.

### The Floppy-Disk Controller

The Altos single-density model uses the Western Digital 1771-1

### A Visit to Altos

Altos computers have acquired quite a reputation for reliability — it's the sort of thing you hear by word-of-mouth in this industry. To find out more, I paid a visit to Altos recently at the invitation of Dr Roger Vass, the Vice-President of Marketing.

Roger described the extensive quality-control procedures used at Altos, which include several burn-in tests of individual components and complete systems in its testing ovens. Another reason for the low failure rate of the computers (eg: less than 1% are returned to the plant because of

defects) is that Altos computers use a single printed-circuit board for the entire computer, thus eliminating many potential inter-connection problems.

Interestingly, Altos sells more computers (ie: about 55% at present) overseas than it does domestically, due in part to the company's vigorous marketing activity in Europe. Roger sees the European market as having great potential for American personal-computer companies. Certainly, the growth of the number of publications and public interest at overseas trade shows confirms this. . .CM

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Photo 1: Front view of the Altos ACS 8000-2 computer, which has 64 K bytes of memory and two dual-density, single-sided disk drives.

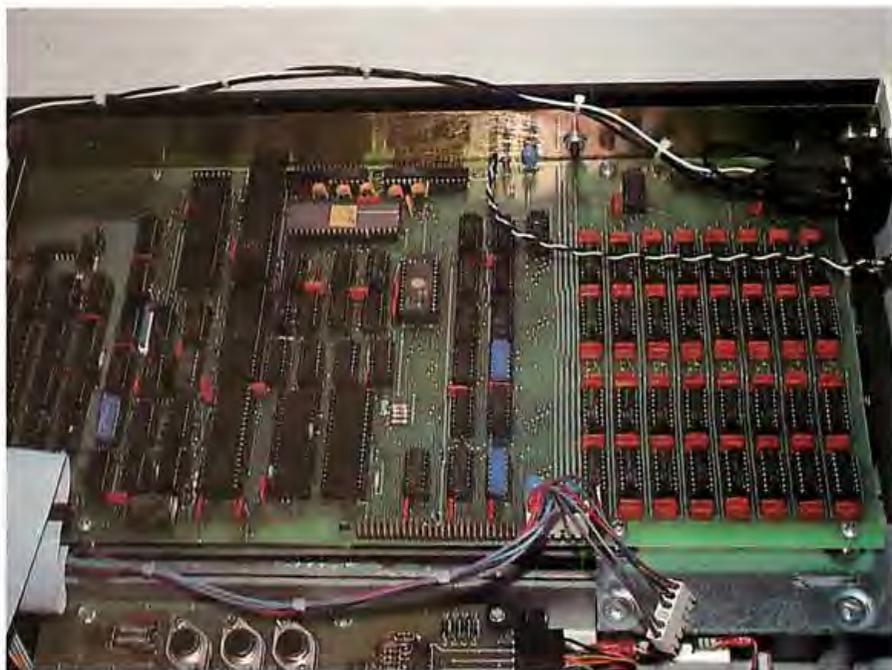


Photo 2: Interior view of the ACS 8000-2, which is, as are all the Altos models, a single-board, Z80-based computer.

floppy-disk controller/formatter device to manage up to four 8-inch drives. The 1771-1 is directly integrated into the single-board design of the Altos.

The double-density version requires some additional control circuitry and uses the 1791-1 device;

thus the board supporting double-density disks is slightly larger. All versions of the ACS8000 are available with either single-sided or double-sided Shugart drives.

All boards have a fifty-pin expansion connector that allows the user to access all Z80 address, data, and con-

Whatever happened to eenie, meenie, miney, mo?

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This may put the Godfather out of business.

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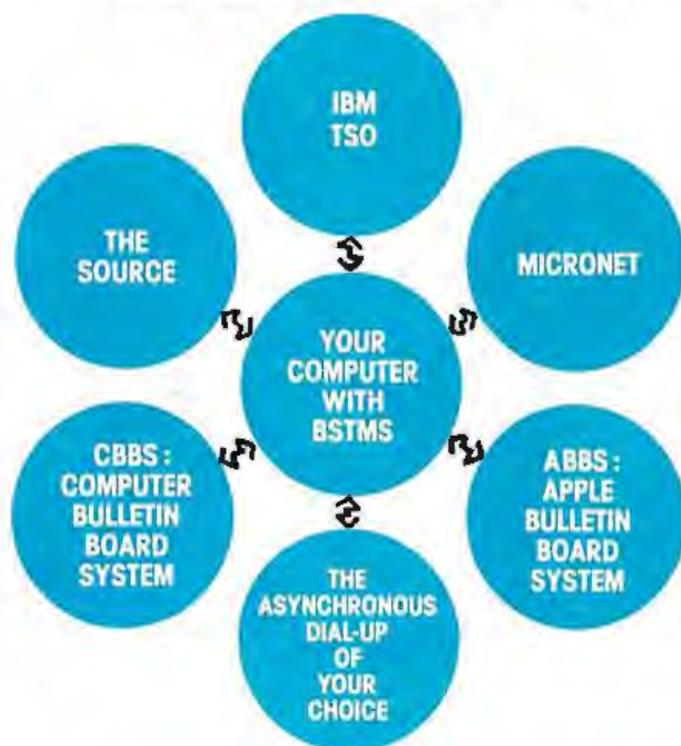
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trol lines. Altos does not use the connector for expansion purposes because of its single-board philosophy, but it is there for the special needs of the users.

### Optional Components

The ACS8000 has provisions for some special components that are optional on all of the standard systems. The Z80 DMA (direct memory access) controller is a very sophisticated device that can be programmed to perform block data transfers from memory to memory, from memory to an I/O port, or vice versa. The device can also be programmed to search for a byte within a block, with or without transfer of the block. The device has one DMA channel that can be set up to work in four different modes:

- single-byte mode — in which each memory access operates on a single byte of data
- burst mode — in which the device keeps control of the bus for as long as data is continuously ready
- continuous mode — in which the device retains bus control for the entire operation
- transparent mode — in which the device operates only during memory refresh time so it does not slow down the processor

I was informed by Altos that, although the Z80 DMA device can be plugged into the system, there is no way to use it under CP/M. The OASIS multiuser operating system is set up to use DMA to access a disk, however.

The Advanced Micro Devices Am9511 arithmetic processor is another optional device that provides fixed and floating-point arithmetic and floating-point trigonometric and mathematical operations. It may be used to speed up computational capabilities of the system. All commands and data transfers take place on an 8-bit, bidirectional data bus. Transfers to and from the 9511 may be handled by the Z80 under program control (with IN and OUT instructions) or through the Z80 DMA device. The Am9511 can be programmed to generate interrupts upon completion of arithmetic functions.

Altos also plans to introduce a 2708/2716 EPROM programmer that will plug into the parallel-port con-

*Text continued on page 166*

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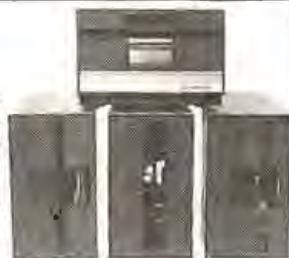
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## CP/M Features With Altos Systems

All the standard CP/M system utilities are available:

- **ED:** context (text) editor.
- **ASM:** CP/M standard (no-frills) 8080 assembler.
- **LOAD:** loader, converts hexadecimal-ASCII format files to absolute machine-code files.
- **DDT:** CP/M Dynamic Debugging Tool.
- **PIP:** Peripheral Interchange Program that is used to move and copy disk files from disk to disk and can also be used to copy files from disk to printer or from a reader device to disk.
- **SYSGEN:** CP/M utility that generates new system disks.
- **DUMP:** prints the contents of a file on the display in hexadecimal (base 16) form.
- **SUBMIT:** CP/M batch facility: executes a series of console commands from a disk file.

Some additional commands and utilities are available:

- **MOVCPM:** CP/M utility that is used to relocate the CP/M operating system depending on system memory size.
- **STAT:** displays status of various device assignments and shows the amount of free space left on each on-line.
- **MTS:** memory-test program that performs a destructive memory test on system memory.
- **SETUP:** utility that modifies the boot-load sector of a disk. It also allows a disk to be flagged for single- or double-density operation and sets the printer data rate at boot-load time.
- **REFORM:** disk-formatting utility that allows the user to format a disk for single- or double-density operation. Disks may be formatted to be either IBM 3740-compatible or Intel ISIS-II format. Altos has its own format for double density.
- **DTEST:** disk-test utility that checks out both drives and disks on the system.
- **SINGLE:** followed by the letter designation of a drive (A, B, C, D), will set up the drive for

single-density operation.

- **DOUBLE:** works the same as **SINGLE** but sets the designated drive for double-density operation.
- **COPY:** will copy data track by track from the disk in drive A to drive B.
- **FILES:** will display the file-control-block information in hexadecimal for all files on a disk.

Other files are included with the system:

- **BOOT.ASM:** an assembler source for the boot loader.
- **ALTOSE.ASM:** an assembler source for the ALTOS-E 2708 EPROM.
- **CBIOS.ASM:** an assembler source for the custom Basic Input/Output System (CBIOS) in CP/M. This allows the user to make further operating-system modifications as needed.

## UCSD Pascal Operating System

### Initializing the System

In order to make UCSD (University of California, San Diego) Pascal fully operational on the Altos, a user-written procedure that does direct cursor addressing on video terminals must be added to the operating system. Referred to as **GOTOXY**, the procedure accepts two integer variables as input and positions the cursor on the screen accordingly. Since there are so many different video terminals, it is the responsibility of the user to write the **GOTOXY** procedure. After compiling it, the user must execute a program called **BINDER** which links **GOTOXY** to the **SYSTEM.PASCAL** file.

The other initialization program is called **SETUP**. When executed, the user is given a set of options including **Help** and **Teach**. **SETUP** modifies a table of key assignments and terminal commands, allowing the user to customize the operating system to a particular terminal. Most keys may also have a prefix (eg: **Escape**) to allow for terminals that send escape sequences for certain user-definable keys. For example, many terminals have a separate keypad for cursor control

(eg: **Up**, **Down**, **Home**, etc). The escape sequence for "cursor home" on many terminals is **Escape-H**; or 27,72 in decimal ASCII codes. In **SETUP**, the cursor-home function could be defined as having a prefix code and the decimal value 72 (or **H** as the character code).

### Other Features

The Pascal Operating System has some other unique features. When compiling a program, Pascal will list error messages and ask if you want to continue or return to the editor. If the latter option is chosen, the operating system loads the editor and places the cursor on the character where the compilation error was detected. This feature saves a great deal of time when correcting syntax and logic errors.

The Filer also has some interesting features. Basically, the Filer is a utility program that lists directories of disks and manipulates files directly in the conventional disk-operating-system mode. On request, the Filer will create a duplicate directory for backup purposes. The Filer also has a routine for locating bad blocks on disk. If a bad sector is found, it will be marked as an immovable file in the directory.

Altos is marketing Pascal/M and a C compiler. The firm is also in the process of providing hard-disk backup on cartridge tape. The company is also introducing an asynchronous communications package for Altos computers (price: \$100) and a bisynchronous IBM 3780 protocol package that allows the Altos to go on line in batch mode to an IBM host computer. The price is \$1000.

In version II.0 of Pascal, the Debugger package is missing. I was informed by Altos that it was having problems with it and that a new version would be available with the next release. Altos also said that Pascal/M does have a full Debug option and that it will be available shortly.

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Text continued from page 162

necter. This project has been delayed because of software development priorities.

### Hard-Disk Capability

Altos' third single-board version of the ACS8000 has an on-board hard-disk controller in addition to the floppy-disk controller. Hard-disk storage may start at 14.5 megabytes and can be expanded up to 58 megabytes.

### Multiuser Versions

The system that I received was an ACS8000-2 with 64 K bytes of memory and two dual-density, single-sided floppy-disk drives. As described in the literature, the ACS8000-2/MU2 is a two-user system with 112 K bytes of memory and two double-density single-sided drives.

Memory is divided into banks, with a 16 K-byte system area and two or more 48 K-byte user areas. A four-user ACS8000-2/MU4 is the same as an MU2 but with 208 K bytes of memory. The largest non-hard-disk configuration would be an ACS8000-

## All Altos systems run either CP/M or Altos multiuser executive AMEX.

4/MU4 with 208 K bytes of memory for four users and four double-density, double-sided floppy-disk drives.

The smallest hard-disk multiuser configuration would be an ACS8000-6/MU2 with 112 K bytes of memory, two double-density, single-sided drives and a one-platter hard disk yielding 14.5 megabytes of space. This system would have four serial I/O ports and two parallel ports.

The largest configuration would be an ACS8000-9/MU4 with 208 K bytes for four users, four double-density, double-sided floppy-disk drives and 58 megabytes of hard-disk space. A total of six serial ports and two parallel ports would be available on the system; these can be used to support four terminals and two other peripherals.

### Software

All Altos systems run either Digital Research's CP/M operating system or Altos multiuser executive AMEX. AMEX is functionally compatible with CP/M, using the same disk formats and operating-system conventions. If you plan to use a hard disk, AMEX is a necessity since straight CP/M supports only floppy disks. CP/M version 2.0, which directly supports hard disks, and MP/M, the multiprogramming version of CP/M, are also available.

### Optional Software

The Altos CP/M has been customized to allow for printout *spooling* and *despooling*. In this process, printed material is stored on disk until the printer is free. This option allows printers to be driven in the background mode so that printing may go on while the computer is doing something else.

Another software option is for use with the Microsoft FORTRAN-80 compiler. A FORTRAN service-subroutine library called APULIB makes use of the Am9511 floating-point processor to speed up arithmetic computations in FORTRAN by a factor of 10 or more. A typical FORTRAN program performing extensive calculations could run about four times faster with APULIB.

The other major software option is the UCSD Pascal operating system. Altos offers it as a separate and distinct operating system for the ACS8000. This operating system consists of a file manager, an editor, a Pascal compiler, a BASIC compiler, a macroassembler for the Z80, an interactive debugger, and a linker/librarian. UCSD (University of California, San Diego) Pascal runs as a P-machine interpreter. All portions of the operating system and some other run-time subroutines are written in Pascal, with the exception of portions of the P-machine interpreter. Pascal is also patched to handle the Am9511 arithmetic processor for greater computational speed. The Z80 CTC is also set up to act like a real-time clock. Unfortunately, the real-time clock is not accessible by the user; it is used internally to improve the performance of the disk interface.

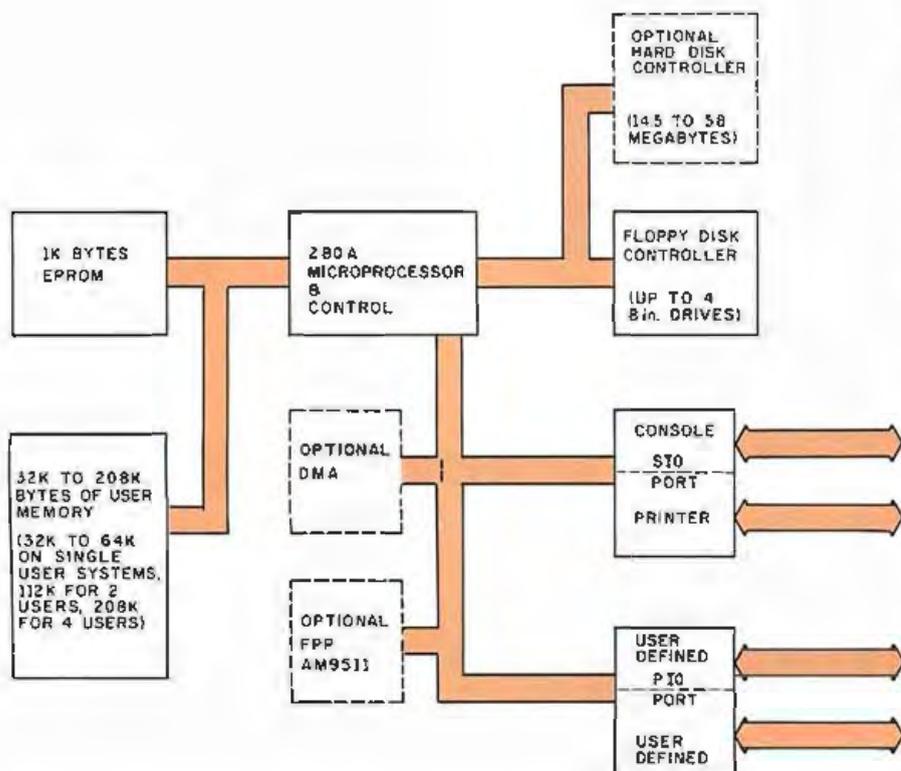


Figure 1: Block diagram of the Altos ACS8000 systems.

### Altos Documentation

The manual shipped with the Altos consists of the following segments:



## Beautiful "Computer Chess" Reproduction—only \$7.95!

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- an operating manual which contains a hardware and software overview section
- setup and checkout guides
- a CP/M operating guide
- a troubleshooting section
- all the schematic diagrams

The manual also includes the SA800/801 disk-drive maintenance manual and six publications from Digital Research covering all aspects of CP/M.

### Setting Up and Using a New System

My Altos is hooked up to a video terminal set to 9600 bps. When power is applied, the Altos displays the two prompt characters %\* on the console, which means that the EPROM monitor is in control. (If reset is depressed, the same response is given.) If a floppy disk is inserted into drive A (the drive on the right-hand side) and reset is depressed, the monitor will automatically begin loading the operating system from the disk. If you are running CP/M, the message "32 K ALTOS DOS VERS 1.47" will be displayed, followed by A> on the next line. The A character means that the disk in drive A is the currently active disk, while the > indicates that CP/M is ready to receive commands.

After the machine displayed the A> prompt, I tried to enter the DIR

command to display the directory, with no success. I reset the system and tried again — still nothing. Then I decided to check the RS-232 cable and connectors to see if the transmit and receive lines were hooked up properly. After experimenting with my own 8080-based system to make sure the terminal would talk to it and still finding no problems, I called Altos: the gentleman I spoke with suggested that I make sure that pin 20 (Data Terminal Ready) of the RS-232 cable was hooked up. I took apart my cable and found that pin 20 was not connected. A quick resoldering job solved the problem. (I later discovered that the Altos manual discusses the problem in the section on troubleshooting, but I had apparently not seen it on my first reading of the manual.)

One of my complaints about the Altos is that the console data rate is defined in firmware — in the EPROM. The system can be used only if you have a 9600 bps terminal (at least, to start with). Even after the initial load, there is no way to easily modify the data rate short of creating a new EPROM.

CP/M has a SETUP command that allows the user to change the boot-load characteristics of a disk. The printer data rate, the system clock rate (2 MHz or 4 MHz), and the density of the disk may be redefined for each system disk. It would seem

reasonable to be able to modify the console data rate also, but this is not currently the case.

### Formatting Disks

The next thing I tried to do was to create a backup copy of the master system disk. The documentation for this procedure is fairly accurate, but important instructions are left out.

The first step is to insert a blank disk (with the label side facing down) into drive B, the left-hand drive. The REFORM command will reformat a disk for any of several disk formats. After typing in REFORM, the computer asks you to enter a number corresponding to the type of format that will be used and to indicate whether the blank disk is in drive B (in a two-drive system) or drive D (in a four-drive system).

The first time I tried to format a disk, I got errors on top of errors. The documentation failed to mention that the write protect notch on the disk must be covered to allow read/write operation. Since I usually work with 5-inch floppy disks, I am used to covering the write protect notch to protect a disk, not to unprotect it. After trying everything I could think of, it finally occurred to me that the notch might need to be covered to work. [This method of disk protection is standard for 8-inch disks, so neither Altos nor its documentation is in error here. Still, this situation

#### At a Glance

Name of computer	Altos ACS8000 series	Software included	ALTOS-E monitor (in read-only memory)
Manufacturer	Altos Computer Systems 2360 Bering Dr San Jose CA 95131 (408) 946-6700	Hardware options	an 9511 arithmetic-processor board; Winchester hard disk; multiple users
Price	from \$2840 (ACS8000-1S)	Software options	Operating systems: AMEX, CP/M, MP/M, OASIS, UCSD Pascal.
Processor	Z80A (8-bit)	Languages	FORTRAN-80; MBASIC, MBASIC-80, CBASIC II; COBOL-80, CIS COBOL; Vanguard APL, PL/I-80, Z80 Macro Assembler
Memory	64 K bytes (expandable to 208 K bytes on a multiuser system)		
Mass Storage	one to four 8-inch, single- or double-density, single- or double-sided, Shugart floppy-disk drives		
Other hardware features	includes serial printer port, two user-definable parallel ports		

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always causes problems for people who are accustomed to working with 5-inch floppy disks. . . .GW]

### Altos Demonstration Programs

The CP/M disk that came with the system had a number of demonstration programs, including a biorhythm program in BASIC, a rather poor implementation of tic-tac-toe, a number-guessing game, and a program that did nothing but compute and print square roots. The business package demonstration programs included a payroll generator and an automobile parts-list/inventory program.

The only documentation provided with any of these business demo programs was a single typed page giving

hopelessly inadequate operating instructions. I never succeeded in making any of the nongame programs work.

### Final Remarks

●The hardware of the Altos ACS8000 is well designed, although the documentation of some of its components is absent. The computer uses several sophisticated, optional support chips such as the counter-timer, the serial and parallel ports, and the Am9511 arithmetic processor. However I had to look over the manufacturers' specification sheets and application notes to find out anything about them.

●The software of the Altos ACS8000 is not as well supported, but the

CP/M, AMEX, UCSD Pascal, and OASIS operating systems are available. Altos has provided no software support for the specialized hardware built into the system.

●Languages available from Altos include FORTRAN-80, MBASIC, MBASIC-80, CBASIC II, COBOL-80, CIS COBOL, Vanguard APL, PL/I-80, and Z80 Macro Assembler. Numerous other languages are available from other sources for use with the CP/M operating system.

●The Altos ACS8000 is strong on hardware and weak on software and documentation. Perhaps someday the Altos people will get around to documenting and supporting the best selling points of their product line. ■

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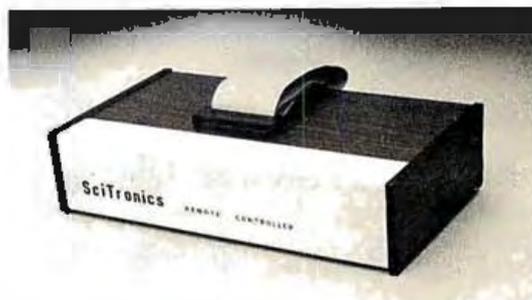
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1515 Superior, Apt 15  
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The Association for Computing Machinery (ACM) Special Interest Group on Computer Graphics (SIGGRAPH) held its seventh annual conference on July 14 thru 18, at the Seattle (Washington) Center (former site of the Seattle World's Fair). This conference, like all of the recent SIGGRAPH conferences, was extremely well attended. Over 1200 people registered for the two-day preconference tutorials. More than 2300 people registered for the three-day conference itself. Participants came from nearly every state, Canada, several European countries, and Japan.

## Preconference Tutorials

Each year, the conference organizers have sought to provide participants with an opportunity to not only attend the conference, but also to acquire additional information and expertise about graphics through a series of tutorial sessions. These are led by well-known computing and graphics professionals from both industry and education. This year's eight tutorial sessions included these topics:

- Introduction to Computer Graphics
- Introduction to Raster Graphics
- Advanced Raster Graphics
- Computer-Aided Design
- Low-Cost Graphics
- Graphic Design and Information Graphics
- Animation Graphics
- User Interfaces to Graphic Systems

These tutorials ranged in level of expertise from novice to expert and provided a means for everyone to advance technically.

The session on low-cost computer graphics addressed issues relating to the use of graphics capabilities of personal-computing hardware. Many of these systems can be configured at costs of about \$2000. Given today's economy, systems in this price range can be very appealing to small businesses, public-school systems, and small

colleges and universities. At the other end of the scale are large CAD/CAM (Computer-Aided Design/Computer-Aided Manufacturing) systems. Typically, these systems are quite expensive, ranging from \$40,000 to \$300,000 for top-of-the-line systems. Obviously, smaller and less expensive (and, therefore, less comprehensive and versatile) systems exist. The computer-aided design tutorial addressed the needs of medium- and large-scale industry users of CAD/CAM systems.

Included in this session were discussions of CAD/CAM standards for data bases and techniques used for geometric modeling. Geometric modeling is a term used to describe the process of representing a three-dimensional object by a series of Cartesian, polar, or homogeneous coordinates with (or without) a series of equations. The object may or may not exist prior to the construction of the numerical or geometric model.

Three other tutorials on raster graphics and animation were oriented toward the use of raster-scan devices. Because raster-scan devices essentially use standard television technology, there is a significant price and performance advantage in their use. Personal-computer owners should be aware of this advantage, as many microcomputer systems have utilized raster-scan (television) technology from the beginning. Discussions of algorithms for modeling three-dimensional objects, simulation of light sources (shading and shadows), surface textures, and display optimization dominated these sessions. An emphasis was placed on the creation of realistic-looking images.

Another group of tutorials centered on what might be termed *human factors* in computer graphics. Human factors means the interface between human beings and machines. It is an area of computing in general that, while not being totally overlooked, has certainly been slighted. Those of us involved in interactive computing (including graphics) realized long ago, by necessity, how important a friendly, forgiving, and possibly even *natural* interface is for successful communication between people and machines. The frustration of having an interactive program bomb or hang before completing its task can be overwhelming.

Our batch-oriented colleagues have discovered this recently, primarily because on-line data bases are becoming more popular, and more batch-oriented computing professionals are finding their way into interactive projects. Recently, we have begun to discover the importance of aesthetically pleasing and more understandable graphic output. Many computer-graphics specialists have come into this area from the technical side, rather than from the artistic side. It should come as no surprise, then, that graphic designers can offer much sound advice about graphics layout and design. This information can be very valuable in businesses where executives are accustomed to expecting and demanding professional quality for graphics presented at board meetings and in annual reports. Two tutorials concentrated on psychological aspects, design methodologies, subjective evaluation, and design concepts as they relate to computer-graphics systems.

All of the tutorials were well attended. Although we were unable to attend all of them (they ran concurrently), those sessions we attended were well thought out and carefully presented.

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Photos 1 thru 6 by Kenneth Livingston.

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## The Conference

In an attempt to emphasize the importance of graphic-design concepts and the human-factors side of computer graphics, the first session was a special panel presentation chaired by Aaron Marcus, research consultant at Lawrence Livermore Laboratories. This panel featured graphic designers from the United States and Europe. They agreed that we have seen far too many examples of poorly designed graphics—especially computer-generated graphics. Anyone engaging in computer graphics would do well to obtain and read some good textbooks on graphic design, in addition to their computer-graphics texts. While a chart or graph is more understandable than a table of numbers, a well-designed chart or graph is more readable than one which has had no design principles applied to its creation.

The remainder of Wednesday's sessions were split into two concurrent sessions. Papers presented in one group of sessions were quite technical in nature: "The Theory, Design, Implementation and Evaluation of a Three-Dimensional Surface Detection Algorithm" and "Simulation and Expected Performance Analysis of Multiple Processor Z-Buffer Systems." Papers presented in the other group of sessions were more applications-oriented: "Geographic and Data Base Systems" and "Computer Graphics Moves into the Business World."

The latter area is of specific interest to one of us (Livingston), who is currently involved in the integration of computer graphics and market research. According to Carl Machover of Machover Associates, who chaired the business-graphics panel discussion, there are four computers used in business applications for every computer used in CAD/CAM types of applications. Assuming that these figures are accurate, the business-computer graphics potential is enormous. This position is supported by IBM's recent entry into the low-cost, color, business-graphics marketplace with its Model 3279 display terminal. Recent articles in *Harvard Business Review* (January 1980) and the *Wall Street Journal* also seem to reinforce this position.

Thursday's sessions embraced a wide variety of topics. Sessions dedicated to graphics software and languages, surfaces, and applications filled the morning. Papers were presented at these sessions ranging from the design of a LISP-based graphics language, to three-dimensional representation and rendering algorithms, and to stereographic displays of atmospheric data. (This latter session proved to be very interesting to us for reasons having little to do with computer graphics. The materials chosen for displays represented conditions existing in the Omaha, Nebraska, area—sixty miles away from our homes—when the 1975 tornado struck that area.)

Thursday-afternoon sessions were oriented toward rather specialized areas of computer graphics:

- Computer Graphics and Television
- Animation
- CAD/CAM
- User Views of CAD/CAM

Recent uses of computer graphics in television were discussed, including a presentation by ABC Sports on their use during the Winter Olympics. The CAD/CAM sessions included reports on graphics used in planning electrical-distribution systems, ship-hull design, and graphics at the Ford Motor Company. There was also a panel discussion addressing productivity gains and expecta-

tations achieved through the use of CAD/CAM systems.

Friday's sessions included discussions of graphics standards, human factors (more), and raster techniques. The question of graphics standards is of particular importance to those who regularly attempt to transport graphics programs or systems from one computing environment to another. While other areas of computing developed standards long ago (eg: COBOL, FORTRAN, Pascal, etc), the graphics area had not attempted such a feat until quite recently. This has all begun to change, thanks to the work of the SIGGRAPH CORE standards committee.

The human-factors presentations included discussions on color and how it is perceived by the human eye, and on a prototype voice- and gesture-input interface being developed at MIT. An afternoon session on raster-graphics techniques completed the conference program.

Perhaps the only negative criticism we offer concerns the famous SIGGRAPH film festival. This has become an annual event since its informal inception, at the first SIGGRAPH conference, on the balcony of one participant's dormitory room at the University of Colorado in Boulder. This year's film festival was held in a hotel ballroom designed to hold no more than 1500 people. With 1900 people packed into the crowded space, and lines waiting to get in, the hotel's management restricted access to the ballroom for safety reasons. A greatly abbreviated second showing left many participants frustrated. The film festival is a forum for some of the best computer graphics and animation produced during the preceding year and is always enlightening and well attended. We sincerely hope next year's conference committee takes the film festival's popularity into consideration during planning.

## The Exhibition

Although this was the seventh annual SIGGRAPH conference, it was only the fifth annual SIGGRAPH exhibition. There were ninety-nine vendors listed in the exhibition guide for SIGGRAPH '80. At SIGGRAPH '76 (the first exhibition), there were only ten. This says much about the growth of this part of the industry. Another indicator of growth, according to Ken Anderson of the *Anderson Report* (a newsletter devoted to computer graphics), is the fact that last year the computer-graphics industry reached \$1 billion in delivered products. The computing industry as a whole does approximately \$40 billion in delivered products per year.

Several vendors at the exhibition were of special interest to personal-computer users. ABW Corporation demonstrated its TEKSIM package. TEKSIM allows the Apple II user to access the Tektronix Plot-10 software. Although the Apple/TEKSIM combination offers only about one-fourth the resolution of a Tektronix terminal, advantages such as lower cost, color displays, selective erase, and standard video output are claimed by the vendor. Apple Computer Inc displayed both the Apple II and III computers. Calcomp, which most of us think of as a vendor for the large-host user, demonstrated its 1051 drum plotter (among other products). The Model 1051 is an RS-232C-compatible, relatively low-cost product, which, considering Calcomp's quality reputation and service organization, makes it a viable product for passive-graphics production on small systems.

Cromemco, with which most personal-computer users are familiar, brought its line of high- and medium-resolution graphics hardware to the exhibition. Recent

emphasis on efficient software designed to increase the productivity of the programmer and end user is evident in Cromemco's recently announced high-resolution graphics-software package. Digital Engineering, Inc. was present with its Retro-Graphics printed-circuit board. This transforms the Lear-Siegler ADM-3A terminal into a graphics terminal compatible with the Tektronix Plot-10 software package. This company also makes a cross-hair graphic-input cursor and a printer for the modified terminal. Houston Instruments, a division of Bausch & Lomb Corporation, displayed much of its pen-plotter line and its more recently developed electro-static plotter line.

An eight-color, eight-pen digital plotter was displayed by Soltec Corporation. This is an interesting approach to low-cost, multipen, passive graphics. The plotter is basically a single-pen plotter with "parking stalls" for additional pens and enough native intelligence to relocate each pen for changes in color and line weight, or for an optional cross-hair cursor for digitizing. Summagraphics exhibited its popular Bit-Pad One, a low-cost approach to graphic-data-entry problems.

Tektronix was present with nearly everything in its line of graphics terminals and its stand-alone 4050 series of desk-top graphics computers. Hewlett-Packard also displayed its line of desk-top graphics computers including the Model 9845C color machine. The space-shuttle image on this machine was very impressive.

Also present were vendors oriented toward heavy



Photo 1: Megatek's new Wizzard color terminal. It also heralds the development of Megatek's device-independent software.



Photo 2: Overview of exhibition area. The Calcomp booth is in the center foreground. Tektronix is in the center mid-way back. IBM and Hewlett-Packard are in the center rear and Megatek is to the right in the foreground.



Photo 3: The Hewlett-Packard 9845C color desk-top computer is being demonstrated by using an image of the space shuttle.

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graphics users. CAD/CAM applications by Computervision, Inc, were shown. IBM showed entries for all levels: the 3279 color terminal for low- to mid-level business-graphics users, the 3277 graphics-attachment feature for the mid-level engineering users, and the 3250 for CAD/CAM applications. Vector General and Adage featured their high-performance vector-display devices. Megatek, with a popular display booth, exhibited its new line of Wizzard graphics terminals.

With nearly 100 vendors displaying recent developments, it is not possible to describe all the new products. Suffice it to say that there was something for everyone at the exhibition. If too little information could be gleaned from vendor representatives at their display booths, many vendors also conducted forum sessions from morning until evening. Technical and management people were there to answer more detailed questions about their products.

There are three things we want to reemphasize as being significant in the computer-graphics industry:

- First, the continued development of lower-cost color graphics terminals—the user's capital expenditures are critical in justifying new approaches in problem solving.
- Second, an increased emphasis on graphics-software standards yielding greater productivity for software developers and end users.
- Finally, the beginning use of computer graphics by and

for management, as opposed to its historically limited use as an engineering tool.

These items are very important to the growth of the computer-graphics industry. This exhibition, the conference, and the tutorials were dedicated to enhancing these three areas.

Harvey Kriloff and Robert Ellis, cochairmen of the SIGGRAPH '80 conference, and the SIGGRAPH '80 committee are to be commended for the quality of this year's conference. Next year's conference will be held in Dallas, Texas, and is scheduled for August 3 thru 7. Somehow we expect it to be hotter than the 75 degrees of Seattle. If present trends hold up, however, it will also be a fine and interesting conference. ■



Photo 4: A Calcomp representative demonstrates the Model 1051 digital plotter.

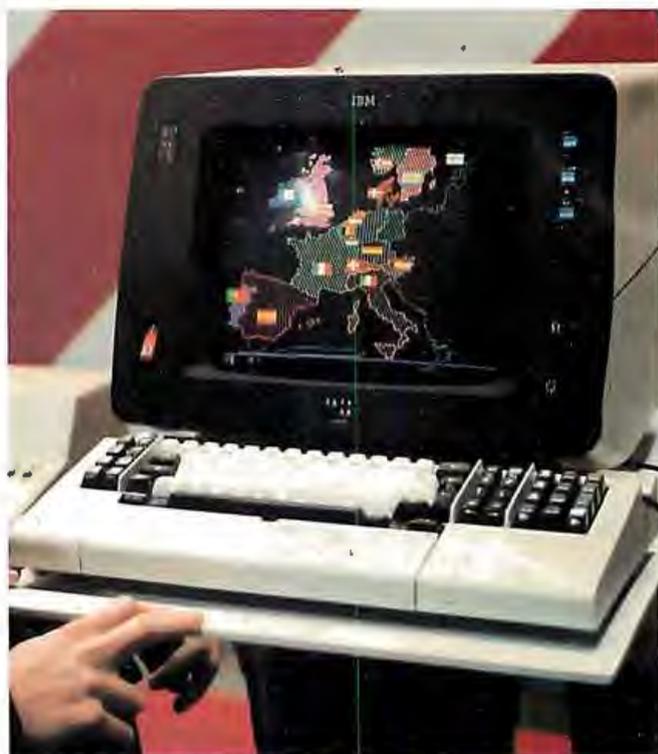


Photo 5: IBM's Model 3279 color-graphics terminal. This terminal is oriented toward business and management graphics rather than toward engineering applications.



Photo 6: The Tektronix Model 4054 features a large-screen storage display tube and built-in cartridge-tape drive, with disk drives optional.

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The Imagination Machine has several unique features that can help you use your time at the computer more effectively.

For example, it stores programs and data on the same cassette tape. (With other computers, you have to read programs from one tape into the computer, remove the tape, put in another tape and store your data on the new tape.)

Another special feature is The Imagination Machine's unique keyword system, which simplifies

BASIC programming. The machine has 24 different programs statements and commands printed at the top of the keyboard. You can enter these 24 into your program without retyping them every time you use them. Instead of typing out "PRINT," for example, you just press two keys and the word appears on the screen. The system helps prevent typing errors and can speed up entering programs.

A third feature is Timed Response Monitoring, which automatically adjusts the computer's pace and level to your own. It makes "tutoring programs," for instance, easier and more interesting to follow.

And then there are The Imagination Machine's three graphic display modes: 1. Alpha numerics, mixed with low-resolution graphics in as many as eight colors. 2. High resolution — up to eight colors — 128 x 192 display. 3. High resolution graphics — up to four colors — with 256 x 192 display.

### And expandability.

A personal computer that can't grow along with your growing requirements soon becomes obsolete. So, we designed The Imagination Machine to be expandable. By adding APF's optional "Expansion Box" and interface cartridges, you can hook up any compatible floppy disk or printer, or an additional 8K RAM memory cartridge.

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For small business and professional use, you may require a full mini-floppy

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# A Simplified Theory of Video Graphics

## Part 1

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Allen Watson III  
1261 Robbia Ct  
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---

This is an interesting time for choosing a personal computer, especially if you are looking for one with a graphics display. As you can see from the summary of specifications in table 1, the available graphics capabilities of the personal computers are all different, and no one model has a clear advantage over all the others. To make your choice even more difficult, some models exhibit undocumented quirks that are not apparent from the specifications.

Your choice of a video-graphics system will depend on what you want to do with graphics and on the performance of the different computers. While I can't help with the first aspect of your decision, I may be able to help you understand system performance by explaining the operating principles of video displays and describing the various combinations of features available on popular personal computers.

### The Importance of Video Graphics

Many applications of personal computers are modeled on conventional practices that have been developed over a period of several

years, while graphics displays have been too expensive for general use until quite recently. Many existing computer programs do not use even the simplest graphics, although there are several notable exceptions, such as chess games that use high-resolution graphics to display the board and pieces, and music editors that display standard musical notation.

Here's the important point: computer-graphics displays can produce schematic diagrams, music scores, flowcharts, architectural drawings, and the like that are much easier for the person using the computer to understand than the unadorned columns of numbers that are usually associated with computers. Of course, you still might not be able to afford video-graphics displays as powerful as the one used by NASA to simulate the view seen by the pilot of the space shuttle during its return from orbit. Even though they have their limitations, the current small-computer displays will enable you to do a lot of interesting things.

### Raster-Scan Video

While there are several different ways of displaying information on a video screen, all of the personal computers presently available use the same kind of *raster-scan* technique that ordinary television does. We'll take a look at the basic features of this technique, since they are shared by all inexpensive video displays.

Television is an imperfect compromise among several factors:

- resolution, which determines how

much detail we can display

- frame rate (to be discussed later), which is the number of complete pictures transmitted in 1 second

- bandwidth, a measure of the frequency response, of the equipment involved

An increase either in resolution or in frame rate requires an increase in bandwidth, which adds to the cost of the equipment. If we must keep within a limited bandwidth, we can obtain better resolution only at the expense of jerkier motion and vice versa. There is a type of television called *slow-scan*, for example, that manages to transmit reasonably detailed images over the narrow-bandwidth channels used by amateur radio operators, but the resulting frame rate is so low that the illusion of motion is lost. We will see how much bandwidth is necessary for ordinary television after we look at the raster-scan process itself.

If we display a sequence of images that change only slightly from one to the next, and do it fast enough, the eye will not be able to separate them: *persistence of vision* will cause the separate images to fuse into a "moving" picture. In order to transmit such a sequence of images electronically, each image must be dissected into a series of dots that may be transmitted one at a time. The television camera does this by rapidly scanning the image in a series of horizontal lines which form a *raster*. The lines are scanned one after another in the same way that a person scans the lines of letters on a printed page. Reading is a process of converting information,

---

#### About the Author

Allen Watson III began writing FORTRAN programs for scientific analysis soon after receiving his bachelor's degree in mathematics. Later, as a full-time programmer, he wrote IBM System/360 assembly-language programs for the computer-aided design of calculators and has prepared and presented training courses about the Fairchild F-8 and Motorola 6800. Allen is currently writing and editing user manuals for Apple computers.

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Level "A" With Hex Keypad/Display

## LEVEL "A" SPECIFICATIONS

Explorer/85's Level "A" system features the advanced Intel 8085 cpu, an 8355 ROM with 2k deluxe monitor/operating system, and an advanced 8155 RAM I/O all on a single motherboard with room for RAM/ROM/PROM/EPROM and S-100 expansion, plus generous prototyping space.

**PC Board:** Glass epoxy, plated through holes with solder mask. I/O: Provisions for 25-pin (DB25) connector for terminal serial I/O, which can also support a paper tape reader... cassette tape recorder input and output... cassette tape control output... LED output indicator on SOD (serial output) line... printer interface (less drivers)... total of four 8-bit plus one 6-bit I/O ports. • **Crystal Frequency:** 6.144 MHz. • **Control Switches:** Reset and user (RST 7.5) interrupt... additional provisions for RST 5.5, 6.5 and TRAP interrupts on-board. • **Counter/Timer:** Programmable, 14-bit binary. • **System RAM:** 256 bytes located at P800, ideal for smaller systems and for use as an isolated stack area in expanded systems... RAM expandable to 64k via S-100 bus or 4k on motherboard.

**System Monitor (Terminal Version):** 2k bytes of deluxe system monitor ROM located at P800, leaving 8000 free for user RAM/ROM. Features include tape load with labeling... examine/change contents of memory... insert data... warm start... examine and change all registers... single step with register display at each break point, a debugging/training feature... go to execution address... move blocks of memory from one location to another... fill blocks of memory with a constant... display blocks of memory... automatic baud rate selection to 9600 baud... variable display line length control (1-255 characters/line)... channeled I/O monitor routine with 8-bit parallel output for high-speed printer... serial console in and console out channel so that monitor can communicate with I/O ports.

**System Monitor (Hex Keypad/Display Version):** Tape load with labeling... tape dump with labeling... examine/change contents of memory... insert data... warm start... examine and change all registers...

single step with register display at each break point... go to execution address. Level "A" in this version makes a perfect controller for industrial applications, and is programmed using the Netronics Hex Keypad/Display. It is low cost, perfect for beginners.

## HEX KEYPAD/DISPLAY SPECIFICATIONS

Calculator type keypad with 24 system-defined and 111 user-defined keys. Six digit calculator-type display, that displays full address plus data as well as register and status information.

## LEVEL "B" SPECIFICATIONS

Level "B" provides the S-100 signals plus buffers/drivers to support up to six S-100 bus boards, and includes: address decoding for on-board 4k RAM expansion selectable in 4k blocks... address decoding for on-board 8k EPROM expansion selectable in 8k blocks... address and data bus drivers for on-board expansion... wait state generator (jumper selectable), to allow the use of slower memories... two separate 5 volt regulators.

## LEVEL "C" SPECIFICATIONS

Level "C" expands Explorer/85's motherboard with a card cage, allowing you to plug up to six S-100 cards directly into the motherboard. Each cage and card are neatly contained inside Explorer's deluxe steel cabinet. Level "C" includes a sheet metal superstructure, a 5-card, gold plated S-100 extension PC board that plugs into the motherboard, just add required number of S-100 connectors.



Explorer/85 With Level "C" Card Cage

## LEVEL "D" SPECIFICATIONS

Level "D" provides 4k of RAM, power supply regulation, filtering decoupling components and sockets to expand your Explorer/85 memory to 4k (plus the original

256 bytes located in the B155A). The static RAM can be located anywhere from P800 to EFFF in 4k blocks.

## LEVEL "E" SPECIFICATIONS

Level "E" adds sockets for 8k of EPROM to use the popular Intel 2716 or the TI 2516. It includes all sockets, power supply regulator, heat sink, filtering and decoupling components. Sockets may also be used for 2k x 8 RAM IC's (allowing for up to 12k of on-board RAM).

## DISK DRIVE SPECIFICATIONS

- 8" CONTROL DATA CORP. professional drive.
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- Access time: 25ms (one track).

## DISK CONTROLLER/I/O BOARD SPECIFICATIONS

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- 2716 PROM socket included for use in custom applications.
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Computer Model	Text:		Graphics:		Color:	
	Lines by Characters	Method	Resolution	Aspect Ratio	No. of	Method
Apple II	24 by 40	Subcell Mapping	40 by 48 280 by 192	4:3 4:3	16 6	NTSC NTSC
Atari 400 and 800	24 by 40	Subcell Mapping	160 by 80 280 by 192	8:5 4:3	16 4	NTSC NTSC
Commodore PET	25 by 40	Special	320 by 200	4:3	--	----
CompuColor II	32 by 64	Subcell	128 by 128	4:3	8	R-G-B
Exidy Sorcerer	30 by 64	Special	512 by 240	4:3	--	----
Radio Shack TRS-80	16 by 64	Subcell	128 by 48	4:3	--	----
Texas Instruments TI-99/4	24 by 32	Special	256 by 192	4:3	16	NTSC

**Table 1:** A summary of some of the features available in personal computer displays. The graphics capabilities of available personal computers differ, and no one model seems to have a clear advantage. NTSC (National Television System Committee) indicates that American-standard color-video conventions are used. R-G-B indicates that separate red, green, and blue video signals are sent to the monitor.

which is actually all present on the page simultaneously, into a sequence of words that follow one another in time. In a similar fashion, the raster-scan process converts a picture into a sequence of rapidly changing signal levels which represent the brightness of successive points on each scanning line.

When this rapidly changing signal is picked up by a television-receiving set, it is converted back into a visible raster on the screen of the picture tube. The neck of the picture tube contains an *electron gun* that projects a beam of electrons onto a thin layer of phosphor on the inside of the screen. Wherever the electron beam strikes the phosphor it produces a spot of light whose brightness depends on the intensity of the signal being received.

If the electron beam is swept across the screen so that the spot of light is always in the same relative position as the scanning dot in the camera, the picture will be recreated on the screen. The circuits in the television set controlling the position of the beam must be able to keep in step with the camera, so the picture information is interrupted for a short time at the end of each line (and for a longer time at the end of each frame). During these intervals the signal is changed to an intensity level that is never used for picture information, thus creating *synchronization pulses* that the television circuits can distinguish from the picture signal.

In this country, the repetition rate for the picture-scanning process was

set at 60 scans per second so that interference from the 60 Hz AC power line will be synchronized; that is, any visible interference effect will stand still on the screen and be less noticeable than it would be if it were moving. Scanning the entire picture 60 times per second amounts to a lot of information per unit of time, and thus requires a very wide bandwidth. The television designers discovered that they could cut the bandwidth requirement in half by making the camera scan every other line during alternate scanning cycles called *fields*. Two successive fields cover all the lines in the raster 30 times each second, to make a *frame*. (See figure 1.) Since the lines of the two alternate fields mesh between each other, this technique is called *interlaced scanning*.

This seems like a rather complicated way of getting 30 frames per second, and you may be wondering whether television wouldn't work just as well with a straightforward scan of the entire raster, 30 times per second. This concept is fine as far as the 60 Hz power-line interference is concerned, but 30 frames per second is too slow for the human eye to merge the image into a continuous picture without noticeable flicker. If you are familiar with filmed motion pictures, you know that they are projected at only 24 frames per second, but a shutter interrupts each frame so that the effective flicker rate is actually 48 frames per second, fast enough for motion to appear continuous.

There are other factors which also

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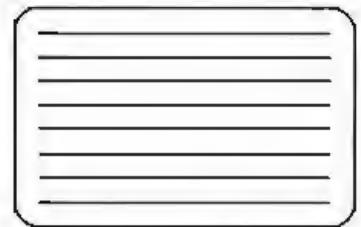
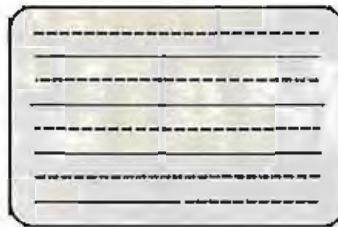


Figure 1: A comparison of the interlaced (1a) and noninterlaced (1b) raster-scanning schemes. The standard home television receiver displays a picture made up of two alternating fields, each composed of 262½ lines. The lines are interlaced to produce a high-resolution picture that can be transmitted on a narrow bandwidth signal.

complicate video-display timing. The vertical-retrace interval provides time for the television circuits to return the scanning dot to the top of the screen after each field has been completed. Since no picture information should be viewed during this time, the electron beam must be turned off or blanked: so, this time is also called the vertical-blanking interval.

A complete frame consists of two field scans and two vertical-retrace intervals. Television in the United States uses a total of 525 lines per frame or 262.5 lines per field. Each vertical retrace uses 21 lines, leaving 241.5 lines per field for the transmission of picture information. The odd half-line per field is necessary in order to make the lines of alternate fields interlace properly.

At 30 frames per second, 525 lines per frame is equivalent to 15,750 lines per second or 63.5 μs per line. Since all the lines are scanned in the same direction, the scanning dot must be returned across the screen between the end of one line and the start of the next. This is called horizontal retrace and takes about 15 μs.

### Video Monitor Versus the Standard Receiver

So that the engineers at the television station can monitor the quality of the signal that is being transmitted, the picture is displayed on a video monitor (something like a television set without the antenna and tuner). It does not pick up other television broadcasts but is connected directly to the station equipment generating video signals. If the outgoing video signal already has the horizontal and vertical synchronizing pulses, it is called composite video. Most video monitors are also capable of accepting the video signals and synchronizing signals separately.

Because the monitor gets the signal

before it has been through the various distortions imposed on it by the transmission and reception equipment, the picture displayed on a monitor is much sharper than the one on a home television set. The bandwidth of the video signal displayed by a home set is limited to less than 4.5 MHz, while most video monitors can handle 12 MHz or more.

Home television receivers display less of the picture in another respect: they crop off the edges by generating a raster which is too large for the screen. This deliberate overscanning is done so that the unavoidable errors in the positioning of the raster (caused by manufacturing tolerances and changes in the power-line voltage) will not leave unsightly gaps at the edges of the picture. In television broadcasting, no important activity is allowed to occur near the edges of the picture where it might be lost. Personal computers that use standard television receivers for their displays must have similar precautions: data is never displayed on the parts of lines near the sides of the screen, or anywhere on the top or bottom lines.

The television signal is transmitted over the air after it is impressed onto a VHF (very-high-frequency) or UHF (ultra-high-frequency) radio signal by modulation. Modulation is the modification of some characteristic of the VHF or UHF signal, or carrier, in step with the changes in the information that is being transmitted. The particular frequency used for the carrier determines which channel you tune your TV set to in order to pick it up. Circuits in the television can detect the changes in the carrier and extract the information they contain: specifically, the composite-video signal.

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\*TRS-80@ of Tandy Corp

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The key to TFORH's flexibility and ease of use lies in its use of a stack for parameters and a unique dictionary for WORDS. These WORDS are stated in terms of other WORDS already defined in the dictionary. It is this rich set of WORDS that provides DO LOOPS, IF-THEN-ELSE statements, BEGIN-END statements, virtual memory, any number base (to base 32) for input or output, a macro assembler, re-entrant code, multithread dictionary, line editor, excellent math package (16 bit integers, double precision floating point, SIN, COS, TAN, EXP and LOG) and it runs under either TRSDOS or NEWDOS. Assembler inherently nests with high level in an easy fashion. Complicated drivers for new devices take only a few lines of TFORH which saves both memory and disk space!

TFORH is a procedural language specifying a process rather than a desired result. The ability to have the language grow in the direction the user desires is excellent for novel applications. New data types and new processes can become part of the language. Due to the modular constructions, a very compact code is produced which executes at exceptionally high speeds between machine code and machine code plus 20% typical overhead speeds. Memory requirements can be "less" than assembler coding or other high level languages.

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dinary television set, we must either modify the set internally to give it a direct composite-video input, like that of a video monitor, or else we must add a *modulator* to our computer. The modulator acts like a tiny broadcasting station; it generates a VHF or UHF carrier that corresponds to a standard television channel (which is not being used by a local transmitting station) and modulates it with the computer video signal. The modulated signal can then be connected to the receiver's antenna terminals.

### Displaying Computer Data

For our computer to produce a display on a television set or a video monitor, it must generate a composite-video signal. Generating the horizontal and vertical synchronizing pulses is relatively easy, since they just repeat over and over in a fixed numerical relationship. Our computer's internal clock can serve as a stable high-frequency source for a few additional circuits to use in producing the horizontal and vertical synchronizing signals.

## Combining functions helps to keep the cost of personal computing down.

To make the display circuits in personal computers simpler and less expensive, the whole complicated business of interlaced scanning lines and alternating fields has been eliminated in most cases. Instead, the odd half-line per field, which would have been needed to make the field lines interlace, is omitted; this leaves 262 lines per field. Without the interlace, the lines of any two successive fields appear in exactly the same places, so we can just as well think of a computer display as having 60 frames per second, with 262 lines per frame. In fact, a different number of lines per frame may be used if the designer finds it convenient, but the number must be within a few percent of 262 for the display to work with a standard television set.

### Video Refresh

While synchronization is easy, generating a video signal with our computer is a little more difficult. First of all, a television picture must be continually regenerated by repeating the entire scanning process 60 times per second. This continual regeneration of the display is called *video refresh*; it requires a stream of data at a rate much too fast for our computer to keep up with—if the system had to compute the data anew for every scan. Instead, most computer designers set aside enough memory to store all of the data that will appear on the display. This reserved memory is called the *video-refresh memory*. Circuits designed especially for video-displaying read data from the refresh memory, in step with the video-synchronizing pulses, and transform the data into the video signal which is displayed.

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The EPROM monitor allows you to display, alter, and search memory, do inputs and outputs, and boot your disk. Debugging aids include register display and change, single stepping, and execute with breakpoints.

The set includes a serial port with programmable baud rate, four independent programmable 16-bit timers (two may be combined for a time-of-day clock), a parallel in and parallel out port, and an interrupt controller with 15 inputs. External power may be applied to the timers to maintain the clock during system power-off time. Total power: 2 amps at +8V, less than 100 ma. at +16V and at -16V.

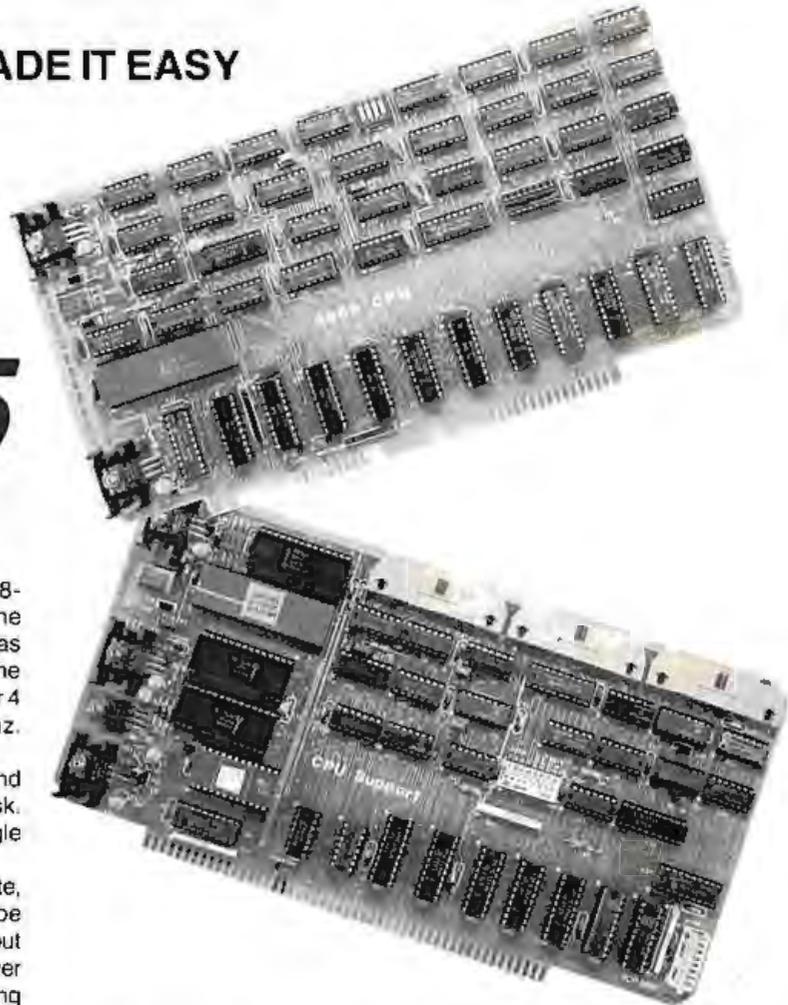
86-DOS™, our \$195 8086 single user disk operating system, is provided without additional charge. It allows functions such as console I/O of characters and strings, and random or sequential reading and writing to named disk files. While it has a different format from CP/M, it performs similar calls plus some extensions (CP/M is a registered trademark of Digital Research Corporation). Its construction allows relatively easy configuration of I/O to different hardware. Directly supported are the Tarbell and Cromemco disk controllers.

The 86-DOS™ package includes an 8086 resident assembler, a Z80 to 8086 source code translator, a utility to read files written in CP/M and convert them to the 86-DOS format, a line editor, and disk maintenance utilities. Of significance to Z80 users is the ability of the translator to accept Z80 source

code written for CP/M, translate this to 8086 source code, assemble the source code, and then run the program on the 8086 processor under 86-DOS. This allows the conversion of any Z80 program, for which source code is available, to run on the much higher performance 8086.

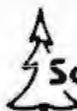
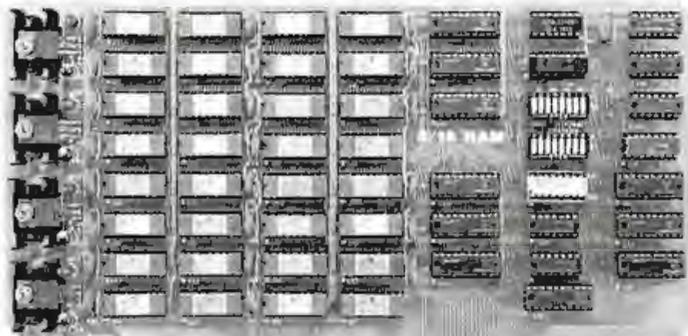
BASIC-86 by Microsoft is available for the 8086 at \$350. Several firms are working on application programs. Call for current software status.

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refresh memory. In other words, a small personal computer is a hybrid: part computer, part terminal. Combining functions in this way helps to keep the cost of personal computing down. Also, putting the refresh memory into the computer makes changing the display faster and easier.

### Bit-Mapped Displays

There are several different methods of transforming the data stored in the refresh memory into an effective video display. The most straightforward method is to take the data just as it is read from the refresh memory and transmit it to the display 1 bit at a time. Each 1 bit in this serial bit stream appears on the screen as a spot of light, and each 0 bit as darkness. The size of the refresh memory is matched to the picture scan so that for each bit in the refresh memory there is one spot on the display screen. A one-to-one correspondence of this kind is called a *map*, and this technique for generating computer video displays is called *bit mapping*. An example of a bit-mapped display is shown in photo 1.

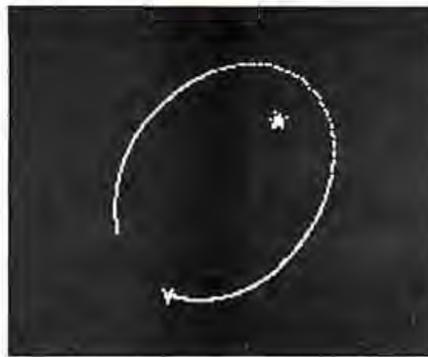


Photo 1: Example of a bit-mapped display. This simulation of a spaceship in orbit around a star is done on a 180-bit by 150-bit map.

Since we can program the computer to store data bits into the refresh memory in any pattern we desire, this kind of display can have all the versatility we want, but there are some drawbacks. For one thing, this system requires a large refresh memory. To store a display which is 200 dots high by 300 dots across, for example, takes 60,000 bits or 7500 bytes. Bit-mapped displays are relatively slow, too; just storing 0s into this much memory in order to

clear the screen to black takes close to 1 second with the fastest micro-processor.

Displaying only letters and numbers means we can get by with a much smaller refresh memory than is needed for bit mapping. A letter that occupies eight rows of eight dots requires 8 bytes of memory in the bit-mapped display, but we can encode the same letter in ASCII (American Standard Code for Information Interchange) and reduce the size of the refresh memory by a factor of 8. This means that instead of sending the data bits directly to the display, it is necessary to decode each stored character and generate the appropriate video information. To do this, the refresh circuits send the character code (along with signals that indicate which of the eight rows of dots is currently being displayed) to another circuit called a *character generator*. The character generator is little more than a read-only memory that contains the video bit patterns for each of the characters we want to display.

Having a smaller refresh memory more than compensates for the additional cost of the character generator. For example, our 200-dot by 300-dot display has a capacity of 925 characters, in twenty-five rows of thirty-seven characters each. The bit-mapped memory needed for this is 7500 bytes, but we can store 925 characters in only 925 bytes if we use the character generator. It takes only one-eighth as long to update the refresh memory, too. The main drawback is its lack of versatility; we can only display characters of a fixed size and spacing. Obviously, a method of getting many different shapes without increasing the size of the refresh memory would be more flexible.

Using a byte of memory for each character, in all possible combinations of 8 bits, requires a total of 256 different codes. A complete set of uppercase and lowercase letters, numbers, and punctuation takes only ninety-six codes, leaving 160 combinations that we can assign to special shapes useful for graphics. Each special shape must be designed using the same number of dots and rows as the other characters. It may often be necessary to use several of them to make up the image of one object in the display. We can allow for this by setting up special characters such as

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straight-line segments, corners, intersections, and so on, in various orientations.

Several personal-computer manufacturers have taken this approach. While keeping the speed and small refresh memory of the character-generator-based design, they also have a reasonable graphics capability with good resolution. To compensate for the limited number of special shapes that you can have with this method, the Exidy and Texas Instruments computers have programmable character generators so that you can design your own shape characters and change them as needed.

### Character Subcells

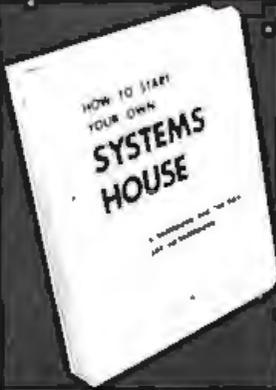
There is another way to add graphics capability to the character-generator display. Suppose we divide each of the character cells into four subcells, each of which is four dots square. By displaying any combination of these four subcells, with all dots illuminated, there will be sixteen possible shapes which we can display in each character location. By allocating sixteen extra character codes to represent these sixteen combinations, we can have a very versatile graphics system; however, it won't have much resolution. Dividing each character in half horizontally and vertically converts the twenty-five rows of thirty-seven characters in our example to a 50-block by 74-block graphics display.

We could increase the resolution by dividing the character cells into smaller pieces, but the number of combinations of blocks we would have to encode would increase very quickly. If we divide each cell by 4 in each direction, we increase the resolution to 100 by 148; but, there will be sixteen subcells in each character cell so we must store 16 bits of data for each cell. Since there are 65,536 different 16-bit codes, using read-only memory for the character generator becomes impractical. Instead, it is necessary to devise some logical method for generating the subcell patterns by decoding an extra byte of information, using additional circuitry. Also, the refresh memory would have to be twice as big to store these 2-byte codes. This may help to explain why the personal computers that use this approach have relatively low resolution. ■

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by Leslie Nelson, May 1980

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## The Power of VisiCalc

Robert E Ramsdell  
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### At a Glance

<b>Software:</b>	<i>VisiCalc</i>
<b>Type:</b>	<i>Screen-oriented matrix calculator for projections, budgeting, and many other numeric/data manipulations</i>
<b>Author:</b>	<i>Software Arts Inc</i>
<b>Distributor:</b>	<i>Personal Software Inc, 1330 Bordeaux Dr, Sunnyvale CA 94086, (408) 745-7841</i>
<b>Price:</b>	<i>\$150.00</i>
<b>Format:</b>	<i>5-inch floppy disk</i>
<b>Language:</b>	<i>Machine language</i>
<b>Computers:</b>	<i>Apple II, Apple II+ or Apple III; Radio Shack TRS-80, Model I or II; Atari 800; Commodore PET and CBM computers, minimum 32 K bytes of programmable memory required, 48 K or more recommended</i>
<b>Documentation:</b>	<i>Loose-leaf binder with eighty-page tutorial manual, reference card</i>
<b>Audience:</b>	<i>Businessmen, accountants, attorneys, real-estate investors — anyone who needs to use a calculator for determining options available under different scenarios</i>

screen facilitates and enhances the manageability and interactivity of the program.

Since I am a certified public accountant, the majority of applications I have written are oriented towards accounting, a usage for which VisiCalc is particularly appropriate. In addition, I know of several attorneys who are using the program for estate- and gift-planning, one of whom is maintaining his accounts receivable, as well, on VisiCalc. A number of real-estate agents are using it to perform real-property investment analysis.

### About the Program

VisiCalc is an electronic scratch sheet that is sixty-three columns wide (lettered A thru BK) and 254 rows long (numbered 1 thru 254). Any column/row coordinate can be referred to by any other column/row coordinate arithmetically or trigonometrically. Once the relationships between the coordinates have been established in the model, a change in any value which affects other values will be instantly updated. This gives the computer operator the ability to play instant what-if situations with the value in the matrix.

The program has a great deal of flexibility in its formatting, allowing any coordinate to be a label or a value, and allowing columns to be adjusted from three characters to full-screen width. The screen can be split into two windows, either horizontal or vertical, and each can be scrolled independently of the other. This makes the comparison of information extremely easy. Values can be formatted as full-decimal notation (up to eleven significant digits), two-place decimal (for financial usage), and integer.

An annoyance that I have found in the program is its inability to round off integers, which causes columns to add up imperfectly. This often creates the need for a great deal of additional work when attempting to prepare financial information directly from the model.

One of the most powerful features of VisiCalc is its ability to replicate an entire series of coordinate functions with a few keystrokes. When creating models with a series of identical calculations (such as a 10-year business forecast), only the calculations for the first column must be entered. Then the subsequent columns can replicate the same calculations (VisiCalc automatically uses the new coordinates) in a matter of seconds. This is a tremendous time-saving device when elaborate models are being created. The authors of VisiCalc have also provided the ability to insert, delete, and move entire rows and columns. This feature is useful if the model is finished and

### Introduction

The most exciting and influential piece of software that has been written for any microcomputer application is VisiCalc. I've been using VisiCalc almost full-time for the past six months and have written over 300 applications (which I refer to as models) for the program. During that time I have learned its strengths and weaknesses and have found that the authors have allowed for a tremendous number of variables and contingencies in its operation. The instant communication between the operator and the

### About the Author

Robert E Ramsdell, CPA, is a microcomputer consultant who lives and works in Rockport, Massachusetts. His company, Pansophics, Ltd, published federal income tax models for 1979 and 1980 using VisiCalc and markets several other financial modeling packages.

the user discovers that an important calculation was omitted.

VisiCalc can be interfaced through most printers, and various printer configuration routines are set up directly through the program. The program will output to a printer with any number of character widths, so the choice of printer depends on the needs of individual users. Finally, the methods by which the program loads, saves, and deletes models on the disk are very well designed.

### Specific Applications

Accounting applications abound for VisiCalc. Financial analysis, business forecasts, and projections which formerly required hours can be completed with VisiCalc in a matter of minutes. The pricing on a bill-of-materials inventory can be updated in a matter of seconds. Production estimates can be updated instantly. Different scenarios can be examined and variables and constants interchanged until a workable model is achieved. Even with the advent of programmable electronic calculators, the complexity of forecasting (due to the interdependency of the variables) has limited the accountant to either the most rudimentary forecast or the extremely expensive alternative of time-sharing on a large computer.

Sophisticated and statistically valid time-series analysis can be performed on VisiCalc. Lead and lag regression analysis becomes as easy as entering the various formulas. Each of the variables can be changed or updated, and the results of the new analysis will be instantly displayed.

Small businesses will also find uses for VisiCalc. A

model can be created which will allow for the printing of a financial statement whenever a trial balance is entered. Financial ratios and analysis are easily performed. The model can even calculate income tax and compare the current results with those of a previous period or a budget. (Some marketed models even print out tax returns.) Also, budgets are relatively easy to prepare (thanks to the replicate command), and changes and updates are easily entered.

More complex models can be designed for areas such as real estate and stock market investment analysis, where many interdependent variables must be given consideration. A change in any of these variables will instantly cause the entire model to be updated, and new comparisons can be made.

### Documentation

VisiCalc comes with an eighty-page tutorial manual that's very useful for the beginner and a well-designed reference card. After one reading, however, the manual is not of very much help in running the program. A new manual is being written and may be available soon. In addition, several books are in preparation which will aid the VisiCalc owner in using the program.

### Program Constraints

The primary constraint of the VisiCalc program is the programmable memory available to the user. In the Apple II, for example, a 48 K-byte machine will have about 25 K bytes available to the user for modeling. This may sound like a lot, but in fact model files require a lot of room. To compound this problem there is no easy way to

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move information between models (for example, in a business consolidation), so that using the same basic information in different models can be a big chore.

The only other limiting factor is the fact that the VisiCalc disk cannot be copied or backed up. The obvious reason for this to avoid software piracy, but it could prove to be a problem if someone decided that 5¼ inches was the perfect size for a coaster. There is a dealer program for instant replacement, however.

### Data Interchange Format

Software Arts Inc, the creator of VisiCalc, has developed a common language for data (which it uses in VisiCalc) called the DIF (Data Interchange Format). The basic goal of the DIF is to allow the interchange of data between many different kinds of programs (such as data bases, graphing programs, report generators etc). The type of data which is addressed by the DIF is data which is stored in tabular form — columns and rows. By setting up a standard for such data handling it becomes easy to manipulate the data through program control.

Programmers and others who are interested in learning more about the DIF or would like to purchase the *Programmer's Guide to Data Interchange Format* (\$1.50) should write to The DIF Clearinghouse, POB 70, MIT Branch, Cambridge MA 02139.

### Conclusions

- VisiCalc is an extremely well-designed software package that can be used by anyone with or without a programming background. There is no programming language involved in the use of VisiCalc.
- The instant interaction between the user and the screen facilitates the understanding of the manipulation of the variables in the matrix.
- The ability to interchange data with other programs helps make VisiCalc an integral part of any business systems package.
- VisiCalc is the first program available on a microcomputer that has been responsible for sales of entire systems. ■

## Farewell to the Florida panther.



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We think the Touch Test 20 is miniaturization at its best, because no compromises in accuracy and versatility were made in the process of squeezing a trunk full of test equipment into a rechargeable battery powered portable test lab.

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individual testers. And in the lab, the Touch Test 20 will go a long way toward cleaning up the cluttered array of equipment found on most test or troubleshooting benches.

## JUST TOUCH

The "touch" in Touch Test 20 means no more knobs and dials to fiddle with: selection of the various functions is accomplished by a tap of the finger on one of the touch sensitive switches on the front panel. When you switch functions, there's an audible bleep and an LED lights to show the function selected. Selecting the range is also a beautifully simple procedure - just touch one of the switches below the display to shift the decimal point to the appropriate place for the signal you're measuring.



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Specialists in the science of staying ahead.

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VOLTS ..... 1 mV to 1 kV @ .2%  
AMPERES ..... 1 uA to 10 A @ 1%  
OHMS .. 10 uOhm to 19.99 MOhm @ .25%  
TEMPERATURE .. -40° C to +150° C +/- 3°  
CAPACITANCE .. 1 pF to 199.9 uF @ 1%  
CONDUCTANCE .01 nS to 199.9 nS @ .2%  
DIODE TEST ... 1 mV to 1999 mV @ .2%  
SIZE ..... 2.9" x 6.4" x 7.5"  
WEIGHT .. 3 lbs 8 oz (including batteries)

## EVEN IDIOTS

While no instrument is totally idiot-proof, the Touch Test 20 certainly comes close: when any function is selected, this instrument automatically selects the least sensitive range of the function, to avoid embarrassing but all too common smoke test situations. We're told (though we do not advise such mistreatment), that you can plug the test leads into a 120 volt wall socket and select any function without causing terminal damage to the instrument.

To complement these remarkable capabilities, the Touch Test 20 is shipped ready to go to work for you, complete with a charger unit, rechargeable batteries, high quality test probes, a component test block, and a temperature probe.

## ONE YEAR WARRANTY

Each Touch Test 20 is individually tested and "burned-in" at elevated temperatures to

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We at JADE have been in the business of supplying computers and related equipment for five years now, and we've always guaranteed our customer's satisfaction. We know that you'll be happy with this piece of equipment, so try it for thirty days; if the Touch Test 20 doesn't live up to your expectations, we'll quickly refund the purchase price. And don't worry about slow delivery - the manufacturer has assured us that we will have priority shipment of the Touch Test 20 directly from the factory. This plus our computerized order processing system assures you of the fastest possible delivery.

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\*32K RAM, 14K 4.0 BASIC

\*IEEE BUS \*80 x 25 CRT

\*Ideal for WordProcessing  
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Multi-Cluster is a product of BMB Compuscience.



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"The Superbrain is ideal for use as an intelligent terminal or stand alone microcomputer system for OEM's, commercial customers, and other sophisticated computer users."

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## The MicroAngelo Video Display

Mark Dahmke  
1515 Superior St  
Lincoln NE 68521

### Introduction

The MicroAngelo high-resolution raster graphics display stands well above other S-100 graphics displays in its price and performance range. Since the MicroAngelo is actually a single-board microcomputer, a great number of functions that previously had to be performed by the host computer are now done in *firmware* on the graphics board. Rather than using the memory-address space of the host as a graphics display buffer (32 K bytes in this case), the host communicates with the MicroAngelo through two parallel ports with simple yet powerful commands. The MicroAngelo decodes these commands and automatically performs the desired functions independently of the host processor. With this parallel-processing capability, system response time is greatly enhanced.

### Hardware Overview

The MicroAngelo consists of a Z80A microprocessor

with 32 K bytes of on-board programmable memory and 4 K bytes (expandable to 8 K bytes) of PROM (programmable read-only memory) firmware. The board contains all hardware necessary to generate a 512 by 480 dot black-and-white display for a television monitor (10 MHz bandwidth or greater). The board communicates with the host through two parallel ports which may be addressed to any of eight blocks of ports from hexadecimal 00 to F0. The video monitor may be connected via composite video (RS-170 standard) or direct-drive transistor-transistor-logic-level video, horizontal and vertical synchronization.

The MicroAngelo has four possible interrupt sources: data from host, data to host, light pen, and 60 Hz timer. Whenever a data byte is sent by the host or the host reads a data byte sent to it, an interrupt will occur in the MicroAngelo. An interrupt will occur when the light pen is fired and also when the timer produces a pulse. Of these four possible interrupts only the data from host and light pen sources is usually enabled.

### At a Glance

**Hardware:** *MicroAngelo high-resolution graphics display.*

**Use:** *High-resolution raster-scan graphics display which may be used to draw character or graphics images on a standard television monitor.*

**Manufacturer:** *Scion Corporation  
8455-D Tyco Rd  
Vienna VA 22180  
(703) 827-0888*

**Price:** *The MicroAngelo graphics board and firmware (the S-100 board only) is \$1095. Also available is the Graphics Subsystem which includes the MicroAngelo S-100 board, a graphics keyboard (IBM Selectric-style keyboard with some special function keys) and a high-resolution 15-inch monitor. Cost: \$2495. A light pen is optional.*

**Features:** *The MicroAngelo S-100 board generates a 512 by 480 dot black-and-white raster display. Communication between the*

**Firmware:** *MicroAngelo and the host computer is facilitated by two parallel ports. The MicroAngelo also has a dumb terminal emulation mode. PROM (programmable read-only memory) firmware is provided on-board the MicroAngelo. High-level commands may be sent via parallel ports. Such functions as "turn on dot" or "draw vector" are implemented by single commands. The on-board Z80 intercepts these commands and performs the desired functions.*

**Hardware required:** *Any S-100 mainframe computer or any computer which has an S-100 bus adapter. Although the MicroAngelo uses a Z80 microprocessor, the host processor need not be 8080/Z80 compatible.*

**Documentation:** *An eighty-page user's manual is supplied.*

**Audience:** *Anyone requiring high-resolution intelligent graphics on a small system.*

New

# S-100 A/D & TIMER

New

Tecmar's new A/D and Timer Board is designed to meet sophisticated data acquisition needs. The board can accommodate various A/D modules providing options such as 12, 14, 16 bit accuracy; 100 MHz throughput; variable ranges and gains. It contains a powerful timer circuit (AMD 9513) which can start A/D conversion and can also be used independently for time of day, event counting, frequency shift keying and many other applications.

## TM-AD200 FEATURES

- Complies with IEEE S-100 specifications
- Transfers data in 8 or 16 bit words
- 30 KHz throughput standard
- 12 bit accuracy standard
- Jumper-selectable for 16 single-ended or 8 true differential channels
- External trigger of A/D
- Provision for synchronizing A/Ds
- Data overrun detection
- Data is latched providing pipelining for higher throughput
- Input ranges:  $\pm 10V$ ,  $\pm 5V$ , 0 to  $+10V$ , 0 to  $+5V$
- Output formats: Two's complement, binary, offset binary
- Auto channel incrementing

- I/O or memory mapped
- Utilizes vectored interrupt or status test of A/D
- Provision for expansion to 256 channels

## TIMER FEATURES

- 5 independent 16 bit counters (cascadable)
- 15 lines available for external use
- Time of day
- Event counter
- Alarm comparators on 2 counters
- One shot or continuous frequency outputs
- Complex duty cycle and frequency shift keying outputs
- Programmable gating and count source selection
- Utilizes vectored interrupt

## TM-AD200 OPTIONS

- Programmable gain up to 500
- 14 bit accuracy
- 16 bit accuracy
- Screw terminal and signal conditioning panel with optional thermocouple cold junction compensation

- 100 KHz throughput with 12 bit accuracy
- Low level, wide range (10mV to 10V FSR) permitting low level sensors such as thermocouples, pressure sensors and strain gauges to be directly connected to the module input



**TECMAR, INC.**

(216) 382-7599

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If your data acquisition needs are simple, the original Tecmar S-100 A/D Board will meet your needs.

### TM-AD100 FEATURES \$495

- Complies with IEEE S-100 specifications
- 16 single-ended or 8 true differential channels
- 12 bit accuracy
- 25 KHz throughput
- I/O or memory mapped
- Input ranges:  $\pm 10V$ ,  $\pm 5V$ , 0 to  $+10V$ , 0 to  $+5V$
- Minimal software required.

For digital to analog conversion, Tecmar's D/A Board provides four independent 12 bit high speed D/A channels. \$395

### TM-DA100 FEATURES

- Complies with IEEE S-100 specifications
- 4 independent digital to analog converters
- 12 bit accuracy
- 3  $\mu$ sec settling time
- I/O or memory mapped
- Output ranges:  $\pm 2.5V$ ,  $\pm 5V$ ,  $\pm 10V$ , 0 to  $+5V$ , 0 to  $+10V$

### S-100 BOARDS

8086 CPU W/vectored interrupts	\$450
RAM 8Kx16/16Kx8	\$395
8086 PROM-I/O	\$495
Serial and Parallel I/O	\$350
Parallel I/O & Timer	\$350

TRS-80<sup>1</sup>

PET<sup>2</sup>

KIM<sup>2</sup>

APPLE

**A/D**

- ▶ 12 Bit
- ▶ High Speed
- ▶ 8 Ch. Differential
- ▶ 16 Ch. Single-ended
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**D/A**

- ▶ 12 Bit
- ▶ High Speed
- ▶ 4 Channel

Each D/A Module \$395

TRS-80 or PET expansion board, power supply, and enclosure \$200.  
Kim expansion board and power supply \$150.

### S-100 Real Time Video Digitizer

- Digitizes and Displays in 1/60 sec, flicker-free
- 16 Gray Levels
- Switch Selectable to display Black and White Graphics (8 pixels/byte)
- Maximum Resolution: 512 pixels/line x 240 lines
- Minimal software requirements \$850

<sup>1</sup>Reg. Trademark of Tandy Corp.  
<sup>2</sup>Reg. Trademark of Commodore

Data Acquisition Systems and  
Video Microcomputer Systems Available

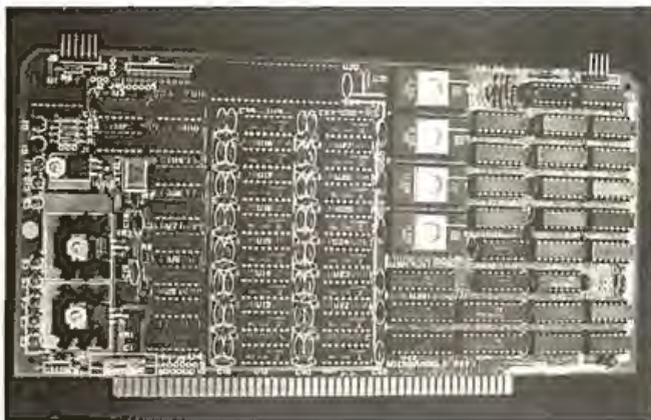
A connector is provided for the light pen interface. Several commercially available light pens will work with the MicroAngelo.

### Jumper Options

Several on-board jumpers are provided for special applications. For example, it is possible to increase the clock speed of the Z80A microprocessor (and hence the speed of the board) from 4 MHz to 5 MHz, assuming that all the components are capable of operating at that speed. Interrupts (as previously discussed) may be enabled or disabled. The number of visible scan lines may be changed from the default 480 to 448 lines. If this option is chosen, the user is responsible for display management. The PROM sockets may be jumped to either the default 1 K byte per PROM or 2 K bytes per PROM.



**Photo 1:** The MicroAngelo Graphics Subsystem. Included in the subsystem are the MicroAngelo S-100 board, the 15-inch high-resolution black-and-white monitor, and a special keyboard that has an IBM Selectric-style layout plus some special function keys on the far left and right. The light pen is optional.



**Photo 2:** A close-up of the MicroAngelo S-100 board. The board has a Z80A microprocessor, 32 K bytes of memory, and four 2708 PROMs (expandable to 8 K bytes 2716 PROMs). The board is actually a stand-alone 32 K computer. The video display generates 512 by 480 dots. In the ALPHA mode, up to 85 by 40 characters may be displayed on the screen.

### Adapting-MicroAngelo to Non-S-100 Systems

Since the MicroAngelo uses a simple parallel-port interface to the host system, it may be attached to almost any host system. Data is transferred via the eight parallel input and eight output lines of the S-100 bus connector. Power is supplied through pin 1 (+8 V), pin 2 (+18 V), pin 52 (-18 V), and pin 50 (ground). Address bus lines A7, A6, A5, A4 and pDBIN may be tied permanently high (+5 V); A1 and pWR are tied low (ground). A0 is connected to the host to select whether port 0 or 1 is addressed. (MicroAngelo uses two ports.) sINP and sOUT are connected to the host as input-and-output-control command lines. Using this twelve-line interface, the MicroAngelo becomes a stand-alone graphics display device. If interrupts are required, they may be easily added to the above set of signals.

### Firmware

The MicroAngelo firmware is what makes the board so powerful. It takes all the work out of designing software and applications programs for the MicroAngelo. The Screenware Pak I is a well-integrated firmware package that allows the board to be used as a terminal emulator, a graphics display, or both.

If a byte is sent to the MicroAngelo (via the parallel port), it is interpreted by the firmware in one of two ways. If bit 7 (the most significant bit) is turned on, the byte is seen as a command. If it is off, the firmware treats it as an ASCII character and passes it to the terminal or ALPHA mode program.

In the text mode, the board will display forty lines with eighty-five characters per line. Text and graphics may be mixed on the screen. In the dumb terminal mode, the firmware will respond to the following control codes: backspace, horizontal tab, line feed, form feed, carriage return, escape, and delete.

Several features are available in the terminal mode. It is possible to display black-on-white or white-on-black characters, for example. Underlining may be turned on and off, and character overstriking may be allowed or disallowed. Two fonts are available, the standard character set or a user-defined font. The winking cursor may be displayed or inhibited, and the scroll mode may be changed. Scrolling may be done on a line-by-line basis, or, to improve response time, block scrolling may be done. Cursor addressing is available — rows run from 0 to 39, columns from 0 to 84. It is also possible to query the firmware to obtain the current cursor location.

### Graphics-Mode Commands

The display may be manipulated in many ways in the graphics mode. First, the graphics cursor may be set to a value, read or queried, or set to the contents of the alpha cursor and vice versa. The format for most graphics-mode commands is:

`<Command> <xh> <xl> <yh> <yl>`

where *xh* and *xl* are the high and low bytes of the X coordinate and *yh*, *yl* are the high and low bytes of the Y coordinate respectively (in hexadecimal). The coordinates (384,256) would be sent as:

`<Command> <01> <80> <01> <00>`

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**16 BIT POWER  
Z-8000<sup>3</sup>**

AND STILL RUN YOUR 8 BIT SOFTWARE

**8 BIT POWER  
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- The 16 BIT systems are the way future systems will go. Why not? There is very little price difference and an order of magnitude performance difference.
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- The systems using 5 1/4 inch disk drives really do not have adequate memory storage or computer power for many business or scientific applications
- Sixty-four kilobytes of addressable RAM, the maximum for 8 BIT systems, is not adequate for many business or scientific applications.
- It is not worth buying 8 BIT systems or boards now if you can get the same software with 16 BIT systems at about the same price.

- The new 16 BIT microprocessors have power comparable to minicomputers but do not require the same overhead in terms of downtime, maintenance, or initial investment. They are more versatile in many applications such as real time applications.

### THIS IS WHAT QDP HAS AVAILABLE:

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- A Z-8000 System configured for your exact needs.
- Software to allow you to run all the available Z-80/8080 software including CP/M.
- Software that includes a Monitor, Debugger, Disassembler, and Basic.
- Software options: a) Extended Monitor, b) Simulators for 8080, Z-80, 6800, 6502, 1802.
- A Z-80 System (QDP-100) that is upward compatible with the Z-8000.

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- UNIX<sup>2</sup> operating system.

## Z-8000 SERIES 16 BIT CPU S-100 BOARD - CAN BE PLUGGED INTO YOUR EXISTING SYSTEM \$695.00

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Quality**

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### SOFTWARE

- Z-80 emulator enables you to execute your existing 8 BIT software without any modifications and allows you to run CP/M immediately.
- Extended Monitor, Debugger, Disassembler.

## QDP-8100 WITH 2 MEGABYTES STORAGE STANDARD (OPTIONAL 4 MEGABYTES)

- Z-8000 series 16 BIT CPU S-100 Board - see above

### SOFTWARE (Provided with system)

- CP/M 2.2<sup>1</sup> operating system
- Basic
- Z-80/8080 Emulator
- Monitor, Debugger, Disassembler software
- Optional software: Pascal
- UNIX<sup>2</sup> operating system coming

**\$6,395.**

## SYSTEMS



## QDP-100 WITH 2 MEGABYTES STORAGE STANDARD (OPTIONAL 4 MEGABYTES)

- Z-80 series 8 BIT CPU S-100 Board (4 MHz, Z-80, Double density disk Controller, 2716 Prom Burner 2 Parallel & 2 Serial Ports, real time clock)

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- CP/M 2.2<sup>1</sup> operating system
- Basic
- Accounts Receivable, General Ledger, Accounts Payable, Payroll with Cost Accounting
- Optional software: Fortran, Pascal, Cobol, C

**\$4,995.**

### EACH SYSTEM CONTAINS:

- Intelligent CRT terminal (80 characters X 24 lines)
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Specifications Subject To Change

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<sup>2</sup>UNIX<sup>®</sup> Bell Lab

<sup>3</sup>Z-8000<sup>®</sup> Zilog

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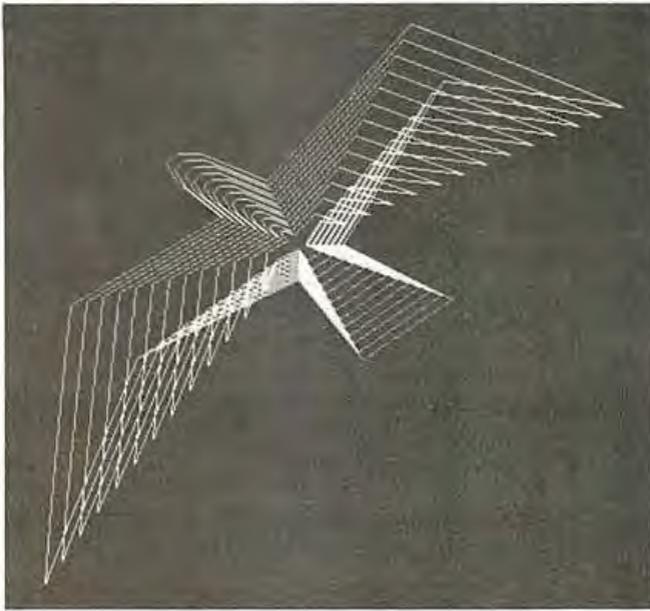
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NO	DATE	DESCRIPTION	UNIT PRICE	QUANTITY	TOTAL
1		MICROANGELO GRAPHICAL BOARD	1,000.00	1	1,000.00
2		WORK WITH LOW STATION	4,500.00	1	4,500.00
3		FREIGHT AND PACKAGING		1	100.00
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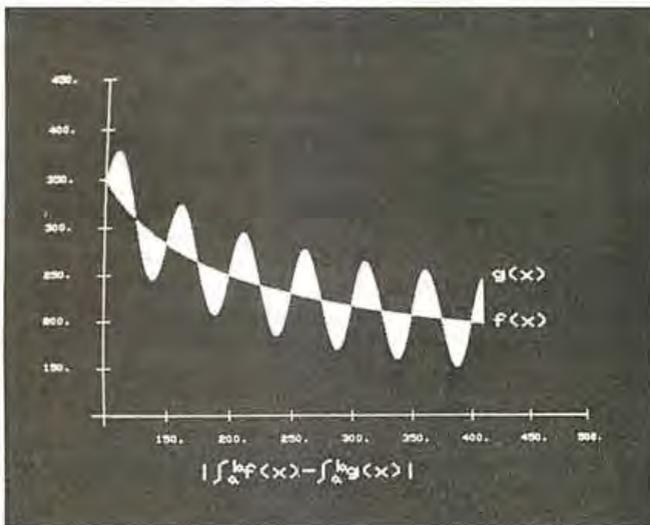
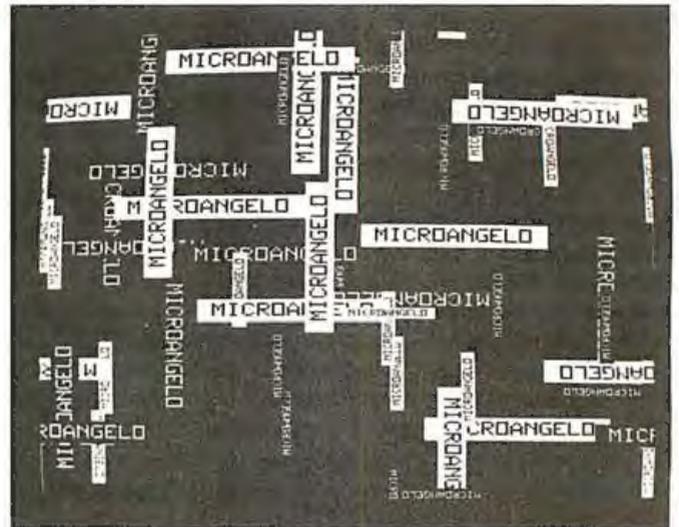
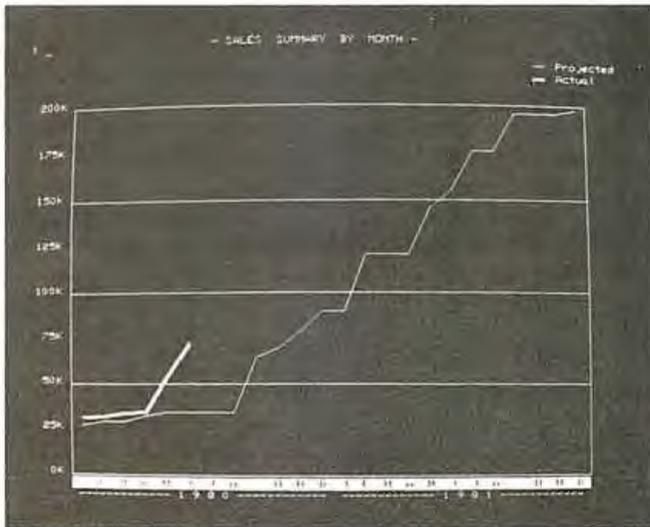


Photo 3a, 3b, 3c, 3d, 3e, 3f: Sample displays produced with the MicroAngelo graphics board. Vectors may be drawn with single high-level commands.

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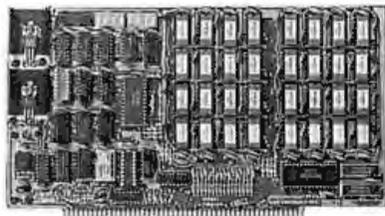
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Replacing <Command> with <84> would cause the firmware to set the graphics cursor to (384,256) on the screen. Some commands have no operands such as "clear screen". It is possible, with one command, to toggle the screen figure/ground. This means that every dot on the screen will be complemented (ie: reversed). If a dot is on (white), it will be turned off (black) and vice versa.

Individual dots may be turned on, off, complemented or queried. The form of this group of commands is also:

<Command> <xh> <xl> <yh> <yl>

In the case of the query command, the response is a single byte from the firmware with a value of 1 or 0.

A vector, the next level of sophistication, may also be turned on, off or complemented. The endpoint of the vector is specified in the command, and the starting point is assumed to be the current value of the graphics cursor.

It is also possible to work with *regions* of the display. If we wish to turn on all dots in a box with corners (X1,Y1), (X2,Y1), (X1,Y2), (X2,Y2) the command:

<95> <x1h> <x1l> <y1h> <y1l>  
<x2h> <x2l> <y2h> <y2l>

would be sent. Regions may also be turned off or complemented.

Characters may be *plotted* depending on the graphics cursor and the mode selected for graphics characters. Options available include:

- normal-size or double-size characters
- black-on-white or white-on-black
- direction and orientation

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Alternate characters may be defined. When the ALPHA mode alternate-character-set option is employed, sending an ASCII character to the firmware will display the alternate character instead of the standard font character. To define the character, the following sequence of bytes must be sent:

<9A> <asc> <s11> <s10>  
<s9> ... <s1> <s0>

where 9A is the command, "asc" is the ASCII character code assigned to the character, and s11, s10, ... s0 are the twelve scan lines (6 bits wide) that make up the character in a 6 by 12 dot array.

### Using the Light Pen

The light pen provides a convenient means of entering data or drawing on the screen without having to enter numeric coordinates. The coordinates of the pen may be read directly, along with a flag indicating whether or not the pen has been fired since it was last queried. Cross hairs may be displayed at any point on the screen when using the light pen. Another set of commands allows the cross hairs to be displayed, moved, and queried without regard to the light pen.

### Memory Uploading/Downloading

Several commands are provided for dumping and loading the screen, thus allowing the user to save images on disk and restore them for later viewing or editing. Memory blocks may be examined or deposited allowing quick loading of alternate character fonts or user-written code. The firmware allows the user to deposit Z80 instructions in unused blocks of on-board memory. The user code may be defined as an op code and thereafter treated as just another firmware command.

### Concerning Gray Levels and Color

The one drawback of the MicroAngelo is that it does not have gray levels — meaning the ability to have levels in between black and white or on and off. However, I was informed by Scion that another product, as yet unnamed, is available. This is another S-100 board which mixes the output of three or more MicroAngelo boards to produce *color, gray levels, or both*; four colors can be obtained with as few as two boards. This scheme does require more than one MicroAngelo board, but compared to other graphics displays with 512 by 480 resolution, this approach is still cost-effective. The board does offer interesting possibilities: 256 gray levels, the 256 possible hues or colors, and the winking of dots on an individual dot basis. Also, it is possible to use the winking effect to alternate between two colors.

### Conclusions

The MicroAngelo video display system provides quality high-resolution graphics capabilities to S-100 bus (or similar) microcomputer systems, with an exceptional price-to-performance ratio.

On-board firmware provides a simple but powerful set of commands that makes system integration easy.

Although the board is designed to run on the S-100 bus, it can be easily adapted to almost any other bus or input/output port organization and does not require an 8080 or Z80 host computer. ■

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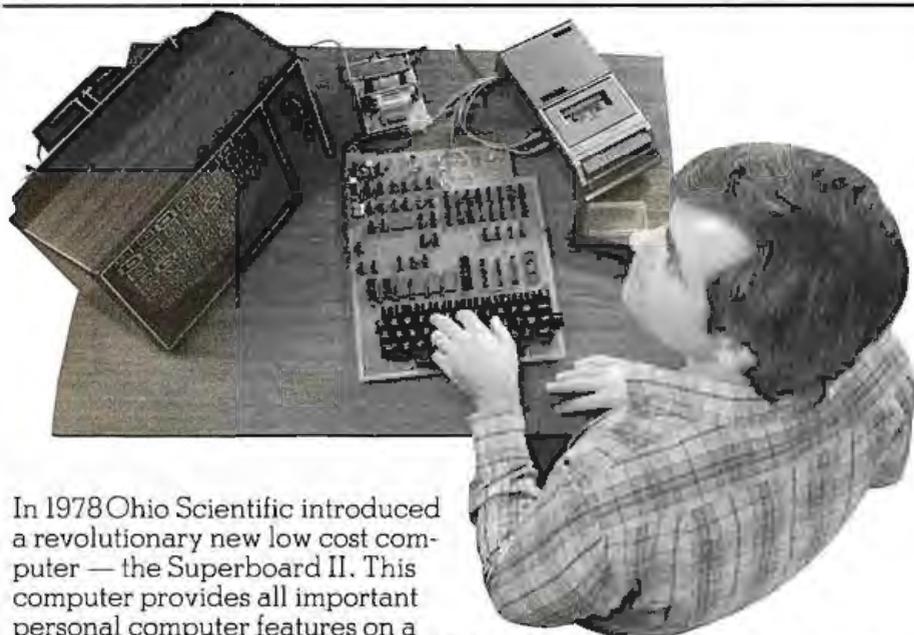
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Inevitably, system failures will occur and can usually be remedied by personal knowledge and help from numerous books and articles on computer-circuit theory. But one frequently neglected area is the operational theory of the most used human-to-computer interface: the monochrome video monitor.

The video monitor is a basic part of most personal computer systems. The theory described here applies to converted television receivers and professional monitors. The two differ mostly in the video amplifier's frequency response and the cathode-ray-tube phosphor color: a professional monitor has a greater frequency response and a green phosphor. Additionally, the professional monitor has no tuner, intermediate frequency amplifier, video detector, sound or AGC (automatic gain control) sections, which are necessary in the broadcast receiver. The latter must have these sections rendered inoperable or selectively switched out when used as a monitor. Our discussion will assume a professional monitor with direct video entry.

## The Picture Tube

The fundamental part of the video monitor is the CRT (cathode-ray tube). Various circuits are used to deflect and modulate the beam.

Figure 1 shows the elements found in the modern picture-tube electron-gun assembly. 6.3 V applied to the heater causes electrons to be emitted or "boiled off" from the cathode surface. The electrons are pulled toward the phosphorus screen by the high positive potential existing at the accelerating anode surrounding the bell of the picture tube. Typically,

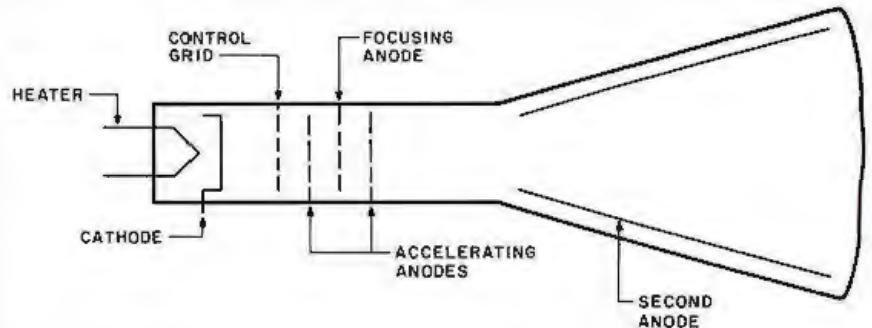


Figure 1: Internal structure of a cathode-ray tube. The electron beam is emitted by the cathode when it is heated. Electrons are attracted to the screen by a high voltage (12 kV to 20 kV) on the second anode.

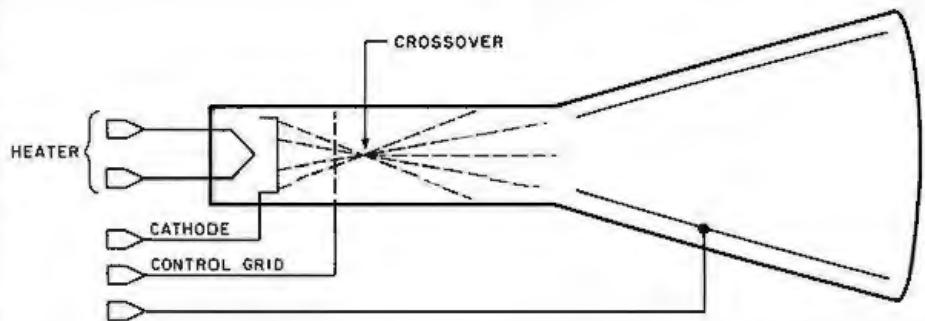


Figure 2: The crossover effect. Two accelerating anodes, in conjunction with the focusing anode, are used to give a sharp beam and a well-defined screen image. Without the focusing arrangement, the electron beam diverges and splatters.

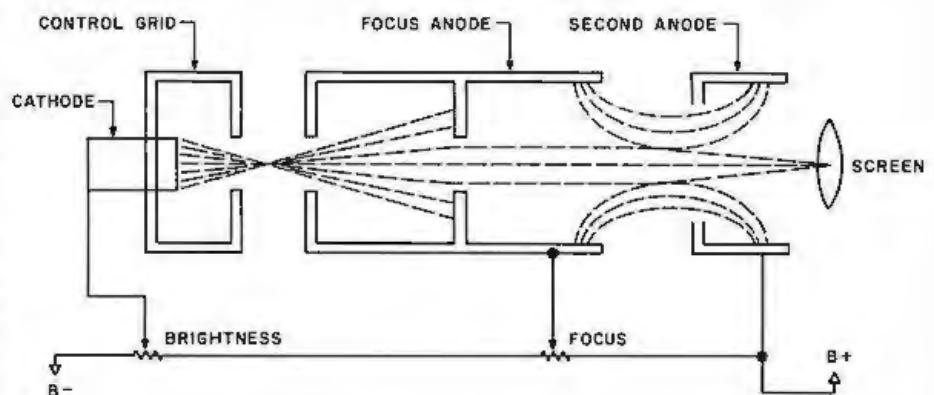


Figure 3: Focusing the beam. By applying the proper potentials to the anodes and control grids, the electron beam can be "squeezed" to a pinpoint, for displaying the image on the screen.



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voltages of 12 kV to 20 kV are fed to this anode from the monitor's high-voltage section.

The emitted electrons pass through various control grids and arrive at the screen in the form of a luminescent dot. The brilliance of the dot is controlled by adjusting the potential at the control grid. A voltage more negative than the cathode surface decreases the beam brilliance, while a more positive voltage increases the beam brilliance. Varying the control-grid voltage modulates the beam and produces the shades of black and white that form the picture elements on the monitor screen.

The two accelerating anodes, in conjunction with the focusing anode, are used to give a sharp, well-defined screen image. Without these anodes, the electron beam, after passing through the control grid, would encounter *crossover* and become broad and splattered, as shown in figure 2.

By applying the proper potentials to the accelerating anodes and the focus anode, the beam is squeezed and formed into a well-defined pinpoint suitable for displaying the images on the screen. This result is

shown in figure 3.

### Deflection Circuits and Rastering

The processes described so far would result in a black screen with a single bright dot in the center of the picture tube. The first step in obtaining a display on the screen is to pull the electron beam from side to side; this illuminates a line on the screen. The beam can be moved from top to bottom, in order to illuminate a whole screen of lines. If this is done rapidly enough, this will produce illumination over the entire area of the picture tube. This process is called *rastering*, and the dimly illuminated screen with no data information present is called the raster.

The *deflection yoke* consists of electromagnetic coils arranged in a vertical and horizontal configuration and is fitted around the picture tube neck; it is the primary device used for deflecting the electron beam. To move the beam from the top to the bottom of the screen (vertically), a rapidly rising (and more rapidly falling) sawtooth-current waveform is passed through the vertical windings

of the yoke. Figure 4 shows a sawtooth waveform produced by a typical vertical circuit and the resultant vertical sweep of the beam.

As the current rises (Time A), the buildup of magnetic flux causes the beam to be swept from the top to the bottom of the screen. When the sawtooth reaches maximum value, it rapidly falls to 0 (Time B), causing the beam to be *retraced* from the bottom back to the top of the screen, where the process begins again. During the beam sweep from top to bottom, the trace is visible, but during the retrace the beam is cut off by the *retrace blanking circuitry* to avoid undesirable retrace lines from showing. Vertical sweep of the beam normally occurs 60 times per second.

The sawtooth wave is produced in an oscillator and amplifier section of the television monitor and is fed to the vertical windings of the deflection yoke 60 times per second. Vertical beam deflection, if used alone, would result in a bright vertical line in the center of the darkened screen. To complete the rastering process, the beam must also be deflected from left to right, and this is accomplished by the horizontal circuitry.

The horizontal windings in the deflection yoke are also fed with a sawtooth current originating in the horizontal oscillator and output circuitry. The frequency of this sawtooth is 15,750 Hz. The rising sawtooth current is passed through the horizontal windings in the yoke, causing the beam to be deflected from the left to the right side of the picture. The beam is then cut off by the *horizontal blanking circuitry*, and the rapidly falling sawtooth current sweeps the beam back to the left side of the screen to repeat the process. Figure 5 illustrates a typical horizontal oscillator and deflection circuit and the resultant screen trace.

The horizontal sawtooth voltage is produced by the horizontal oscillator and output section. The sawtooth is coupled into a horizontal output transformer before being fed to the deflection yoke windings. The main purpose of this transformer is to produce the high voltage necessary for the accelerating anode at the picture tube. The rapidly falling sawtooth voltage present during beam retrace is fed to the horizontal output transformer which steps it up to a

Text continued on page 212

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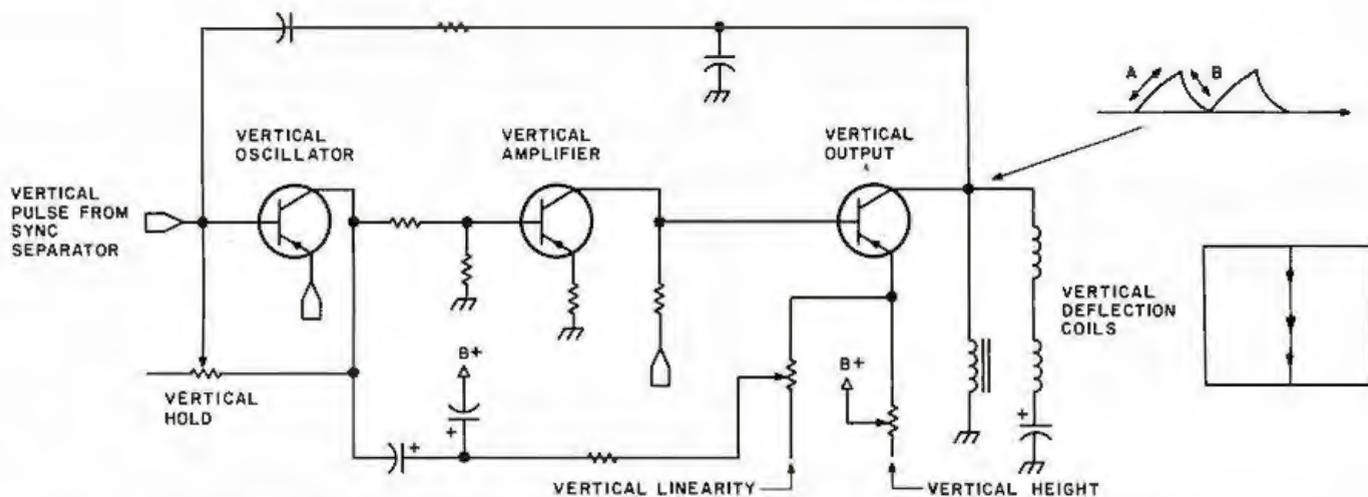


Figure 4: Typical vertical oscillator/amplifier section. The circuitry shown creates a sawtooth waveform to drive the vertical deflection coils. This enables the electron beam to move from the top of the screen to the bottom 60 times per second.

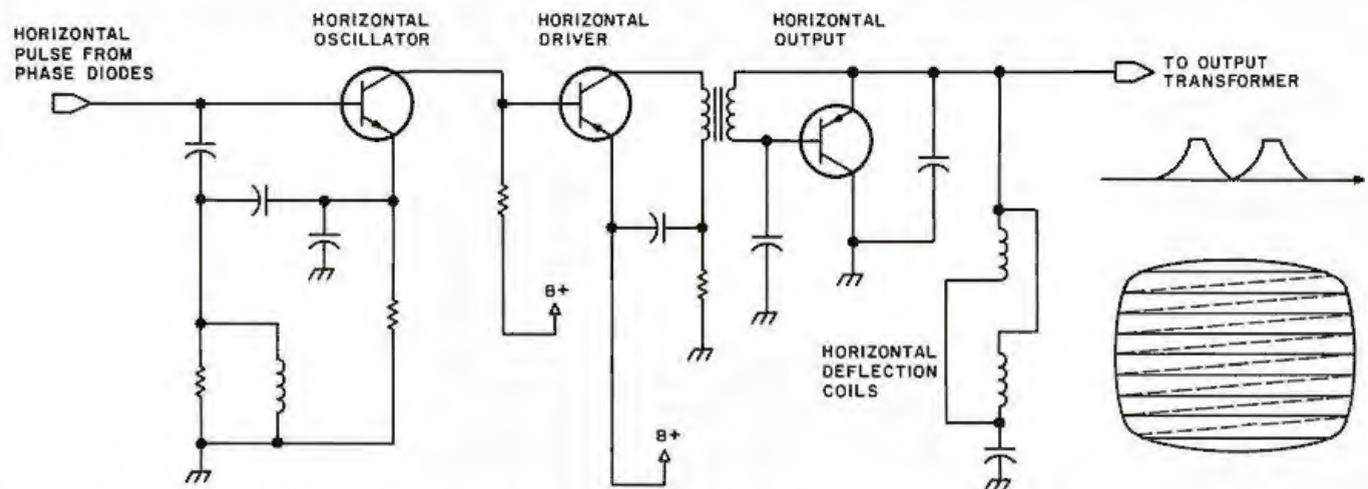


Figure 5: Typical horizontal oscillator and output yoke. The horizontal deflection coils are driven in a manner similar to the vertical deflection coils, but at a much higher rate of 15,750 Hz.

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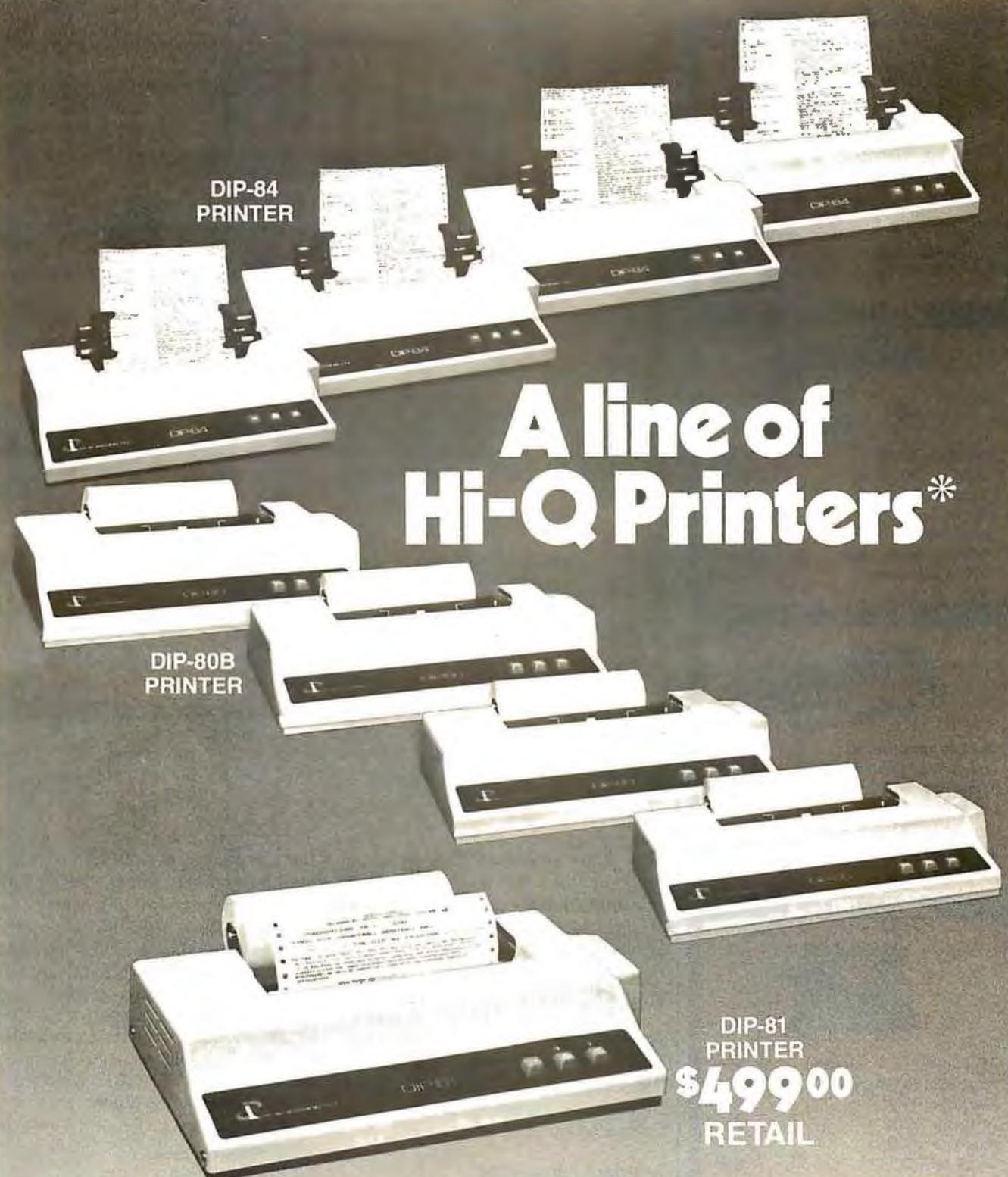
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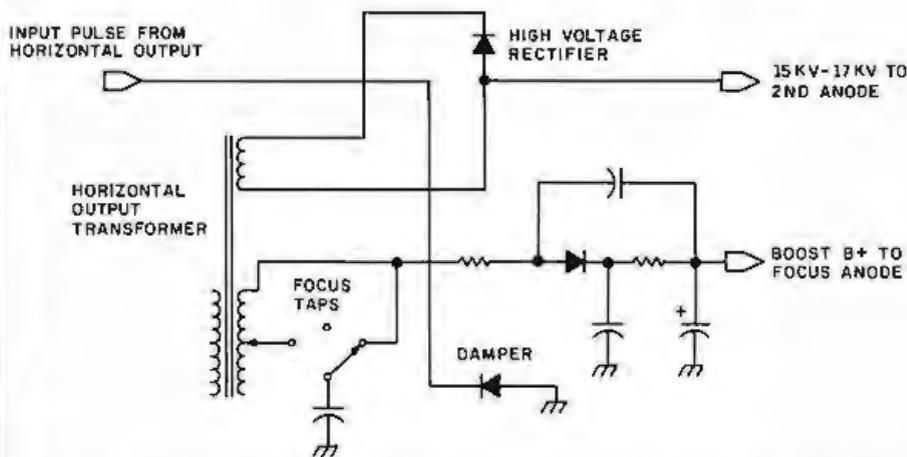


Figure 6: Typical high-voltage circuit. High-frequency AC from the horizontal-deflection circuitry is also used to produce the high voltage supplied to the focusing and second anodes. After passing through a step-up transformer, the AC is rectified and filtered for use in various other circuits.

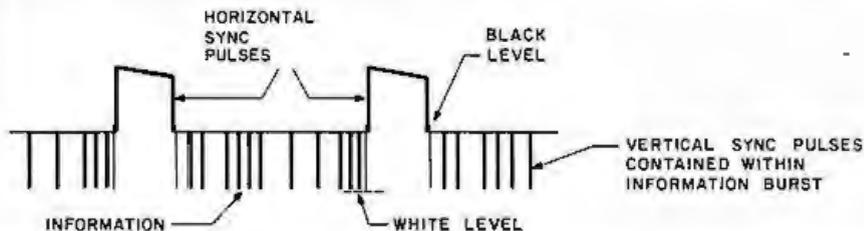


Figure 7: Composite video signal. The signal sent to most video displays contains large pulses used to keep the horizontal oscillator in time with the picture information. The picture information is essentially an on/off control of the electron beam. In most video monitors, a low pulse turns the beam on, illuminating a dot on the screen; an intermediate voltage turns the beam off.

Text continued from page 208:

very high potential. This pulsating high voltage is then rectified, filtered, and applied to the picture tube anode. Various taps on the transformer give alternate circuit voltages, including the focus voltage. Figure 6 illustrates a typical high-voltage circuit.

The production of high voltage to accelerate the electron beam combined with the horizontal and vertical deflection of the beam all work together to produce a dimly illuminated raster on the screen.

**Interlaced Scanning**

A careful study of the raster reveals the precision with which it is produced. The raster is usually composed of 525 finely spaced parallel horizontal lines, approximately 480 of which are visible within the viewing area of the picture tube. The number of lines and the scanning method used depend on the particular video interface used, and I will assume a high-quality monitor used with a video system outputting sixty-four or more characters per line.

The vertical oscillator and output section utilize an interlaced scanning method which traces 262.5 lines across the screen in 1/60 second, then returns to trace a second set of 262.5 lines between the previous lines. Each set of lines is called a field, and the two fields combined produce one complete data picture or frame. When the electron beam is modulated to produce a picture, one frame occurs once each 1/30 second, and thirty complete pictures occurring each second are sufficient to give the illusion of a continuous display. Exceptions to this process are video-interface techniques which do not interlace their fields but which trace a complete picture in one field. The 60 Hz scan rate can also vary.

**The Composite Video Signal**

In order to synchronize the monitor's vertical and horizontal oscillators with the video-interface output, a composite video signal or separate video and synchronization signals are coupled to their respective stages. The purpose of the syn-

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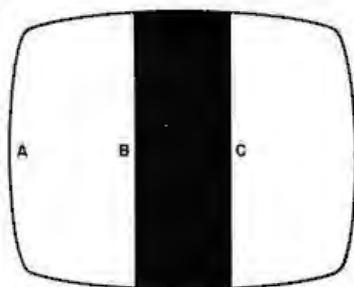
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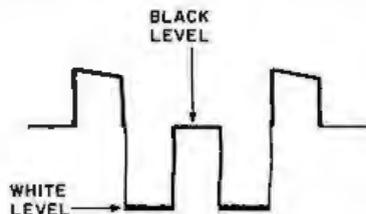
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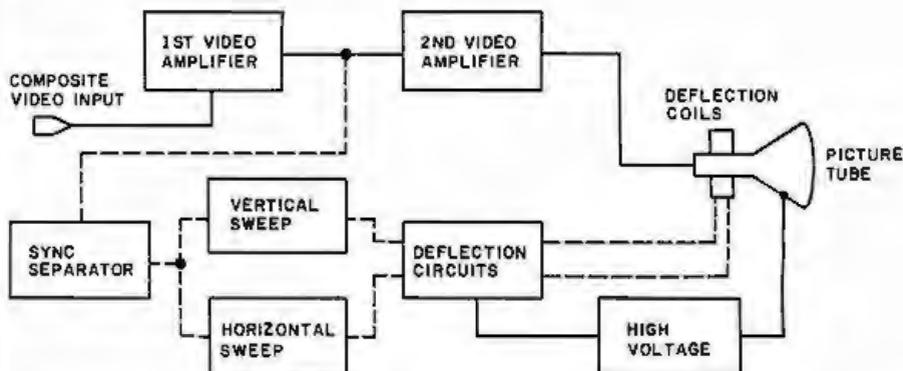


(a)



(b)

**Figure 8:** Sample video display and corresponding composite video signal. The low portion of the composite signal (b) turns on the electron beam to illuminate the screen (a). When the intermediate voltage of the black portion is encountered, the beam is turned off. As the composite signal returns to the low white level, the screen is illuminated again.



**Figure 9:** Block diagram of the signal path in a typical monitor. The solid lines represent actual video information, while the dashed lines indicate the path of synchronization signals.

chronization signals is to time the vertical and horizontal oscillator stages to the video information fed to the picture tube. Figure 7 is a sketch of the most widely implemented composite video signal.

This signal contains both the horizontal and vertical synchronization pulses (called sync pulses) and is applied to the sync separator where the horizontal and vertical pulses are separated, amplified, and sent to their respective oscillators to synchronize their respective traces. Included in the vertical sync pulses (assuming interlaced scanning is used) are equalization pulses whose function is to assure that the second field of lines is interlaced with the first.

**Electron-Beam Modulation**

The last link in the chain to create an image is to modulate the electron beam, turning it on and off to display white dots on the dim raster; this forms the dot matrices arranged as alphanumeric characters. The infor-

mation contained in the composite video signal is actually a series of voltage reference levels which are amplified in the video amplifier and applied to the control grid or cathode of the picture tube to turn the electron beam on or cut it off. The black field in the display is represented by a voltage near the black level just under the horizontal sync pulse. Figure 7 illustrates this. The white dots in the picture are represented by the white level, or minimum voltage. In scanning the display shown in figure 8a, when the beam begins its trace at point A, the voltage level is minimum, or white as in figure 8b. When point B is reached, the voltage level jumps to the black reference level and cuts off the beam at the picture tube. A black screen is evident. At point C, the beam is on again, and white is presented.

Production of a display on a video terminal is more complex, but the beam is modulated in the same way to produce numerous dots of white



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(corresponding to data elements sent from the video interface). Alternate methods employ black data elements on a white field. The frequency response of the video amplifier stages determines how fast the beam can be turned on and off; the faster the response, the more data elements can be displayed on each line with good resolution.

### Home Television Receivers

The video amplifier section in a professional monitor differs greatly from that in a television receiver. Television receivers can rarely be modified to produce dots of a rate beyond 5 MHz, while monitors can be purchased with from 12 to 100 MHz response. The converted television receiver must have its tuner, intermediate frequency amplifier and sound section switched out when employing direct video input. The limited frequency response generally allows only up to thirty-two characters per line, but the low cost of such receivers makes them an attractive choice.

After injection and amplification of the composite video signal in a televi-

sion receiver used for video display, the video is separated from the synchronization pulses, and the latter are sent to the synchronization section. The separated video information is then amplified by the video amplifier, coupled to the picture tube, and used to modulate the electron beam. In systems using separate video and synchronization inputs, the vertical and horizontal pulses are not processed in a synchronization separator, but are fed directly to their respective oscillators. The separate video is directly coupled to the video output stage.

### Troubleshooting

When all the circuits described above are working in perfect unison and are synchronized by the composite video signal, a stable display will be produced. A malfunction at any stage in the monitor creates a problem peculiar to that particular section. So, what do you do when the monitor fails?

The first step is to obtain a good, accurate schematic of the circuitry (preferably *before* any problems occur). The manufacturer should sup-

ply this. Locating problems can be somewhat simplified by considering a monitor as consisting of the sections shown in the block diagram of figure 9. Using this diagram, we can observe the signal flow lines to generally predict the section where the problem may lie. Some symptoms and their solutions will prove helpful.

- **No Video or Raster:** Assuming that the power supply is functioning, the absence of raster could mean that the electron beam is not being deflected across the picture tube screen. Perhaps no beam is present, so the logical checkpoint is the high-voltage section to see if the beam accelerating potential is present. Use of a high-voltage probe is necessary here.

If the high voltage is present at the anode of the picture tube, it is best to measure voltages at the control grid and cathode of the picture tube, assuming that a visual check revealed that the heater was lit. Having cleared the picture tube and proving that a beam can be formed, proceed to check the horizontal-sweep section where

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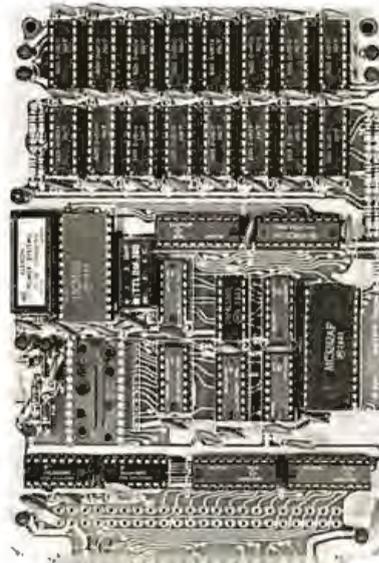
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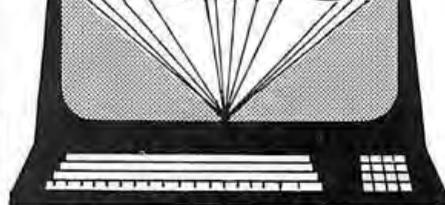
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voltages originate which directly or indirectly affect both horizontal and vertical deflections of the beam. The final step would be a check of the deflection system itself.

- No Video — Raster Present: A raster always indicates that vertical and horizontal sweep, deflection, high-voltage and low-voltage sections are working. Assuming a video signal is present, we should investigate all portions of the monitor's video amplifier section, also the picture-tube-control-grid and cathode circuits.
- Raster and Video Present — Vertical Rolling: Assuming the vertical hold control does not stop the vertical roll, this indicates that the vertical oscillator is not in step with the video interface signal. The obvious starting point is the vertical sweep section, particularly the vertical oscillator.
- Raster and Video Present — Horizontal Lines: This problem is very similar to the above vertical problem, except that horizontal lines are the problem. Again, this indicates that the horizontal oscillator is out of step with the video interface circuitry. Investigate the horizontal oscillator to correct this problem.
- Raster, Video Present — Display Rolling and Drifting Sideways: This is both a vertical *and* horizontal problem. Obviously the circuit feeding both horizontal and vertical oscillators is at fault, and this would be the synchronization separator or amplifier. When symptoms or tests indicate one section as the probable point of trouble, proceed to check voltages for direct-current biasing and use an oscilloscope to investigate waveforms.

Troubleshooting is a logical, step-by-step procedure. In repairing your monitor, the screen is the best visual aid you have, and should be utilized to the utmost in preliminary generalizations as to the problem circuit. And troubleshooting a video monitor yourself, whether or not it's homebrew, can give you the satisfaction of knowing your hardware a little bit more. ■

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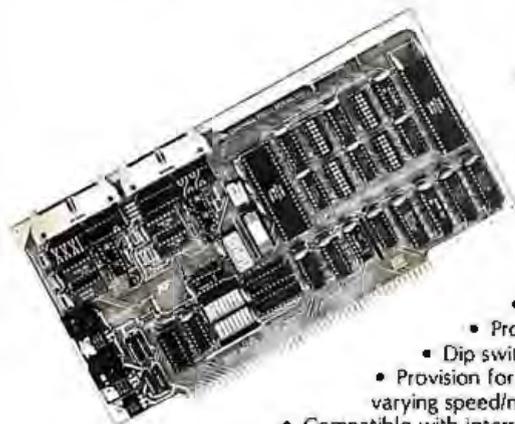
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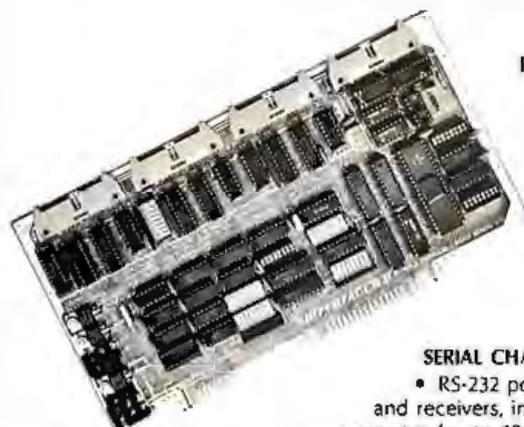
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# Digital Storage of Images

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Thomas Williams  
39A Mill St  
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The availability of inexpensive computer memory has brought high-resolution gray-scale and color graphics within the reach of the home computer experimenter. Over the last decade the ability to capture video signals in digital form, manipulate the stored data, and display it has moved from military and research engineers to undergraduates and interested hobbyists.

## Quantization

Before examining methods of capturing video signals, let's look at image quantization, which is the process of converting an image into one or more arrays of numbers. The value of each array element represents the measure of light present in the area of a corresponding point in the original image. These array or picture elements are called pixels.

A typical gray-scale image might be quantized into a two-dimensional array of values that range from 0 to 15, representing intensity values from black to white. If the array were 256 by 256 elements or 64 K pixels, each with a 4-bit value, the array would occupy 32 K 8-bit bytes of memory.

## Scanning

To perform the quantization, the image is scanned by a transducer capable of converting light into an electronic signal. This signal is sampled periodically, and each sample is converted into a numeric value. Transducer sensitivity, scanning rate, and sampling rate all affect the quality and form of the digital image.

There are basically four methods of

scanning images. The first requires the movement of the transducer with respect to the image or scene. This is typically done by drum scanners where an image is spun under a light source and photodiode. (See figure 1.)

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No matter how much effort is spent on improving the system, the results are only as good as the input.

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The second method deflects either a light beam or sensor optics in two dimensions to scan the image. This method is often used in a device called a flying-spot scanner; such devices were used during the first decades of television for transferring movies to video form for broadcast.

The third method is the use of a television camera. In a television tube (ie: a vidicon) the image is focused on a target that is scanned with an electron beam. (See figure 2.) It can be thought of as a CRT (cathode-ray tube) working in reverse.

The fourth method, which is still rather expensive, is the photodiode-array camera. It uses an integrated circuit which contains an array of photodiodes and circuitry to help scan the array. Advantages of this camera over vidicons are the stability of its geometry (as vidicons require electron-beam deflection which is never completely repeatable and accurate) and the inherent immunity to

shock (as vidicons are vacuum tubes and thus sensitive to abuse).

## Video Costs

As with anything electronic, there are uncontrollable costs of precious metals and precision parts, and controllable costs of design and assembly. Hardware hobbyists with good supplies of parts can usually find clever ways of cutting costs. Most of us, though, have limited resources and must buy kits or search for bargains on assembled equipment. Video cameras sometimes show up at flea markets in various states of repair and can provide you with a good video signal at very low cost. Home-video enthusiasts and closed-circuit security systems have also provided a marketplace for inexpensive cameras.

Cameras with sufficient quality for use with digital image-capture systems can be quite expensive. The increased costs usually provide more geometric linearity and a more uniform imaging-target surface. Black-and-white cameras range in price from about \$200 to \$10,000. At the lower end of the price scale you can expect about 5% error in the linearity of the vertical and horizontal scanning. Usually these errors are not noticeable. Geometric linearity is only important when the image-capture system is used for a precise geometric task, such as measurement of object size.

Target nonuniformity is a source of concern. Inexpensive cameras may have differences in video level (for uniform illumination) across the im-

# Why is the 88G Printer the new industry leader?



## QUALITY

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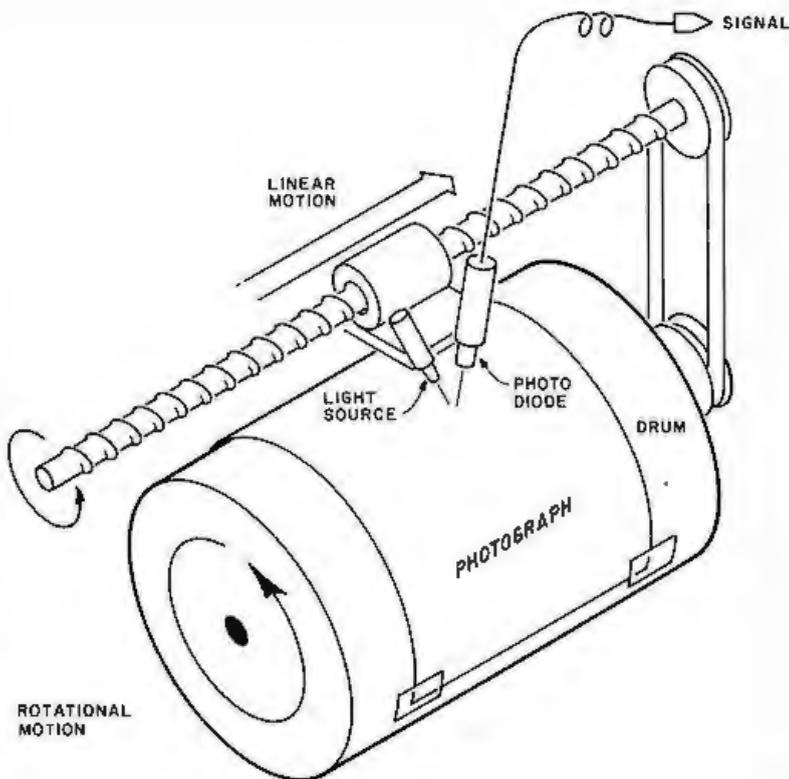
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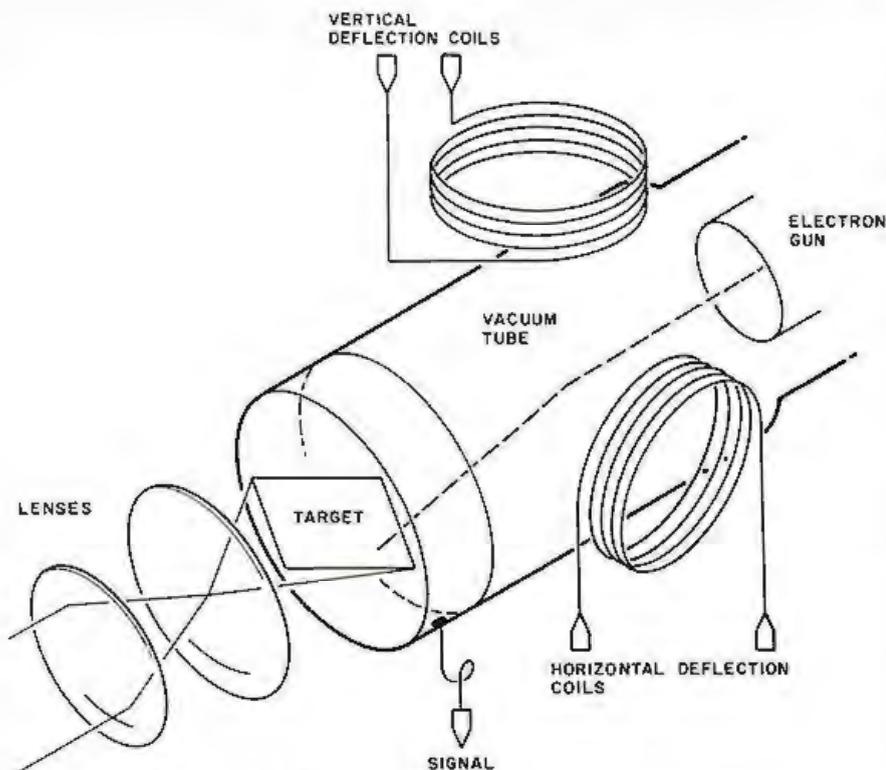


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**Figure 1:** A drum scanner produces high-quality results by moving the photograph relative to the sensor. Its drawbacks are that it requires precision mechanical construction, works very slowly, and the signal it produces is not video-compatible.



**Figure 2:** A vidicon tube. This most popular method of converting an image into an electronic signal uses a photo-sensitive imaging target which is scanned by an electron beam. The resulting signal is the scanned image in the form of a changing voltage. Disadvantages of the vidicon are its unstable geometry (since electron-beam deflection is never completely repeatable and accurate) and its low resistance to shock (since vidicons are vacuum tubes).

age as much as 20%. This error (also called *shading*) is still present in more expensive cameras where it's typically reduced to 10% or less. Fortunately, the shading effect changes slowly across the image target. Actual defects in the target are often found in inexpensive cameras, leading to black or white spots in the image.

It is possible to make some correction for the effects of shading and defects after the image is quantized. To do so, you first quantize an image of a solid-gray surface. The deviation of each point's value from the average value indicates the amount of correction that is necessary. By storing this image (or an image of corresponding correction values) the recorded target sensitivity can be used to improve the quality of another image quantized from the same television camera.

A television camera is to an image-capture system as an antenna is to a television set. No matter how much effort is spent on improving the system, the results are only as good as the input. Although the system can be made to compensate for some of the deviations in the camera, improvement of the video source is usually the choice for further investment once an image-capture system is in place.

A video image is normally generated in a 4:3 aspect ratio. This means that a properly operating camera produces it in a format that must be presented on a screen with three units of height and four units of width. Typical television sets are adjusted to approximately this ratio. If the video signal is quantized into a square array of square pixels, only a portion of each line should be quantized. (See figure 5.) Because there are approximately 512 lines of useful video image in a frame (approximately 256 lines in a field), it is often convenient to work with 512 or 256 squared resolutions. Some manufacturers of quantizers offer nearly square pixels by quantizing during 3/4 of the horizontal period, while others offer square pixels by digitizing the entire image at 640 by 512, 320 by 256, or other resolutions. Still others offer rectangular pixels. To achieve square pixels, the sampling rates must be increased by a factor of 1.33. If the entire image is to be quantized with square pixels, the memory requirements must also be increased by a factor of 1.33.

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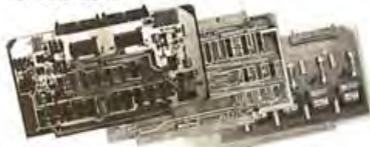


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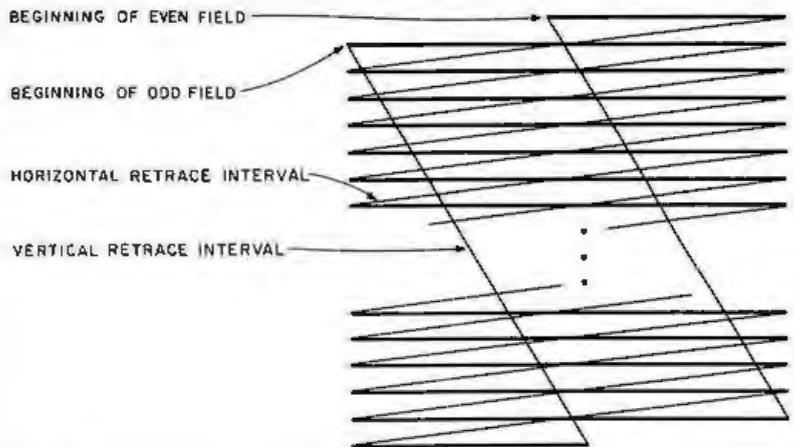
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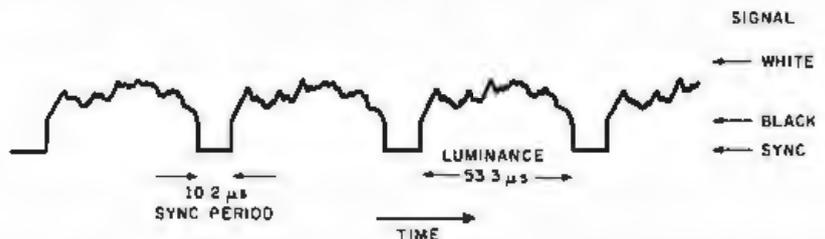
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**Figure 3:** Video lines are interlaced in a 2:1 ratio to reduce image flicker. Each frame of a video image (1/30 second) is made up of two fields. During the first 1/60 second the even-numbered lines are scanned, followed by the odd-numbered lines during the second 1/60 second. The luminance signal (black-and-white intensity) is indicated by the heavy lines. The narrow lines indicate intervals during which the electron beam is off in order for the deflection circuits to prepare for the next luminance signal.



**Figure 4:** Each line of a video signal is composed of a horizontal active-line period (53.3  $\mu$ s), which contains the luminance information, and a sync period (10.2  $\mu$ s), which contains reference levels and the horizontal sync period.

## Noise and Averaging

Video signals, like all signals, contain noise. It arises from several sources, primarily the circuits which amplify the sensor output. Very high quality video sources can have signal-to-noise ratios exceeding 45 dB. This is approximately equivalent to a noise of  $\pm 1/2$  the least-significant bit in a 7-bit quantization. However, many inexpensive home cameras, videotape, and off-the-air sources often exhibit signal-to-noise ratios worse than 25 dB or about  $\pm 1/2$  the least-significant bit in a 4-bit quantization. Why is it that such noisy video is still quite acceptable to a viewer? The noise is random; it changes every 1/30 second; and the eye averages out the noise. If you carefully view still video frames, such as on television sports events, the noise becomes apparent.

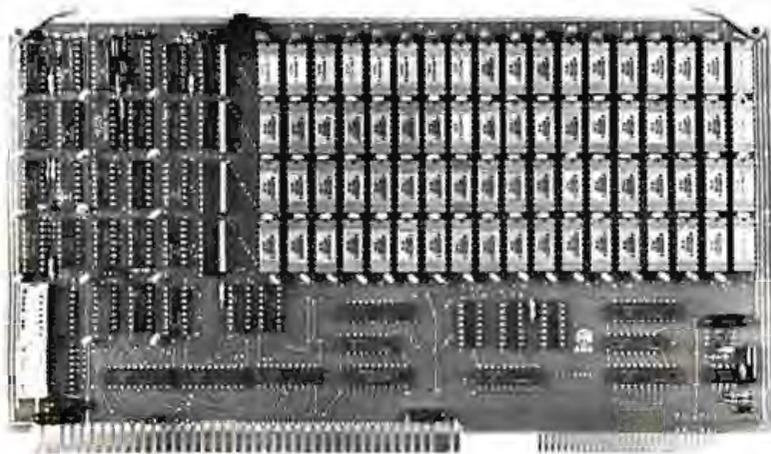
To improve the noise figure and the quality of the captured image, a number of frames can be pointwise averaged. Several frames are used to accomplish this: the first frame is

digitized and stored; the second and successive frames are digitized; and each value is added to the corresponding stored value. The resulting array of numbers is divided by the number of frames used. Thus, the value for each point becomes the average of digitized values for that point across all the frames used, effectively cancelling out random noise. The improvement can be quite dramatic in situations where considerable noise is present. One can expect to achieve about  $6.3 \times \log_2 N$  dB improvement for  $N$  frames up to a practical limit of about 45 dB. This maximum figure depends on the signal source, and the improvement depends on the randomness of the noise.

## Sampling

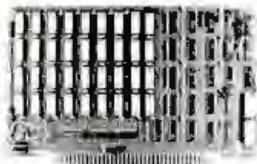
The process of quantization consists of a sampling and a digitization phase. The sampling phase determines exactly when the signal value is to be frozen in time so the instantaneous value can be converted into a

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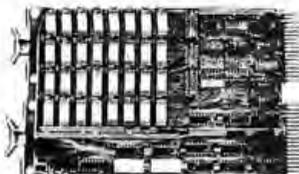
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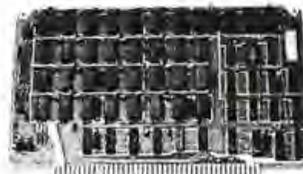
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number (ie: digitized). The sampling function is accomplished by periodically pulsing a sample circuit. The value of the video signal is then used to charge a capacitor that holds that value during the time needed by the digitizer until the next sample pulse. A sample-and-hold circuit provides the necessary components in hybrid or monolithic form. (See figure 6.)

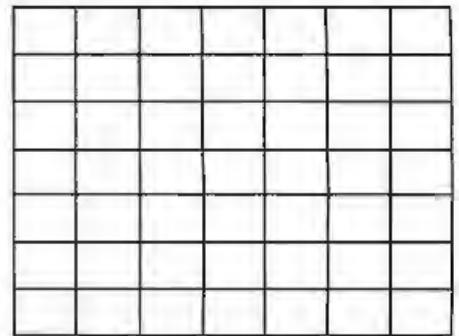
The choice of sampling rate determines the spatial resolution with which the video signal is quantized. The sampling theorem tells us that a sample frequency must be chosen that is at least twice the value of the highest frequency component in the signal that we wish to record. Thus if we choose to sample at 10 MHz, or once every 100 ns, we will be able to record components of the video signal which are changing at rates up to 5 MHz. Sampling at this rate guarantees adequate data for all normal black-and-white video sources, since they contain very little energy beyond 4 MHz.

Examination of the sampling process shows that if there are frequency components in the signal above half of the sampling rate, false informa-

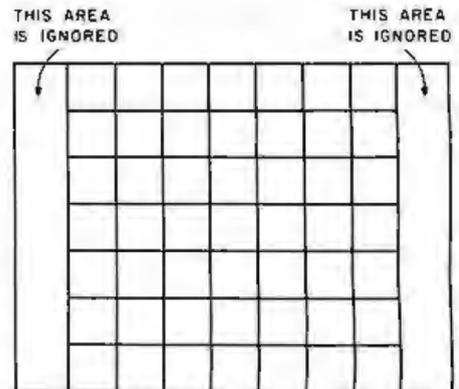
tion (called *aliasing*) results. (See figure 7.) The aliasing component is effectively a beat frequency between the sampling frequency and the signal components above *half* the sampling frequency. In the case of standard video, the luminance signal is already filtered to roll-off in amplitude above 4 MHz. However, the chrominance signal in color video occupies the range from about 3 MHz to 4.5 MHz.

Therefore, you must either filter the signal to remove frequencies above about 3 MHz, derive a pure luminance signal from a properly designed video demodulator, or use a strictly luminance source, such as a black-and-white television camera. When digitizing at lower resolutions (and sampling at lower rates), the signal must be filtered accordingly.

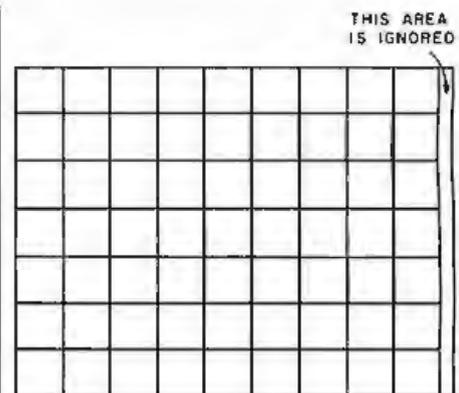
The quality of a quantized video signal depends on accurate timing. If every element of the digital image is to be precisely aligned with the corresponding element in the video lines above and below it, the digitizer clock must be precisely synchronized with the television horizontal-sync signal. Also, the digitizer clock must not drift during the time between



(a)



(b)



(c)

**Figure 5:** The aspect ratio (width:height) of normal video is 4:3. The aspect ratio of each individual pixel is determined by the image-sampling rate.

**a:** This 7 by 7 square array of rectangular pixels is produced by sampling the same number of points per line as there are lines in a frame. For example, each line in an American-standard television frame (512 lines) would be scanned as 512 points.

**b:** By increasing the sampling rate by 1.33, square pixels result and a 7 by 7 array results from a square portion of the frame.

**c:** With the same increase in the sampling rate as in b, nearly the entire frame can be quantized into a 9 by 7 rectangular array of square pixels.



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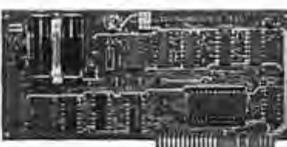
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by Phelps Gates



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To aid in learning APL, lessons are included on the disk. Starting from the basics, you are brought step by step through the various programming techniques involved with APL. These lessons act as a tutor in a "learning by doing" atmosphere which will have you "talking APL" in no time. Also available is the book, **APL: An Interactive Approach**, which reinforces many of the examples given in the lessons. The book also provides additional insight into APL programming.

### LIMITATIONS

Due to the absence of the special APL character set on the TRS-80, APL-80 uses shifted letters to represent the various APL characters. These shifted letters are identified on the screen by a graphics block before each shifted letter. If you have a modified TRS-80 (Electric Pencil Modification), a lower case driver is included to display the shifted letters on the screen.

In addition to the keyboard limitations, there are several other limitations. Lamination, domino, and matrix inverse are not implemented but can be derived with user-defined functions.

Multiple specifications must be split into two statements unless the left-hand assignment is to a quad. This also applies to implied multiple specifications.

Reduction and reshape (p) are not permitted for empty arguments; the argument of add/drop may not be scalar; empty indices are not permitted.

A quad (q) can't be typed in response to a quad (nor can the name of a function which itself gets input from a quad). Quote-quad (m) is permitted.

No more than 32 user functions can be defined in a single workspace and a function may not contain more than 255 lines.

A comment (c) must occupy a separate line; a comment can't follow a function statement on the same line.

In the tape version, arrays are limited to five (5) dimensions.

### FEATURES

APL-80 on disk contains the following features: )SAVE and )LOAD workspace on disk; )COPY other workspaces into current ones; Return to DOS for directory or commands without losing your workspace; Send output to lineprinter. Five workspaces of lessons included; Sequential and random files; 15 digit precision; Monadic and dyadic transposition; Easy editing within FUNCTION lines; Latent expression (FUNCTION can "come up running" when loaded); Tracing of function execution; Real-time clock; User-control of random link; Workspace is 25587 bytes (in 48K machine); Arrays may have up to 63 dimensions.

### COMMANDS | APL-80

APL-80 supports the following commands: Absolute value, add, and, assign, branch, catenate, ceiling, chr\$/asc, circular, combinatorial, comment, compress, deal, decode, divide, drop, encode, equal, expand, exponential, factorial, floor, format, grade down, grade up, greater, greater/equal, index generator, indexing, index of, inner product, label, less, less/equal, logarithm, maximum, member, minimum, multiply, nand, negate, nor, not, not equal, or, outer product, peek, poke, quad, quote quad, random, ravel, reciprocal, reduction, reshape, residue, reverse, rotate, scan, shape, sign, system, subtract, take, transposition.

### SPECIFICATIONS

Minimum system requirements: 32K disk system (48K recommended) Includes APL-80, Five workspaces of lessons, instruction manual.

Price: \$39.95 on disk

Reduced feature: 16K Level II tape version, no lessons.

Transpositions, format, and inner product not implemented. Reduced domain for some functions. 6 digit accuracy.

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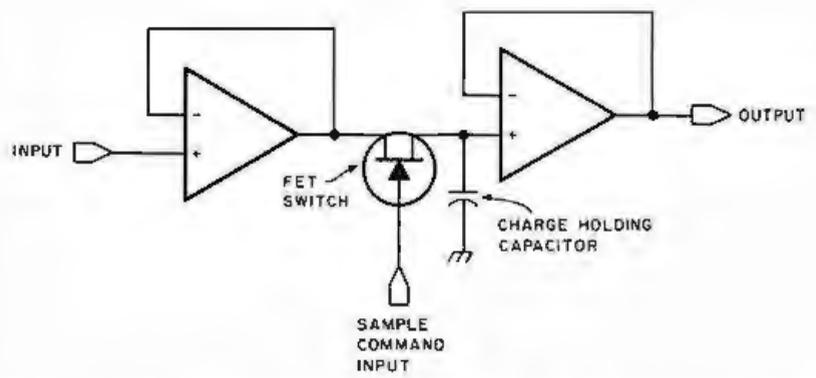


Figure 6: An image is quantized in two phases: sampling and digitization. Sampling freezes the signal value so that it can be converted into a number (digitized). A sample-and-hold circuit such as shown here performs the sampling phase. Because of the low output impedance of the first operational amplifier, the capacitor is charged nearly instantaneously when the switch is operated by the video signal. The high input impedance of the second operational amplifier holds the capacitor at its full charge during the time the digitizer reads the signal.

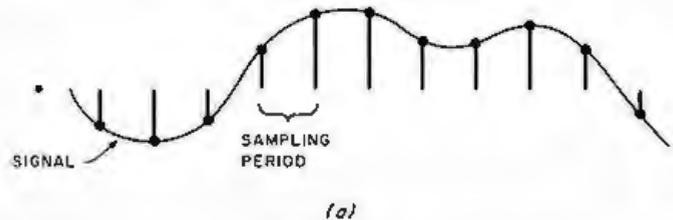


Figure 7a: A correctly sampled video signal. Each dot indicates an instantaneous value read by the digitizer.

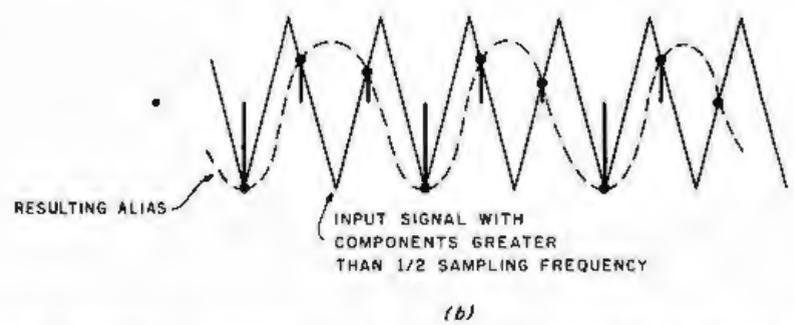


Figure 7b: If high-frequency components are present in the video signal which are above one-half the sampling rate, false information (aliasing) results. Aliasing is a beat frequency between the sampling frequency and those signal components above one-half the sampling frequency. A low-pass filter is used to filter the frequency components and eliminate aliasing.

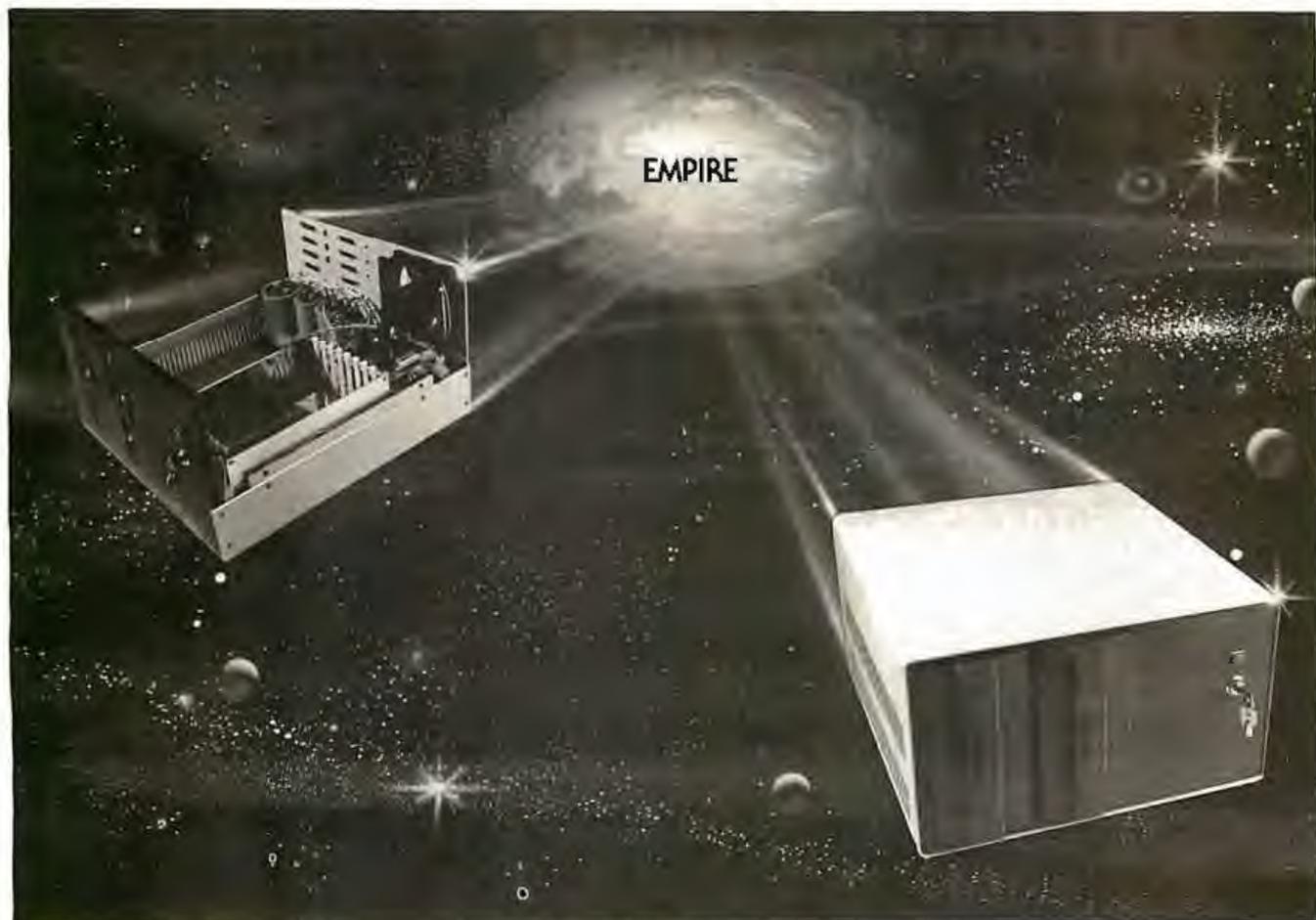
horizontal-sync pulses. It is as much the attention to timing as to the high-speed technology that makes quality digitized video a reality.

### Low-Speed Digitization

The digitizer, or A/D (analog-to-digital) converter, is commonly thought of as a device that takes on the order of 20  $\mu$ s to 50  $\mu$ s to determine an 8-bit or 12-bit value. Such converters are inexpensive and are adequate for sampling slowly changing signals, such as an audio signal.

To digitize a video signal with such a converter, you can sample the signal no more often than about once per scan line. (See figure 8.) During the first frame, the first point of each line is digitized. During the second frame, the second point of each line is digitized, and so forth, until the entire image is digitized. If 512 samples per line are needed, 512 frames of video would be required to digitize every point. Thus, it would take about 17 seconds to complete the digitization of one frame. To do this the camera

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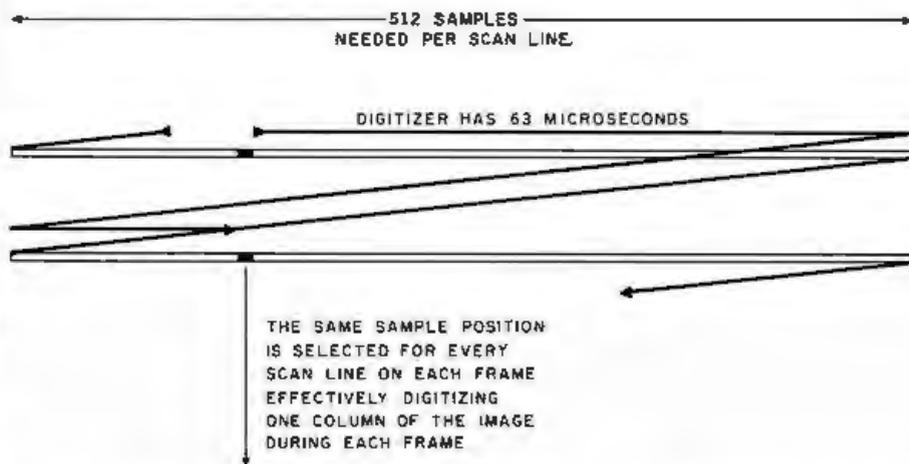


Figure 8: By sampling a single point per scan line, the digitization of each pixel can be completed within 63  $\mu$ s, and data is produced at a slow enough rate (15.7 k bytes/second) for transfer to mass storage.

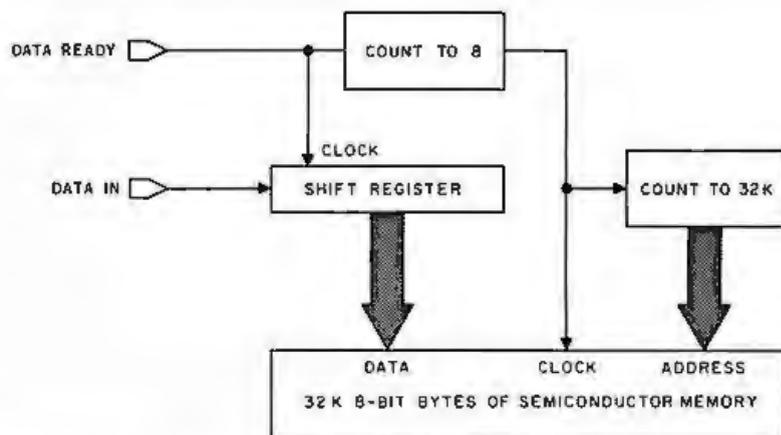


Figure 9: Through the use of a shift register, standard programmable memory can be used to transfer a single-bit image at video rates. If a single bit is deposited into the shift register every 100 ns, an 8-bit value can be deposited into memory every 800 ns. The same process can be reversed for displaying the image.

must be stationary on a tripod with respect to the object being viewed to keep the image stable. Tape players with freeze-frame options might seem attractive for this purpose. However, home videotape machines do not produce a truly stable image and are not usually adequate for this purpose.

The digitizer has plenty of time to produce a digital value. Precision is defined by the number of quantization levels, and more can be obtained for a small additional cost. Unfortunately, the sample circuitry must sample a very precise portion of the video signal, and its accuracy becomes more important if greater quantization levels are desired. Additionally, the decay rate of the sample circuitry becomes important because the sample must be held for up to 50  $\mu$ s versus the 100 ns

necessary for the high-speed digitization technique.

The advantages of slow digitization are the use of a relatively inexpensive A/D converter and low data rates, permitting direct storage of the data using floppy disks. The disadvantages are the need to hold the camera and scene stable for a length of time (depending on resolution) and the inability to capture other video sources, such as television programs and videotape. The requirements for the sampling phase are also more substantial than those for the high-speed method.

There is a hidden disadvantage of the low-speed method. The stored image cannot be readily viewed by reversing the process. The only way to reproduce the data in image form is to place a photographic camera in

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Or to add fractions: ?1/3 + 5/6 + 2/5 + 3/7;

The instantaneous answer: 419/210.

Or to perform a more difficult trigonometric expansion you enter: SIN(2\*Y)\*(4\*COS(X) ↑ 3 - COS(3\*X) + SIN(Y)\*(COS(X+Y+ #PI) - COS(X-Y));

Just a few seconds later, the computer replies: @4\*SIN(Y)\*COS(X)\*COS(Y).

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muMATH and muSIMP were written by The Soft Warehouse, Honolulu, Hawaii. Priced at \$74.95, the package includes muMATH, muSIMP and a complete manual. It requires a Model I TRS-80 with 32K and single disk. muMATH for the Apple II Computer will be available later this year.



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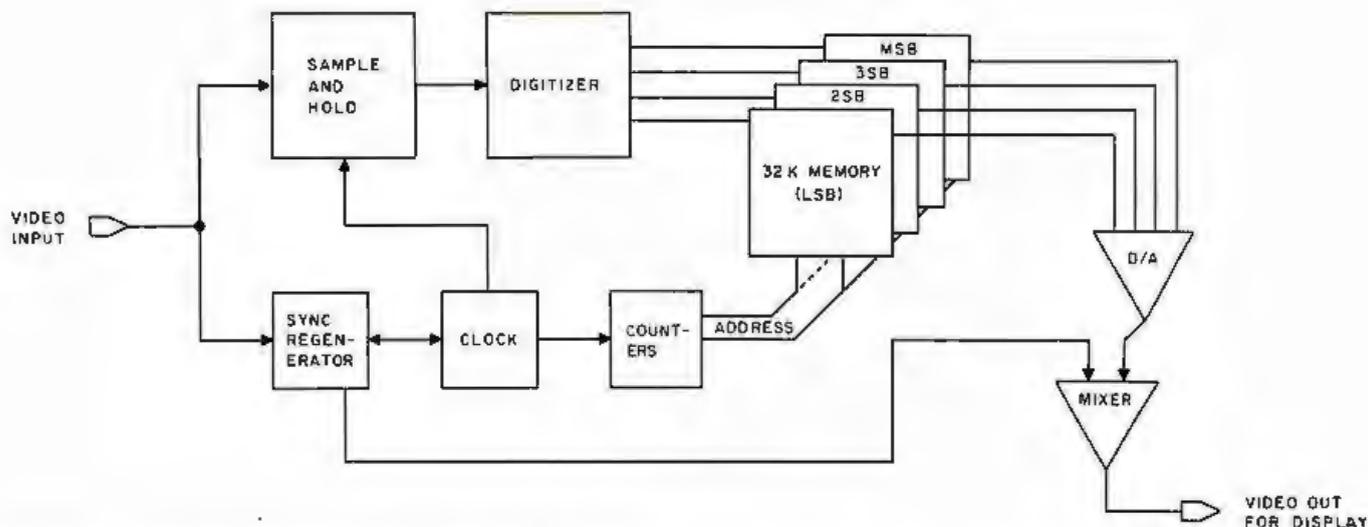


Figure 10: Block diagram of an image-quantization system. In this example, a single memory board is used for each bit of quantization. Four boards would be needed for a 4-bit quantization.

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front of a television monitor and open the shutter for 17 seconds while the data are converted back into video, one point per line. Then, of course, the film must be processed: this is hardly conducive to interactive use.

## High-Speed Digitization

If we want to digitize 512 points during each scan line, the converter must operate at very high speeds. The active portion of a video line is about 53  $\mu$ s. Roughly, this means it must quantize the signal once every 100 ns. Such converters were available 10 years ago for about \$2000, but today they can be built for less than \$100! Next I'll examine the problems of storing the data produced at this rate.

Most home computers have central memory that can be cycled at about 250 ns to 1000 ns per 8-bit transfer. If the digitizer obtains one 4-bit quantity every 100 ns (at 512 samples per line with rectangular pixels), or 8 bits every 200 ns, standard computer memory cannot cope with the speed requirement. Most experimenters own configurations with 32 K bytes

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or less of central memory. Although 32 K bytes would be barely sufficient for a 256 by 256 4-bit image, 128 K bytes are necessary for a 512 by 512 4-bit image. Therefore, memory is usually dedicated to the image-storage function and accessed by the computer through either a processor-controlled or DMA (direct-memory access) port.

The problem of providing large memories capable of 200 ns cycle times can be solved by the sequential nature of data transfers. By dividing memory into a number of parallel segments it's possible to use memories with 800 ns read/write-cycle times to simultaneously digitize, display, and communicate with the computer.

Proper memory organization

allows ease of expansion, depending on whether higher spatial resolution or more bits per picture element are anticipated in the future. Also, good designs can be software-reconfigured to trade off spatial resolution for the number of bits per pixel. Methods for reconfiguration are left for the ambitious designers to discover on their own.

### A Hypothetical Design

Assume that we'll require a 512 by 512 image with 4-bit quantization of each pixel. Memory is physically organized as four 32 K-byte memory boards. This is because there are 256 K points in the image, and we wish to have 1 bit of each 4-bit pixel value on each memory board. We will use memory which transfers 8-bit quantities.

If we shift 1 bit every 100 ns into a serial-in, parallel-out shift register, then every 800 ns the resulting 8-bit value can be deposited into memory. (See figure 9.) The same process can be reversed for real-time display. To do so, the memory is read every 800 ns, the 8-bit value is placed into a parallel-in, serial-out shift register, and shifted out at 100 ns per pixel.

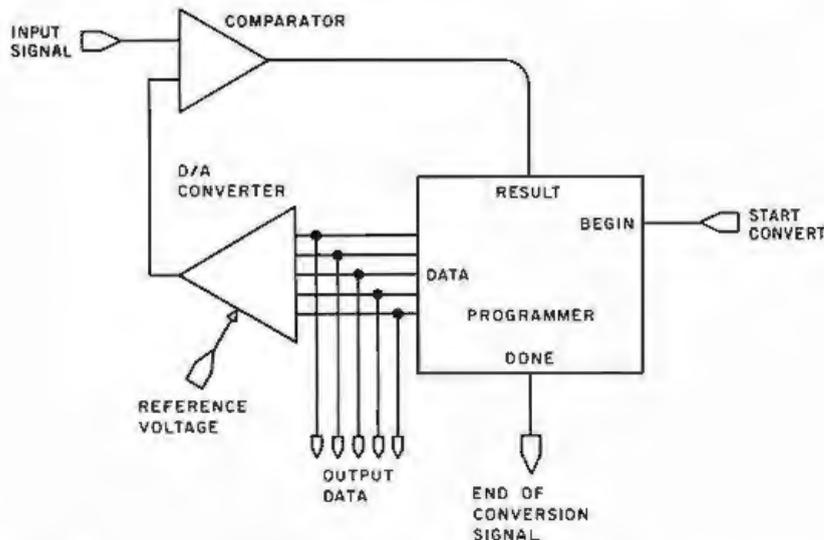


Figure 11: The configuration of a conventional A/D converter.

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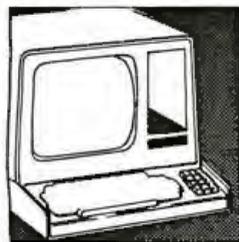
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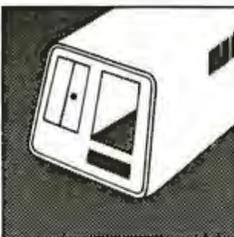


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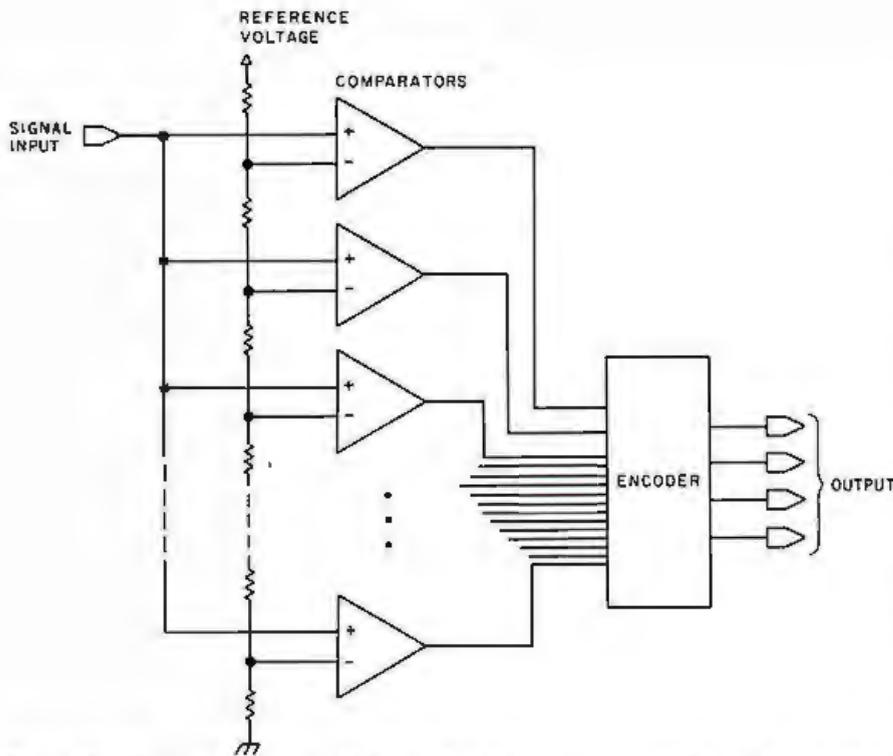


Figure 12: The small number of bits required for image quantization makes flash (or parallel) A/D conversion practical. One comparator is used for each quantization level. For a 4-bit quantization, sixteen comparators would be needed. A reference voltage equal to full scale is fed to a voltage divider to form a set of comparator thresholds. The output of each comparator is then fed to the encoder, where the number of on-comparators is converted into a binary output. Parallel converters are available in DIP form and allow for high data-conversion rates.

To achieve the desired number of quantization bits per pixel, we stack the appropriate number of memory boards. (See figure 10.) In our case, four boards would be needed for 4-bit pixels. Of course, there would have to be an address bus common to all boards and an extra board to provide control and A/D conversion. The extra board would be needed to decode the video sync signals to keep memory-addressing in step with the video signal. Additionally, D/A (digital-to-analog) conversion and sync generation are necessary to drive a display monitor.

Notice that the memory is running at very slow speeds by modern standards. If we use memory that allows two operations per 800 ns, the computer can access or deposit data completely transparent to the digitization or display process.

Now consider high-speed A/D converters. Normal converters use a D/A converter, a programmer, and a comparator to derive a numerical quantity representing the voltage on the input. (See figure 11.) The programmer tries successive numbers, generating successive voltages out of the D/A converter. These voltages are compared with the analog input to determine if they are above or below the input voltage. The comparator output is used by the programmer to decide what number to try next until the process converges on a final value.

The fastest A/D programs take about as many tries as there are bits of quantity. Each try consumes as much time as the total of the programmer gate delay, the D/A-gate delay, the D/A-settling time, and the comparator-settling time. The fastest converters perform conversion on the order of the 100 ns per bit. This is obviously unacceptable for our purposes, since we consider 4 bits to be a minimum quantization and 100 ns to 200 ns to be a maximum conversion time.

The small number of bits that are required does make another conversion technique very practical. It has several names, the most popular being *flash* or *parallel* conversion. It consists of one comparator for each quantization level, or sixteen comparators for 4 bits. (See figure 12.) A reference voltage equal to full scale is fed to a voltage divider (ie: a network of resistors) to form a set of comparator thresholds, and the outputs

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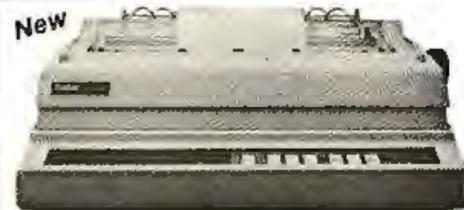
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The video standard has three primary components, synchronization signals, a luminance (black-and-white) signal, and a chrominance (color) signal. The synchronization (sync) signals tell the receiver when to begin a new frame and a new line. The luminance signal provides intensity values that comprise a picture. The signals are effectively separate, allowing compatibility between color and black-and-white television receivers. Our primary interest here is the luminance signal, but the chrominance signal must still be considered. It must be filtered out of a color video signal before quantization. (The reason for this requirement has been described in the section on sampling.)

Each complete picture, called a

frame, takes 1/30 second to complete. To reduce flicker, 2:1 interlacing is used. During the first 1/60 second, the even-numbered lines are displayed; and during the second 1/60 second, the odd-numbered lines are displayed. Each set of lines (half of the frame) is called a field. (See figure 3.)

Each field consists of 262.5 lines, each line transmitted in 63.5  $\mu$ s. Nine of these lines are used for the vertical synchronization pulse, which is actually a series of pulses that are easy for receiver circuits to recognize. Each line is composed of a horizontal active-line period during which luminance information is present, and a sync period when reference levels and the horizontal sync signal are present. The horizontal active period is 53.3  $\mu$ s, and the sync period is 10.2  $\mu$ s. (See figure 4.)

of the comparators are fed to an encoder. The analog voltage determines which comparators are on, and the encoder then turns the number of on comparators into the corresponding binary number. The only delays are the settling time of one comparator and the encoder-logic delay. I've built three of these for under \$100. They are also commercially available in DIP (dual-in-line package) form in 3-bit or 4-bit designs that allow for cascading to achieve 1 or 2 additional bits.

## Summary

Inexpensive semiconductor memory and other technological developments have made digital image storage with real-time video input and output a practical reality for the home computer experimenter. Several complete hardware and software systems are available for the display and digitization of real-time video. At least one company offers an inexpensive, real-time digitizer and display, while several offer very inexpensive digitizers to accomplish low-speed digitization. A high-speed system costs \$1500 to \$5000 or more, depending on options. The primary price difference is due to the amount of image memory desired. Low-speed systems range from about \$350 to \$4000.

Flash-conversion products range from \$30 to \$90 for 3-bit and 4-bit units with about 30 MHz maximum rate. These save you the headaches of finding matched resistor values for homebrew flash converters.

Although there isn't enough information in this brief article to construct an image-capture system, there should be enough to familiarize an ambitious designer with the techniques and problems. You would be well advised to obtain a technical manual from a manufacturer to help assess the potential difficulties. With healthy competition in the growing marketplace for image-capture and display, the power/price ratio of complete systems will continue to increase. ■

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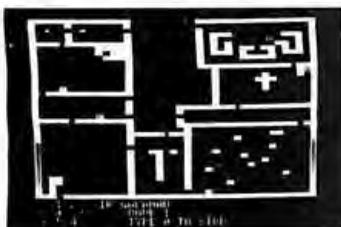
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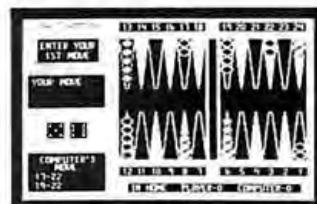
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NEWS AND SPECULATION ABOUT PERSONAL COMPUTING

Conducted by Sol Libes

**DEC Opens Computer Museum:** Digital Equipment Corporation (DEC), the pioneer in minicomputers, has opened a "computer museum" in the lobby and mezzanine level of its Marlboro, Massachusetts, "Tower Building." It illustrates, through actual equipment, the evolution from calculator to microcomputers. The exhibits include precomputer devices, the four generations of digital logic used in computers, and some early computer systems (eg: PDP-1 with the original *Spacewar* program and others). The museum is open to the public.

**Random News Bits:** Casio, Inc, the Japanese electronics manufacturer, has introduced a personal computer in the US. The FX-9000P can store programs directly in 4 K-byte CMOS (complementary metal-oxide semiconductor) memory cartridges (with lithium batteries) that can be removed from the unit. The basic unit is priced under \$900.... Pascal can now be considered as having "made it." IBM has announced that Pascal will be available for IBM systems using OS/VS and VM/CMS operating systems. IBM will charge \$235 a month for it. To think that most microcomputer users pay less than IBM's monthly charge to buy Pascal outright.... A study conducted by the National Institute for Occupational Safety and Health found that video-terminal users suffer problems of eye strain, blurred

vision, color perception, numbness, and loss of strength in their arms. These users also experience higher levels of anxiety, depression, confusion, and fatigue.... The University of Southern California will offer a graduate degree in voice I/O (input/output). The curriculum includes courses in electrical and biomedical engineering, communications, computer science, linguistics, otolaryngology, and psychology...

**Fujitsu Overtakes IBM In Japan:** For the past thirty years, IBM has dominated data processing over the entire globe. Now, however, it is reported that in Japan Fujitsu, Ltd, has overtaken IBM in sales. Fujitsu and several other Japanese computer suppliers are now preparing a massive onslaught into the US and European markets.

**IEEE Local Network Standard Moves Ahead:** The IEEE Local Network Standards Committee expects to have a draft of its standard by year's end. At this time, it appears that the Ethernet system, proposed by Xerox, Digital Equipment Corporation, and Intel, will *not* be adopted as the standard. The reasons for this are that Ethernet is still in a preliminary-definition state with many areas not precisely defined. Further, Ethernet is highly depen-

dent on coaxial cables and a particular modulation technique. Also, Ethernet does not have any provision for acknowledging datagrams, which could lead to possible incompatibilities in error control between different manufacturer's devices.

**Super Computer Planned:** The Ames Research Center of NASA (National Aeronautics and Space Administration) is planning a special super computer capable of performing a billion floating-point operations per second. The computer will be designed to simulate a wind tunnel. It is expected to have 40 M words of directly addressable memory plus 200 M words of block-addressable memory. NASA wants the system operational in 1986.

**US Government Shifting To Smaller Computers:** The US government now has a reported 15,000 computers in operation, worth more than \$5.4 billion. The trend is shifting from large, costly mainframes to smaller units. In fact, now at least two-thirds of the machines cost less than \$50,000. The GSA (General Services Administration) recently disclosed that at the end of 1979 the three leading computer suppliers were Digital Equipment Corporation (3656 units), Sperry Univac (1778 units), and IBM (1284 units). However, IBM still ranked

number one in dollars (\$1.45 billion), Control Data was second (\$754 million), and Sperry Univac was third (\$686 million).

**Ribbon Recycling:** The word-processing and printer markets have created the new business of recycling printer ribbons. About fifty vendors are offering consumers recycled ribbons at a saving of as much as 60%, along with deliveries in 5 to 10 days. Several ribbon manufacturers are introducing sealed ribbon cartridges to prevent recycling. They claim that sealing improves ribbon reliability.

**Microsoft Signs UNIX Agreement:** Microsoft, of Bellevue, Washington, has signed an agreement with Western Electric for the rights to develop and market versions of UNIX, an operating system originated by Bell Laboratories. The Microsoft versions will be specifically designed for 16-bit microprocessors, such as the Intel 8086, Zilog Z8000, and Motorola 68000. The Microsoft version will be called XENIX. UNIX seems to be the most popular minicomputer timesharing operating system in current use. It is very popular in the educational community, probably because Western Electric sold it to educational institutions for a very low fee. However, due to its sophisticated features, UNIX has been gaining in popularity in the profes-

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sional and business worlds as well.

Microsoft plans to charge an initial fee for the package ranging from a low of \$500 to \$3000 for a four-user system. The company also has plans to adapt its BASIC, FORTRAN, and COBOL compilers to run under XENIX. Microsoft has purchased a DEC PDP-11/70 minicomputer specifically for the XENIX development project. The Z8000 version is slated for introduction by year's end, and the 8086 and 68000 versions are to follow sometime in the second quarter of 1981.

Considering that Digital Research plans on developing only an 8086 version of its very popular CP/M operating system, it seems likely that Microsoft's XENIX will become the dominant operating system for 16-bit microcomputer systems.

## 5-Inch Winchester Disk Drives Coming On Strong:

At least a half-dozen companies will have 5-inch hard-disk drives on the market late in the first half of 1981. Latest to jump on the 5-inch disk-drive bandwagon are International Memories Inc (IMI) (the Cupertino, California, firm that marketed the first 8-inch Winchester drive) and Shugart Associates (the largest producer of floppy-disk drives). These drives typically store 5 million to 7 million bytes and sell for less than \$1000 in OEM (original equipment manufacturer) quantities.

## 64 K-Bit Memory Devices Becoming Available:

Several integrated-circuit manufacturers are currently supplying samples of the new 64 K-bit programmable memory circuits to OEMs for evaluation and development. Look to see these devices in use starting in early 1981.

The introduction of these

components has already caused the price of 16 K-bit devices to drop significantly; just a few months ago, these circuits cost six to eight dollars—now they are four or five dollars. Currently, the 64 K-bit memories are in the forty- to sixty-dollar range, which may drop to thirty or thirty-five dollars in production quantities.

It is expected that Japanese suppliers will dominate the 64 K-bit device marketplace. The 16 K-bit device market has been dominated by American suppliers, although the Japanese currently have 40% of that market. The demand for the 64 K-bit memories does not, as yet, appear to be very strong. However, the price erosion of the 16 K-bit memories and increasing competition from Japanese suppliers should cause the 64 K-bit memory prices to drop quickly.

## Protecting The Software Copyright:

Software vendors are very concerned about software being pirated by unauthorized copying. The problem is acute simply because it is very easy to duplicate cassette- and disk-based software. Further, it isn't especially difficult to copy software stored in read-only memories.

The personal-computer user does not appear to be the cause of the problem because most of that type of pirating is for personal use, and it occurs only on a small scale without a significant impact on vendor sales. However, several software vendors are complaining that software pirates are making copies of their software packages and selling them. The software pirate frequently changes the name of the software package and may even make some minor changes so that the consumer is unaware that the software is a fraud. The practice appears to be widespread outside the US,

where this kind of activity is very difficult to prevent.

As a result, software vendors are seeking ways to prevent pirating. Several are now experimenting with software techniques that cause the copied software to self-destruct if it is run on an unauthorized machine. I suspect that this will prove to be a deterrent for the experimenter and small-time thief, but the professional software pirate should be able to overcome this system.

## Tandy, Apple, And Commodore Are Top Personal-Computer Performers:

Each year *Dotamation* analyzes and rates the top one hundred computer companies. For the second year in a row, Tandy Corporation (parent company of Radio Shack), Apple Computer, and Commodore have made that list. In fact, for this past year Tandy ranked thirty-ninth (up from last year's fifty-eighth), Apple ranked sixty-first (up from one-hundredth last year), and Commodore ranked seventy-fifth (up from ninety-fourth last year). Tandy had gross sales of \$150 million, a 131% increase. Apple had \$75 million in sales, up from \$10 million the previous year, a 650% increase. Commodore had \$55 million sales, a 150% increase.

These three personal-computer makers had the highest growth rates of the top one hundred computer-product vendors in the US. IBM, which ranked number one in total sales, had only a 7% increase in sales.

## Talking Computers To Be The Rage:

1981 should be the year that consumers first see the widespread use of voice output in products ranging from computers to household appliances. Many manufacturers are currently supplying

samples of speech-synthesis integrated circuits to OEM customers. The manufacturers include Texas Instruments, National Semiconductor, General Instrument, Hitachi, and Votrax. The Hitachi HD38880 integrated circuit, for example, can produce up to 200 words or one hundred seconds of speech from data stored in a 128 K-bit ROM (read-only memory). The Texas Instruments TMS5200, essentially the same device used in the Speak & Spell toy, has been given an 8-bit data-bus interface and should operate easily with personal computers.

**Random Rumors:** It is rumored that Intel, Motorola, and Fujitsu are all working on the development of microprocessors that will implement the IBM System/370 instruction set. Performance is expected to be comparable to an IBM 370/115. IBM is rumored to already have such an integrated-circuit version running.... Xerox is rumored to be attempting to buy Apple Computer.... Digital Equipment Corporation is rumored ready to release a 16-bit microprocessor device that will be compatible with 8080, Z80, and 6800 support circuits. It is expected to have the power of a PDP-11/23. At least one company is rumored to be investigating an S-100 implementation....

**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 stamped, self-addressed envelope.

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# Machine Problem Solving

## Part 3: The Alpha-Beta Procedure

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Professor Peter Frey  
Northwestern University  
Cresap Neuroscience Laboratory  
2021 Sheridan Rd  
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### Zero-Sum Games

In many problem-solving situations, the wisdom of a particular decision often depends upon the range of options that someone else may have. Many real-world decision-making environments can be modeled in terms of a two-person game. When each player is aware of his own and his opponent's options at each choice point, the game is described as one of *perfect information*. If the rules of the game require that each player's gain must come at the expense of the other, then the game is strictly competitive, or *zero-sum*. Familiar games that meet these criteria are chess, checkers, three-dimensional tic-tac-toe, go, gomoku, and Othello.

The first two articles in this series considered decision-making situations in which a single individual was responsible for a series of choices. By constructing programs that searched among a large number of choice combinations, we were successful in developing mechanical solutions for these problems. When two people are making choices and each is trying to better his own position at the other's expense, the standard look-ahead search that we described earlier is no longer adequate.

### Minimax Strategy

Instead, it is necessary to consider choices in which the two players attempt to satisfy conflicting goals. Most of the important strategic ideas which are used in analyzing these games date back to a very influential book which was written in 1944 by Von Neumann and Morgenstern (see reference 4).

The key idea for our present purposes is the *minimax* strategy. In analyzing any given position in the game, a

look-ahead tree is constructed which represents the sequence of options that the two players have (as a hierarchical branching structure which grows exponentially as one proceeds away from the initial position).

The minimax strategy consists of evaluating "final" positions at some arbitrary depth (usually defined by practical constraints of time and space) and then following parent nodes all the way down the tree to the starting position. This path is defined by assuming that each player will decide among the options that are available to him at *his* choice points by selecting the one that guarantees the best possible outcome.

If the terminal evaluations are chosen such that high numbers favor the first player (and low numbers favor the second player), the first player is expected to choose the pathway that guarantees as large a terminal value as possible, and the second player is expected to choose the pathway that guarantees as small a terminal value as possible. In practical terms, the first player always maximizes, the second player always minimizes.

This description would seem to explain the derivation of the name. This is not historically correct, however. The "minimax" name is actually based on the underlying strategic idea that each player attempts to minimize his opponent's maximum potential gain.

### History and Practicality

The minimax technique appeared to be of limited practicality when it was first discovered because of the rapid increase in the number of terminal positions as the look-ahead tree grows. The number of terminal positions that need to be analyzed in a minimax search is equal roughly

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This complete and very powerful program provides five levels of play. It includes castling, en passant captures and the promotion of pawns. Additionally, the board may be preset before the start of play, permitting the examination of "book" plays. To maximize execution speed, the program is written in assembly language (by SOFTWARE SPECIALISTS of California). Full graphics are employed in the TRS-80 version, and two widths of alphanumeric display are provided to accommodate North Star users.

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to the average number of options at each choice raised to a power equal to the depth of the search tree. For example, consider the game of chess, which averages thirty-eight options at each choice point. A minimax search considering a look-ahead of four moves for each player would have  $38^4$  terminal positions. That is more than 4 trillion (4,000,000,000,000) positions.

You do not have to be a mathematical genius in order to determine that a process that grows exponentially like this one is going to get out of control very quickly. Because of this exponential explosion and because there were no computers in the 1940s, the minimax algorithm initially received little attention.

In practical terms, the first player always maximizes, the second player always minimizes.

**The Alpha-Beta Technique**

In 1956, at the Dartmouth Summer Research Conference on Artificial Intelligence (see reference 1), John McCarthy pointed out that Bernstein's chess program did not need to analyze all of the terminal positions in order to select the move that was best in terms of the minimax strategy.

Although no formal description of the idea was given at that time, several of the game-playing programs written in the late 1950s appear to have employed an enhanced version of the minimax procedure, which has come to be called the  $\alpha$ - $\beta$  (ie: alpha-beta) pruning algorithm. The name seems to have been coined by McCarthy.

The first clear description of the technique for English-speaking audiences was published in 1969 by Slagle and Dixon (see reference 3). The  $\alpha$ - $\beta$  procedure provides a remarkable increase in the efficiency of the search process; and, with the advent of the high-speed computer in the late 1960s and 1970s, the minimax idea finally came of age.

Although there are many references to the  $\alpha$ - $\beta$  minimax technique in the popular literature, the procedure has not received much detailed analysis in the academic literature. The best expository presentation on this topic is a recent paper by Knuth and Moore (see reference 1). The technical details that enhance the efficiency of the  $\alpha$ - $\beta$  strategy are scattered throughout a number of hard-to-find sources. The purpose of this article is to summarize the main ideas and to present a sample program with the key algorithms.

**Treasure Search**

To provide an explicit example, I have devised a new game that is easy to play and is easily programmed. One of the difficulties of describing the  $\alpha$ - $\beta$  minimax procedure within the context of a familiar game is that move generation and position evaluation are sufficiently complex that these aspects of the program tend to mask the fine points of the  $\alpha$ - $\beta$  search. The game we will consider involves very straightforward move-generation and position-evaluation routines. For this reason, we will be

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able to concentrate on the tree-searching algorithm in the absence of unwanted distractions.

This new game is called Treasure Search and is played on an 8-by-8 grid. A digit between 1 and 9 is randomly assigned to each of the sixty-four squares. Each contestant has a single playing piece which is initially positioned in the central portion of the grid. The players take turns moving their pieces. A piece can be moved only one square at a time in one of four orthogonal directions (ie: north, south, east, or west). The object of the game is to

visit squares where a large number has been assigned and to collect as many of these as possible. Once a number has been taken from a square, that location is empty and subsequent visits provide no additional benefits. The first player to accumulate one hundred or more points wins the game.

Table 1 depicts the playing board as it might appear at the start of the game. The human player has the token designated as "X" and always moves first. Move selection is made by pressing one of the four arrow keys (-, -, |, |) on the computer keyboard. The program I will present is written for the Radio Shack TRS-80 computer in Level II BASIC.

### The Treasure Search Game

The specific numbers that appear in table 1 are set randomly at the beginning of each game; therefore, a new playing field is present for each and every game. The strategy for each player is to find a pathway in which he can collect large numbers for himself and at the same time deny large numbers to his opponent. The game was originally planned for young children. I have subsequently found that it is fun for children of all ages.

To begin my presentation, I will provide a listing of the computer instructions for creating the playing field and accepting moves from the human player. Subsequently, I will present the algorithm for selecting moves for the machine and then discuss enhancements that substantially increase the efficiency of the search.

Treasure Search 4	
	8 6 1 7 5 8 9 6
	4 9 5 6 2 6 9 1
George	4 1 4 6 4 7 4 1
0	9 1 4 * 7 5 3 5
	6 2 5 9 X 4 4 4
TRS-80	5 9 9 3 4 8 8 1
0	3 7 6 2 4 5 1 8
	8 8 6 4 6 9 1 3

Which Direction for X?

Table 1: Starting position for Treasure Search. The human player moves the "X" one square at a time and attempts to collect as many big numbers as possible. The computer moves the "\*" on alternate turns with the same objective. The first player to accumulate one hundred points wins.

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### The Program

The initial statements in this program are very similar to those at the beginning of its two predecessors. Certain housekeeping functions are required, such as setting aside memory for string storage, clearing the video display, telling the machine to treat all variables as integers, resetting the "seed" for the random-number generator, and initializing important variables:

```
100 CLEAR 100:CLS:DEFINT A-Z:RANDOM:
SH = 0:ST = 0
```

(Several versions of this program are given in the body of the text and in listings 1 thru 3.) The variables SH and ST represent the cumulative score for the human and the TRS-80, respectively.

Our next objective is to solicit the human player's name so that we can communicate with him in a civilized manner:

```
110 PRINT@463,"PLEASE ENTER YOUR NAME";:
INPUT N$
```

The next step is to create several arrays that will be needed by the program. Two arrays are needed for remembering move directions (A and D), one is needed to provide an internal representation of the playing field (B), and several more are used by the tree search: M stores the move that is being considered at each level of the look-ahead tree; E stores the evaluation score for each of those moves; Q keeps track of which moves have been considered at each level of the tree; V keeps track of the best pathway value for each level of the tree; Z

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remembers a "killer" move for each level of the tree (this is explained later in this article); and PV is used to remember the principal variation that is selected by the tree search. The lines we will need are:

120 DIM A(8), B(99), D(4), E(12), M(12)  
130 DIM PV(12,12), Q(12), V(12), Z(12)

The array representing the playing field, B, is treated as a 10-by-10 grid with the first row having indices of 0 to 9, the second row, 10 to 19, the third row 20 to 29, etc. With this organization, the "squares" adjacent to any position are always separated by a constant value. The square to the right is always the current square plus 1. The square to the left is always the current square minus 1. To go up, add 10; to go down, subtract 10. For move generation, we create an array with the following coefficients:

140 D(1) = -10: D(2) = -1: D(3) = 1: D(4) = 10

We will use a special feature of the TRS-80's architecture to produce moves for the human player. A special array is needed to take advantage of the fact that the keyboard is memory-mapped.

150 A(1) = 10: A(2) = -10: A(4) = -1:  
A(8) = 1: CLS

Since our program is designed for children of all ages, we will let the human player adjust the playing strength of the machine. Young children can play against a weak opponent. Older children can select a more competitive opponent.

160 PRINT@461, "TRS-80 PLAYING STRENGTH  
(1 TO 5)":INPUT Y

The larger the number, the deeper we will have the machine search.

The variable DM is used to set the maximum depth of the look-ahead search. It is defined as twice the value Y minus 1. This will produce searches of one ply, three plies, five plies, seven plies, and nine plies for playing-strength settings from 1 to 5. A five-ply search involves three moves for the machine and two for the human opponent. [A ply is a move by either opponent; the combination of one move by both sides is called a play or a turn; thus two plies equal one move. . . GW] It is also necessary to create the array that provides an internal representation of the playing field. This is done by assigning a digit from 1 to 9 to each of the squares in the playing area:

170 DM = 2\*Y: FOR I = 11 TO 88:  
B(I) = RND(9): NEXT I

The squares that surround the grid are used to designate the edge of the board and are set to a value of 99 for this purpose:

180 FOR I = 0 TO 10: B(I) = 99: NEXT I:  
FOR I = 89 TO 99: B(I) = 99: NEXT I  
190 FOR I = 19 TO 79 STEP 10: B(I) = 99:  
B(I + 1) = 99: NEXT I

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The playing field also needs to be presented on the video display, along with a title for the game:

```
220 CLS: FOR I = 11 TO 88: IF B(I) = 99 THEN 240
230 X$ = RIGHT$(STR$(B(I),1): GOSUB 1000
240 NEXT I: PRINT@22, "TREASURE SEARCH";Y;
```

The subroutine starting at line 1000 computes a location on the video screen (R = row; C = column) and prints a character there:

```
1000 R = INT (I/10): C = I-10*R:
      K = 141 + (8-R)*64+C*4
1010 PRINT@K, X$;: RETURN
```

Our next objective is to enhance our video display by printing the names of the contestants on the left-hand side of the screen where the score will be recorded. We also need to put each player's piece on the playing field and to define several useful variables. Y\$ is a string variable of twelve blank spaces. Z\$ is similar except it represents thirty-two blank spaces. These two variables will be used when we wish to erase part of the video display. The variable T represents the position (row-column) of the computer piece, and H represents the position of the human piece:

```
250 PRINT@256, N$;: PRINT@448, "TRS-80";:
      Y$ = STRING$(12, " ")
260 T = 54: T$ = ""; H = 45:
      H$ = "X"; Z$ = STRING$(32, " ")
270 I = T: X$ = T$: GOSUB 1000:
      B(T) = 99: B(H) = 99
280 I = H: X$ = H$: GOSUB 1000: GOTO 300
```

The position where each player's piece is located is not available for a move, so those positions in the B array are temporarily set to the value 99.

Now we are ready to create the module that solicits the human's move. First we will start with a message to present when the requested move is not legal. This can occur if the human attempts to move off the playing field or to a position occupied by the machine's playing piece:

```
290 PRINT@788, "ILLEGAL MOVE, TRY AGAIN";:
      FOR I=1 TO 999: NEXT I
```

In most situations, line 290 will not be executed. Instead, the message will usually be a request for the human player's move:

```
300 PRINT@788,Z$;:
      PRINT@788, "WHICH DIRECTION FOR X";
```

The machine waits for the human's response by doing a rapid cycle from the beginning to the middle of line 310. When a keyboard response occurs, the machine checks a special location in memory that keeps track of the arrow keys and determines which bit has been set by the key-press:

```
310 IF INKEY$ = "" THEN 310 ELSE R = PEEK(16444)
```

The player's response is then processed to determine the

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new square (J) for his piece.

A test is also made to make sure that the new square is on the playing field and not currently occupied by the machine's piece:

```
320 R = INT(R/8): J = H + A(R)
330 IF B(J) = 99 THEN 290 ELSE PRINT@788, Z$;
```

If the move is legal, the necessary changes are made to the video display and to the internal representation of the board. In addition, the player's score is modified approximately and a check is made to determine if the game is over:

```
360 I = H: B(I) = 0: X$ = "--":
    GOSUB 1000: SH = SH + B(J)
370 H = J: B(H) = 99: I = H: X$ = H$:
    GOSUB 1000
380 PRINT@321, SH,: IF SH > 99 THEN 930
```

### Move-Selection Strategy

This completes the module for soliciting and processing the move selected by the human player. We can see that Treasure Search is much easier to program than more familiar games such as chess or checkers. We are now ready to address the major focus of this article, namely, move selection by the machine. As a first approximation, I will present a relatively simplistic strategy and then subsequently will consider more sophisticated approaches.

The following initial strategy surveys the playing field in each of the four directions from the current position (T) of the machine's playing piece and selects as the best move (BM) the square which has the largest value (BV):

```
530 BV = -1: I = 0
540 I = I + 1: J = T + D(I): IF B(J) = 99 THEN 560
550 IF B(J) > BV THEN BM = J: BV = B(J)
560 IF I < 4 THEN 540
```

This is equivalent to a look-ahead search of one ply. Once a move has been selected, it is then necessary to make that move on the video display and to make the appropriate changes in the internal representation of the playing field. In addition, the score for the machine needs to be modified and a check needs to be made to determine if the game is over:

```
800 I = T: B(I) = 0: X$ = "--":
    GOSUB 1000: PRINT@179, Y$:
810 T = BM: ST = ST + B(T): B(T) = 99:
    I = T: X$ = T$
820 GOSUB 1000: PRINT@513, ST,:
    IF ST < 100 THEN 300
```

To complete the program, we need two messages to signal the end of the game:

```
910 PRINT@915,
    "THANK YOU FOR A PLEASANT GAME";
920 GOTO 920
930 PRINT@917,
    "CONGRATULATIONS, YOU WIN";: GOTO 920
1000 R = INT(I/10): C = I - 10 * R:
    K = 141 + (8 - R) * 64 + C * 4
1010 PRINT @ K, X$,: RETURN
```

*[Please note that this simple version of the game is not the version given in listing 1. To acquire this version, type in all the BASIC lines presented so far in the text. . . GW]*

### Implementing $\alpha$ - $\beta$ Techniques

If you run this program on a TRS-80, it will play a legal game, but it will not be particularly challenging. Your children will probably enjoy playing it because they will beat it most of the time. A one-ply look-ahead does not produce brilliant play. To make the machine more intelligent, we need to add the  $\alpha$ - $\beta$  minimax algorithm. To do this, we will substitute the following code for lines 530 to 560:

```
510 DT = DM
520 L = 1: SC = 0: S = -1
530 V(0) = -99: V(1) = -99: M(0) = T:
    M(1) = H
```

The maximum depth of the search, DT, is set to the value DM which was calculated at line 170. Next, we initialize several key variables. The depth of the search (L) starts with a value of 1. The variable that remembers the cumulative difference between the changes in the players' scores (SC) is set to zero. The variable that keeps track of which player has the move (S) is set to a -1.

The array that retains the best values obtained so far at each level of the tree is initialized at a -99 for index values of 0 and 1. The array that keeps track of the move (M) currently being considered at each level of the tree is set to the value T (the location of the machine's piece) for the index value of 0 and to H (the location of the human's piece) for the index value of 1.

The first move considered in the look-ahead process will be for the machine. The value of L at the base of the tree will be 2. You may think this a bit curious, but it is a useful strategy since we will want to refer to  $V(L - 2)$  and  $M(L - 2)$  at several points in the search process.

To begin the main loop of the tree search, we increase the depth (L) by 1 and then initialize the variable Q (an index for the moves that have already been considered at this level of the tree), the variable S (an index indicating whose turn it is to move), and the variable V (the value for the best move found so far at this level of the tree):

```
540 L = L + 1: Q(L) = 0: S = -S: V(L) = V(L - 2)
```

The next step is to increment the Q index so that the machine can consider the next move option at this level of the tree. If we have exhausted all of the move options at this level, it is time to branch to a special section of code that instructs the machine to back up one level in the tree:

```
580 Q(L) = Q(L) + 1: IF Q(L) > 4 THEN 760
```

If the move options at this level have not been exhausted, the machine is instructed to generate the location (J) of a square to which the player can consider moving:

```
590 J = M(L - 2) + D(Q(L))
```

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## Making Moves

Move generation is quite simple because  $M(L-2)$  always represents the current location of the piece of the player whose turn it is to move and  $D(Q(L))$  represents one of the four directions in which a move can potentially be made. I say potentially because the new location could be off the playing field or could already be occupied by the opponent's piece. Our next statement checks for this:

```
600 IF B(J) = 99 THEN 580 ELSE M(L) = J: E(L) = B(J)
```

If the move is legal, the new location is recorded as the current move at this level in array  $M$ , and the digit at this location is recorded as the current value at this level in array  $E$ . In addition, the internal representation of the playing field,  $B$ , is modified to reflect this move, and the variable  $SC$  is altered to keep track of the relative points accumulated by each player:

```
610 B(J) = 99: B(M(L - 2)) = 0: SC = SC + S * E(L)
```

In order to provide a visible record of the machine's "thought" process, the machine is instructed to print the move location ( $J$ ), the cumulative change in the score at this point ( $SC$ ), and the best value so far at this level,  $V(L)$ , in the empty area on the right side of the video display. The machine also checks to see if the current depth is the maximum possible depth. If not, it branches to line 540 which starts the main loop again by going one level higher in the tree:

```
620 PRINT@179 + 64*L, J; SC; V(L); " ";  
IF L < DT THEN 540
```

If the search is at the maximum depth (ie:  $L = DT$ ), then the machine records the current value of  $SC$  as a potential new best value:

```
670 V(L + 1) = -S * SC
```

The next step is to reverse the move we just made. When a new move is made, the board representation is updated at line 610. When the move is taken back at line 680, we refer to the process of "downdating" the board:

```
680 B(M(L)) = E(L); B(M(L - 2)) = 99:  
SC = SC - S * E(L)
```

## Negamax

To determine whether the value recorded at line 670 is better than the current value at this level, we employ the *negamax* procedure (see reference 1). This is equivalent to the minimax procedure except that its implementation requires fewer programming steps. Rather than minimizing and maximizing at every other level, the negamax approach always maximizes the results at a given level, but it reverses the arithmetic signs at every other level to produce the identical result as the minimax procedure. (You may recognize the similarity between this approach and the use of the logical NOR operation in circuit design. Two levels of NOR logic are equivalent to a level of ANDs followed by a level of ORs.) The following line implements the negamax calculations:

```
700 IF V(L) < -V(L + 1) THEN  
V(L) = -V(L + 1) ELSE 580
```

If the new value is worse than or equal to the current value, the machine branches to line 580 and considers another move at this level. If the new value is better than the current value, the machine continues to the next statement:

```
740 IF L = 2 THEN BM = M(L):  
PRINT@180, BM; V(2);
```

If the search process is at the base of the tree ( $L = 2$ ), then the new best move is recorded for later use and an announcement of our new find is printed on the video display. This includes both the new location,  $BM$ , and the net difference in the score produced by the anticipated sequence of moves,  $V(2)$

## Evaluating for Cutoff

At line 700, the minimax rule was applied to select the best option for the player with the move. The next consideration is whether the current move will produce an  $\alpha$ - $\beta$  cutoff. The logic for this decision is based on the idea that the opponent may already have a move at this level in the tree that guarantees him a value that is at least as

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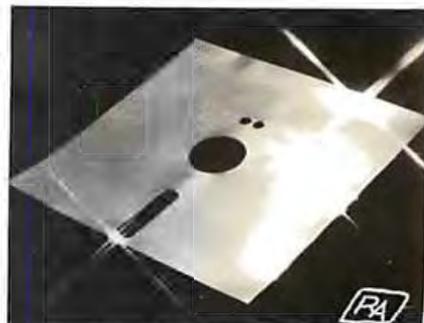
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This procedure is easy to implement but not particularly easy to understand. The general idea was explained by an example by W D Maurer in an earlier issue of this magazine (see reference 2), and a detailed exposition is provided by Knuth and Moore (reference 1). For our pur-

**Listing 1:** Listing for the game of Treasure Search, written for the TRS-80 using Level II BASIC. This game, in its various versions, illustrates the usefulness of alpha-beta pruning when searching a tree for the best strategy in a two-player game. The game, as written here, plays an unmodified alpha-beta strategy against a human player. See listings 2 and 3 for additions that cause the computer to play more rapidly.

```
100 CLEAR 100: CLS: DEFINT A-Z: RANDOM: SH = 0:
    ST = 0
110 PRINT@463, "PLEASE ENTER YOUR NAME": INPUT N$
120 DIM A(8), B(99), D(4), E(12), M(12)
130 DIM PV(12,12), Q(12), V(12), Z(12)
140 D(1) = -10: D(2) = -1: D(3) = 1: D(4) = 10
150 A(1) = 10: A(2) = -10: A(4) = -1: A(8) = 1: CLS
160 PRINT@461, "TRS-80 PLAYING STRENGTH (1 TO 5)":
    INPUT Y
170 DM = 2*Y: FOR I = 11 TO 88: B(I) = RND(9): NEXT I
180 FOR I = 0 TO 10: B(I) = 99: NEXT I: FOR I = 89 TO 99:
    B(I) = 99: NEXT I
190 FOR I = 19 TO 79 STEP 10: B(I) = 99: B(I + 1) = 99:
    NEXT I
220 CLS: FOR I = 11 TO 88: IF B(I) = 99 THEN 240
230 X$ = RIGHT$(STR$(B(I)),1): GOSUB 1000
240 NEXT I: PRINT@22, "TREASURE SEARCH": Y:
250 PRINT@256, N$: PRINT@448, "TRS-80":
    Y$ = STRING$(12, " ")
260 T = 54: T$ = "4": H = 45: H$ = "X":
    Z$ = STRING$(32, " ")
270 I = T: X$ = T$: GOSUB 1000: B(T) = 99: B(H) = 99
280 I = H: X$ = H$: GOSUB 1000: GOTO 300
290 PRINT@788, "ILLEGAL MOVE, TRY AGAIN":
    FOR I = 1 TO 999: NEXT I
300 PRINT@788, Z$: PRINT@788, "WHICH DIRECTION FOR
    X":
310 IF INKEY$ = "" THEN 310 ELSE R = PEEK(16444)
320 R = INT(R/8): J = H + A(R)
330 IF B(J) = 99 THEN 290 ELSE PRINT@788, Z$:
360 I = H: B(I) = 0: X$ = "-": GOSUB 1000: SH = SH + B(I)
370 H = J: B(H) = 99: I = H: X$ = H$: GOSUB 1000
380 PRINT@321, SH: IF SH > 99 THEN 930
510 DT = DM
520 L = 1: SC = 0: S = -1
530 V(0) = -99: V(1) = -99: M(0) = T: M(1) = H
540 L = L + 1: Q(L) = 0: S = -S: V(L) = V(L - 2)
580 Q(L) = Q(L) + 1: IF Q(L) > 4 THEN 760
590 J = M(L - 2) + D(Q(L))
600 IF B(J) = 99 THEN 580 ELSE M(L) = J: E(L) = B(J)
610 B(J) = 99: B(M(L - 2)) = 0: SC = SC + S * E(L)
620 PRINT@179 + 64 * L, J: SC: V(L): " ": IF L < DT THEN
    540
670 V(L + 1) = -S * SC
680 B(M(L)) = E(L): B(M(L - 2)) = 99: SC = SC - S * E(L)
700 IF V(L) < -V(L + 1) THEN V(L) = -V(L + 1) ELSE 580
740 IF L = 2 THEN BM = M(L): PRINT@180, BM: V(2):
750 IF V(L) < -V(L - 1) THEN 580
760 L = L - 1: S = -S: PRINT@243 + 64 * L, Y$: IF L > 1
    THEN 680
800 I = T: B(I) = 0: X$ = "-": GOSUB 1000: PRINT@179, Y$:
810 I = BM: ST = ST + B(T): B(T) = 99: I = T: X$ = T$:
820 GOSUB 1000: PRINT@513, ST: IF ST < 100 THEN 300
910 PRINT@915, "THANK YOU FOR A PLEASANT GAME":
920 GOTO 920
930 PRINT@917, "CONGRATULATIONS, YOU WIN":
940 GOTO 920
1000 R = INT(1/10): C = I - 10 * R: K = 141 + (8 - R) * 64 +
    C * 4
1010 PRINT@K, X$: RETURN
```

poses, the job is accomplished by a single statement:

```
750 IF V(L) < -V(L - 1) THEN 580
```

If the condition specified in line 750 is satisfied, then a cutoff is not called for, and the process branches to line 580, where the next move option is considered at this level. If the condition in line 750 is not satisfied, the process continues to line 760, which instructs the machine to back up one level in the tree:

```
760 L = L - 1: S = -S: PRINT@243 + 64 * L, Y$:
    IF L > 1 THEN 680
```

The backup procedure includes decreasing the value of L by 1, changing the index that indicates which player has the move, erasing the move information printed on the right side of the video display, and branching to line 680 to execute the downdate instructions for the new value of L. If the value of L decreases to 1, all options at the base of the tree have been examined and the search is completed. In this case, the machine drops to line 800 and makes the move which has been stored by variable BM.

It is important to note that the jump to line 680 for downdating is followed by execution of the minimax test (line 700) for a new best move at the new value of L; sometimes the program proceeds again to line 750, where another cutoff may occur. Note, also, that line 760 can be entered from two different locations. In addition to dropping through from line 750, the machine can be directed to line 760 from line 580 as a result of exhausting all possible move options at a given level. The  $\alpha$ - $\beta$  test at line 750 provides a means for terminating the search at a node before all of the options have been analyzed.

The version of Treasure Search just completed is given in listing 1.

### Traditional Techniques

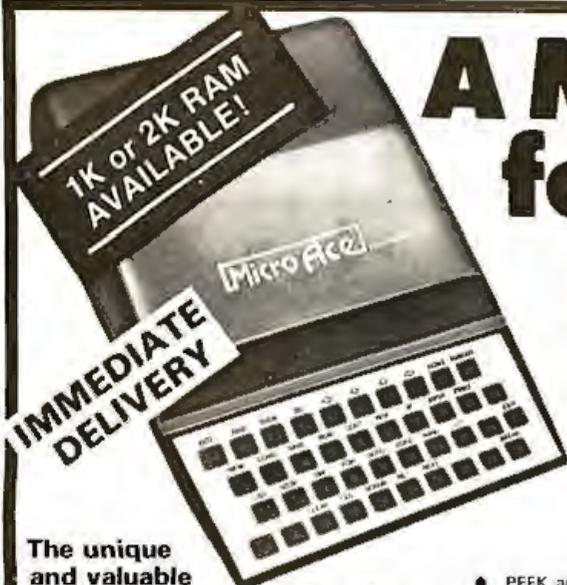
This completes the  $\alpha$ - $\beta$  minimax module. You may be surprised that this algorithm can be presented in only a few lines of BASIC. The simplicity of the presentation is possible because we used the negamax procedure and because Treasure Search is a simple game. It is very straightforward in terms of move generation (line 590), move evaluation (line 600), and the ease of updating (line 610) and downdating (line 680) the internal representation of the playing field. This simplicity also means that the algorithm will execute fairly rapidly, and thus a search of nontrivial depth can be completed in a reasonable amount of time.

The algorithm that I have presented for the  $\alpha$ - $\beta$  minimax procedure is quite different from the one that appears in most textbooks. Traditionally, the algorithm generates all of the moves at each node and then orders them using a plausibility routine before proceeding to the next deeper level of the tree. This approach is based on

**Listing 2:** To implement the killer heuristic, these lines are to be added to listing 1, replacing line 590 of listing 1 and inserting lines 550, 560, and 710.

```
550 J = Z(L): I = 0
560 I = I + 1: IF J = M(L - 2) + D(I) THEN 600 ELSE IF I < 4
    THEN 560
590 J = M(L - 2) + D(Q(L)): IF J = Z(L) THEN 580
710 IF L > 2 THEN Z(L) = M(L)
```

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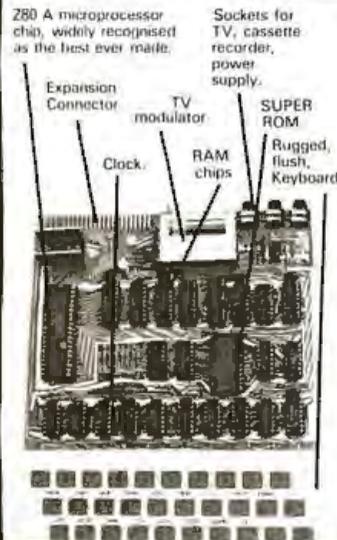
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the well-known finding that the efficiency of the  $\alpha$ - $\beta$  method is increased greatly when the strongest moves for each player are examined first at each level of the tree. The disadvantage of generating, ordering, and storing all of the moves at each level is that most of them will never be examined if an  $\alpha$ - $\beta$  cutoff occurs. If a cutoff can be produced by some other means, a great deal of time and memory can be saved by ignoring most of the moves at each node and omitting the ordering process.

The obvious question is, of course, how can we have our cake and eat it too? The competition among chess programmers over the last decade has led to some useful discoveries that are relevant to this problem. We will consider two of these discoveries that are especially effective in increasing the efficiency of the  $\alpha$ - $\beta$  minimax procedure. The first is the *killer heuristic* and the second is the *iterative search*.

### The Killer Heuristic

The killer heuristic is a simple, yet powerful, idea that greatly improves move ordering. Instead of trying to order moves on the basis of a special plausibility analysis, the killer procedure simply remembers moves that were effective in the past. That is, information generated as a byproduct of the regular tree search is remembered; and it is applied later on in the search when a similar situation is encountered. In our implementation, we will remember the move that was judged most recently to be the best by the minimax rule at each level of the tree; each time we visit a new node in the tree, this move will be tried first.

To implement this idea, a few additions and modifications are necessary (see listing 2). When the tree search moves to a higher level, the first move examined should be the killer for that level (lines 550 and 560 of listing 2).

First, the appropriate move is read from the Z array, then a check is made to make sure the move is legal. If the killer does not produce an immediate cutoff, the search process will revert back to the normal procedure of examining each of the possible options. This process is controlled at lines 580 and 590.

We need to modify line 590 of listing 1 to make sure that a move is not examined twice (first as the killer and then as a regular option).

The final step in implementing the killer heuristic is to provide a means for remembering the move which is currently most effective in terms of the minimax strategy at each level of the look-ahead tree. This is accomplished by recording the current move each time the search process finds that it is the best one so far; this is done at line 700 of listing 1.

If the process is at the base of the tree ( $L = 2$ ), then the move need not be recorded since the killer strategy does not apply at this level. It is too late to define a move that should be searched first at the base of the tree. By not altering the killer at  $L = 2$ , we make sure that the move examined initially will be searched only once even if it turns out not to be the one eventually chosen.

The killer heuristic is a very powerful addition to the  $\alpha$ - $\beta$  minimax algorithm. It requires only a small change in the algorithm, involves a negligible amount of time in terms of code execution, and often results in a decrease of 50% or more in the number of nodes actually visited in the search tree. At the deeper levels of the tree, it accomplishes essentially the same function as plausibility

ordering, but does it much more efficiently.

The killer heuristic does not provide a means for ordering the moves when the machine is constructing the initial "limb" of the look-ahead tree. Because the search is a depth-first search, the process begins by selecting a sequence of moves that starts at the base node and goes to the maximum depth. The  $\alpha$ - $\beta$  cutoffs are most effective if this initial limb contains the strongest moves at each node for each player. This first stage of the search can be very time-consuming if the moves that are initially examined are eventually discarded for better ones. Because the killer heuristic employs strong moves only after they have been discovered by the regular search process, it is not helpful in structuring the initial "limb" of the look-ahead process.

### The Iterative Technique

A different technique has proven its effectiveness for this purpose. This procedure is the *iterative tree search*. Its effectiveness for increasing the efficiency of the  $\alpha$ - $\beta$  minimax procedure was discovered serendipitously. At Northwestern University, for example, the Slate-Atkin chess-programming team was concerned about time control in move selection. Occasionally, in a complex position, their chess program would conduct its regular look-ahead search and would not complete the task in the amount of time anticipated. In several instances, the search would require four to five times as long as anticipated. This was a serious problem because chess tournaments are conducted under strict time allowances. If a program takes too much time for move selection during the early stages of the game, very little time will be available when it is needed during the latter part of the contest.

To cope with this problem, Slate and Atkin implemented an iterative procedure whereby the search is conducted in stages. At first, a complete two-ply search is conducted, then a three-ply search, then a four-ply search, etc, until a search of the desired depth is reached. The advantage of this procedure for time control is that a search can be aborted at any time and the machine can fall back upon the move selected by the immediately preceding search of one less ply in depth. It is possible to use information gained in the early, shallow searches to help structure (ie: order) the deeper searches.

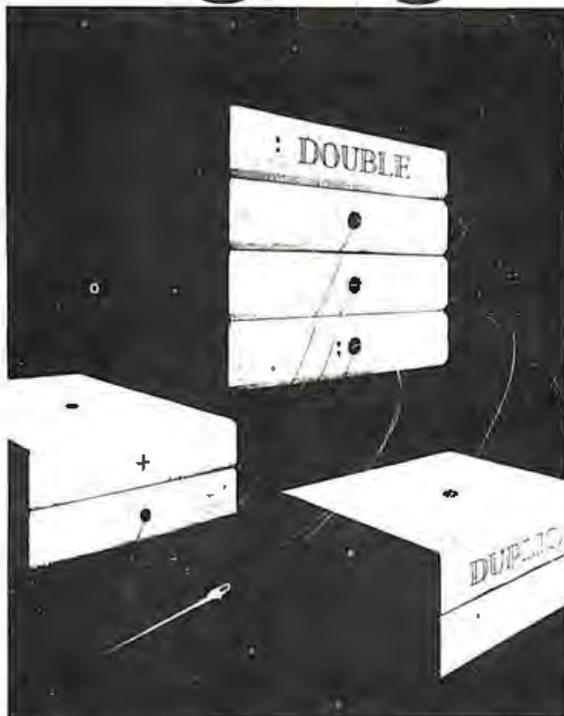
Interestingly enough, Slate and Atkin discovered that this ordering information caused an increase in the efficiency of the deeper searches which more than made up for the time spent conducting the shallow searches. They also found that the beneficial effect of the iterations increases as the depth of search increases.

The iterative search is much easier to implement than you might think. The key idea for enhancing the efficiency of the  $\alpha$ - $\beta$  search is that the best sequence of moves (as judged by the minimax strategy) from a shallow search can be used to order the initial moves in the deeper search which follows. It is necessary to develop and record the *principal variation* for each of the searches.

This means that, instead of remembering just the best move at the base of the tree, the machine needs to record the best moves for each side at every level of the tree. Thus, it predicts the initial move, the best reply, the best counter-reply, etc. This principal variation is then used for selecting the initial limb for the next deeper search in

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Listing 3: Additions to listing 1 to implement an iterative tree search algorithm. These lines are to be added to the combination of listings 1 and 2.

```
500 FOR I = 4 TO DM: Z(I - 2) = PV(2,I): NEXT I
510 IF PV(2,3) = H THEN DT = DM ELSE DT = 2
720 I = L: PV(L,I) = M(L): IF L = DT THEN 740
730 I = I + 1: PV(L,I) = PV(L + 1,I): IF I < DT THEN 730
780 IF DT = DM THEN 800
790 FOR I = 2 TO DT: Z(I) = PV(2,I): NEXT I: DT = DT + 2:
      GOTO 520
```

the iteration. In our present algorithm, we employ this strategy by placing the principal variation from the previous search in the killer array at the start of each iteration.

The first requirement is the development and storage of the principal variation. This is fairly difficult to explain but not very difficult to implement (see lines 720 and 730 of listing 3). Once we have a principal variation, we then modify the initial preparation for the look-ahead search (see lines 500 and 510 of listing 3).

This accomplishes two important things. At line 500, the killer array receives the moves for each side that were ascertained to be best on the move calculation from the previous turn (not the previous iteration of this turn, but rather the last time the machine made a move). The index I-2 is used because the first two moves anticipated by that variation (one for the machine and one for the opponent) have already been played.

Line 510 checks to see if the opponent actually made the anticipated move. If so, an iterative search is unnecessary since the principal variation from the previous move calculation provides the same ordering information as would be obtained by the iterations. The search depth, DT, is therefore set to the maximum depth, DM. If the opponent does not make the anticipated move, an iterative search is required and therefore the search depth, DT, is set at the minimum value. Note that DT = 2 calls for a one-ply search.

When a search has been completed, it is necessary to determine if the maximum depth has been reached or whether another iteration is required. If the latter case holds true, the principal variation from the most recent iteration is stored in the killer array and the search depth is increased. In our present implementation, each iteration is two plies deeper than its predecessor. Lines 780 and 790 of listing 3 accomplish this task.

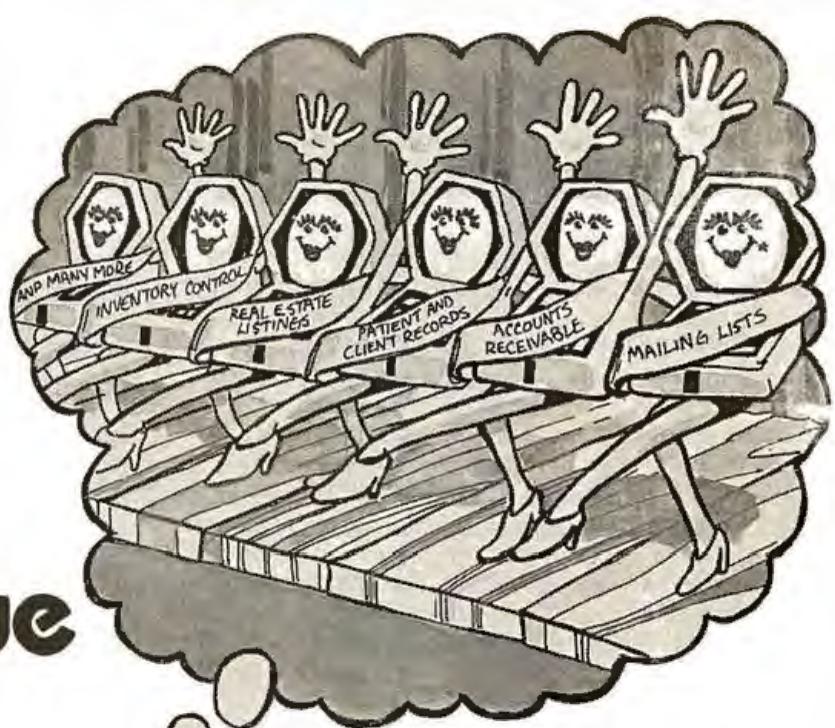
### Analysis of Modifications

With these additions, the program will select a move in the Treasure Search game by using an iterative  $\alpha$ - $\beta$  minimax procedure enhanced by the killer heuristic. To demonstrate the power of this modified algorithm, I have made some sample runs which count the number of nodes visited in the look-ahead tree in an actual game with and without the various modifications. These results are very informative.

The program was examined in four variations: minimax,  $\alpha$ - $\beta$  minimax,  $\alpha$ - $\beta$  minimax with the killer heuristic, and iterative  $\alpha$ - $\beta$  minimax with the killer heuristic. The version involving the minimax strategy without  $\alpha$ - $\beta$  is produced simply by replacing line 750 with:

```
750 GOTO 580
```

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To insure comparability of our results, an initial game configuration (digit assignment) was constructed and placed in an array such that each game started with the playing field depicted in table 1. In addition, the same series of moves was made by the human opponent in each game. Each version of the program calculated a move for the machine's first four times to play. In each case, the search depth was set for a seven-ply search. The number of nodes in each of the look-ahead trees is presented in table 2. The node count for the iterative search is the sum across all iterations.

An analysis of these results demonstrates the powerful effect of the  $\alpha$ - $\beta$  procedure. By using the IF statement at line 750 in the  $\alpha$ - $\beta$  versions, the search effort is reduced dramatically. In our example with a seven-ply search and with four options at each node, the  $\alpha$ - $\beta$  modification reduces the node count by a factor of about 10. Since there is an approximate linear relationship between the number of nodes in the tree and computation time, the  $\alpha$ - $\beta$  procedure selects a move in one-tenth the time of the full minimax search. Since the two procedures always select the same move, this enhancement in speed comes at essentially no extra cost.

The results in table 2 indicate that the killer heuristic is also a powerful addition to the  $\alpha$ - $\beta$  algorithm. In our example, the node count was reduced by 30% to 50% by simply remembering moves that had proved themselves effective at an earlier stage in the search.

This modification also provides substantial benefits at minimal extra cost in terms of processing time and memory requirement. The empirical analysis presented in table 2 also demonstrates the beneficial effects of the iterative procedure. The number of nodes generated in the calculation for the first move was reduced by almost 25% despite the fact that searches of one ply, three plies, and five plies were conducted prior to the seven-ply search.

In the calculations for moves 2, 3, and 4, the prior principal variation correctly predicted the human's move so that the machine dispensed with the iterations because it already had the ordering information they would have produced. The results presented in table 2 clearly indicate that the iterative procedure enhances the efficiency of the search process.

### Improvements

A comparison of the full minimax procedure as it was employed in the early 1950s with the modern, enhanced  $\alpha$ - $\beta$  procedure indicates a truly dramatic increase in search efficiency. The full minimax procedure averaged approximately 17,000 nodes for the first four move calculations. The modern algorithm as presented in this article averaged approximately 600 nodes for these same four calculations. This difference is large enough to convert an impractical but elegant idea into a powerful programming tool. I should also point out that the effectiveness of these procedures would be even more notable if we had examined a game like chess with more than thirty options at each node instead of a simple game with only four options at each node.

There is an additional way to increase the efficiency of the  $\alpha$ - $\beta$  search. In the present program, the evaluations of the terminal positions are based on a cumulative process in which the treasures collected at each node in the tree

	Number of Nodes in the Look-ahead Tree			
	First Move	Second Move	Third Move	Fourth Move
Minimax	13157	18456	20029	17609
$\alpha$ - $\beta$ Minimax	1965	1650	1641	1794
$\alpha$ - $\beta$ Minimax with Killer Heuristic	969	1023	926	830
Iterative $\alpha$ - $\beta$ Minimax with Killer Heuristic	753	571	675	363

**Table 2:** An empirical analysis of the minimax algorithm and enhancements as applied to the Treasure Search game. Each version of the program conducted a seven-ply look-ahead search.

are added or subtracted to a running total. As the search process nears the maximum depth of the tree, it is possible to set boundary conditions (ie: a window) that determine whether the final value can influence the selection process.

In many cases, the nonterminal score will be sufficiently deviant that the search can be terminated prematurely without any change in the ultimate decision process. This enhancement can significantly reduce the time required to complete the search.

### Strategic Weakness

This program for Treasure Search will play a fairly intelligent game. As presented here, however, it has a major weakness. When the game reaches its final stages, the machine continues to search for a pathway which gives it the greatest amount of treasure in the long run. This is not an optimal strategy because the game is won or lost at this stage by short-range planning. The first player to reach 100 wins. The machine with its present strategy may pass up a large treasure which would provide an immediate win in favor of a smaller one which ultimately leads to a rich lode. This could throw away an easy win.

Serious players may wish to introduce a special set of instructions for the endgame to correct for this weakness. The machine's game can also be strengthened by converting the program to assembly language. The deeper the look-ahead search, the greater the apparent intelligence of the machine. Conversion to assembly language will permit the program to search six plies deeper without increasing move-selecting time.

This article should provide useful information to anyone who wishes to write a game program which employs the  $\alpha$ - $\beta$  minimax procedure. ■

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3. Slagle, J R, and J K Dixon, "Experiments with Some Programs That Search Game Trees," *Journal of the Association for Computing Machinery*, 1969, Volume 16, pages 189 thru 207.
4. Von Neumann, J, and O Morgenstern, *Theory of Games and Economic Behavior*. Princeton NJ, Princeton University Press, 1944.

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Dear Steve,

I would like to congratulate you on your remote-control article using the BSR X-10 ("Computerize a Home," January 1980 BYTE, page 28). I have built a unit, and it is now so

much a part of my life that I take it for granted. It wakes me up, controls the lights, and guards the apartment in conjunction with a simple burglar alarm.

I have envisioned a system of lighting control that would illuminate any room that I enter, while darkening the one I just left.

*In "Ask BYTE," Steve Ciarcia answers questions on any area of microcomputing. The most representative questions received each month will be answered and published. Do you have a nagging problem? Send your inquiry to:*

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For this system to work, it must keep track of the number of people in the apartment (if there are more than one), and it must be able to sense their motion from room to room. Thus, if one person is in the living room, and he goes to the kitchen, the kitchen light should come on, while the living room light should go off. If there were more than one person in the living room, the light should remain on until the last person has left. Of course, manual control should be available, and the system should be able to recognize any sensing errors it may make, and reset itself accordingly.

Obviously, I need a doorway sensor that will detect a person passing through, and also detect the direction he is going. Would you suggest ultrasonic sensors, or would infrared optical sensors be more practical? Could you provide some circuit ideas to help me along?

Jim Porter

*I am always glad to hear*

*from someone who takes computer control seriously. Having a computer and automating your apartment makes being "gadget happy" sound almost respectable. In any case, I am familiar with your problem, and I'll try to offer a few circuits that might help.*

*When I first got involved with security systems, I did a lot of investigation on motion detectors, ultrasonics, and infrared systems. Very few companies offer automatic systems that count people and control lights in rooms. This should give you some indication of what you are getting yourself into.*

*Two possible methods that come to mind are detecting the motion of people within a room or counting them as they enter and exit.*

*Motion detectors usually incorporate one of three techniques: infrared, ultrasonic, and microwave. The infrared types are the cheapest. They rely upon changes in ambient light,*

*Text continued on page 270*

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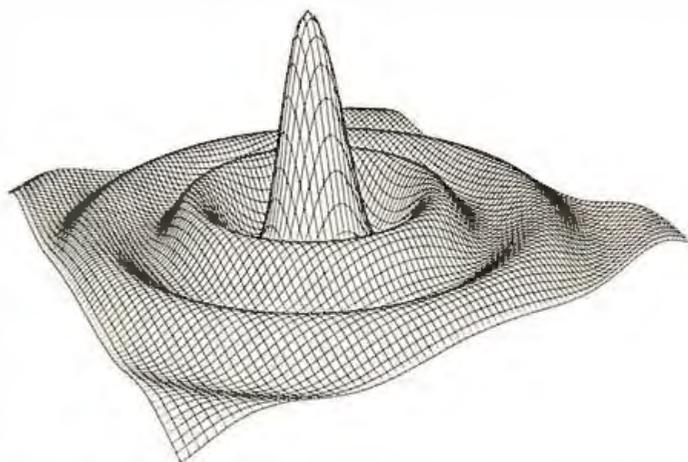
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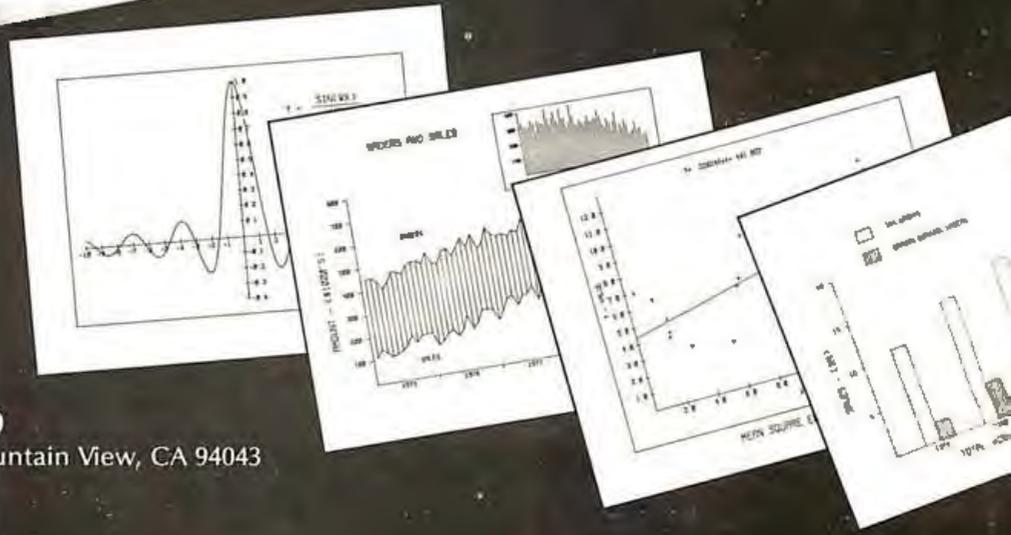
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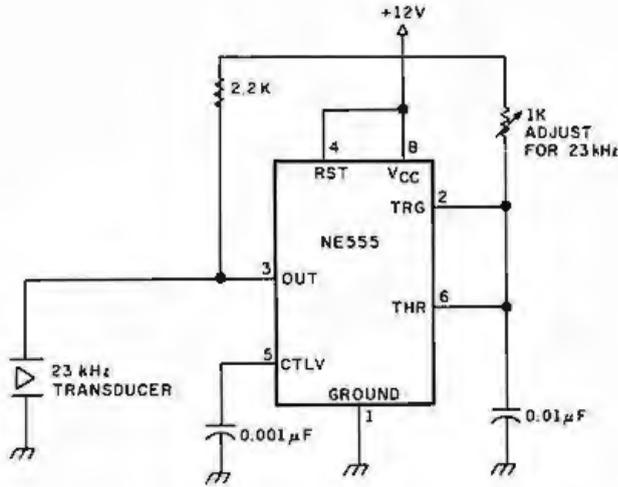
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IC1	LM1812		5, 10, 15	12
IC2	NE555	8	1	
IC3	7404	14	7	

1b

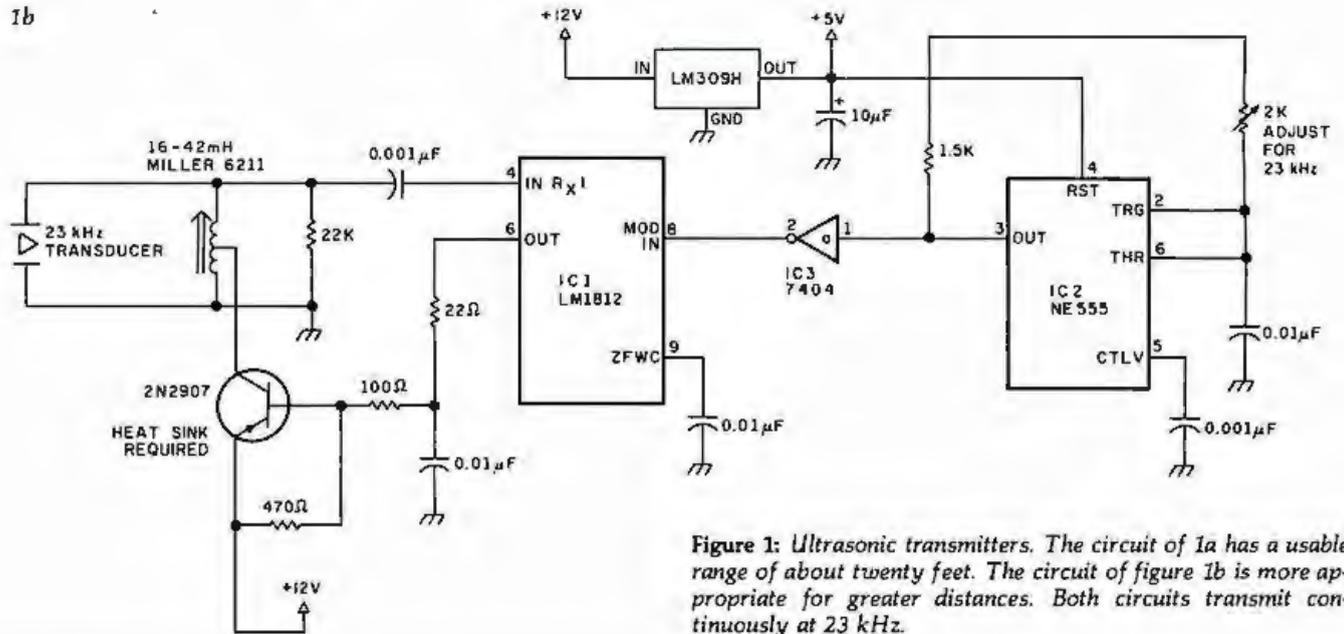


Figure 1: Ultrasonic transmitters. The circuit of 1a has a usable range of about twenty feet. The circuit of figure 1b is more appropriate for greater distances. Both circuits transmit continuously at 23 kHz.

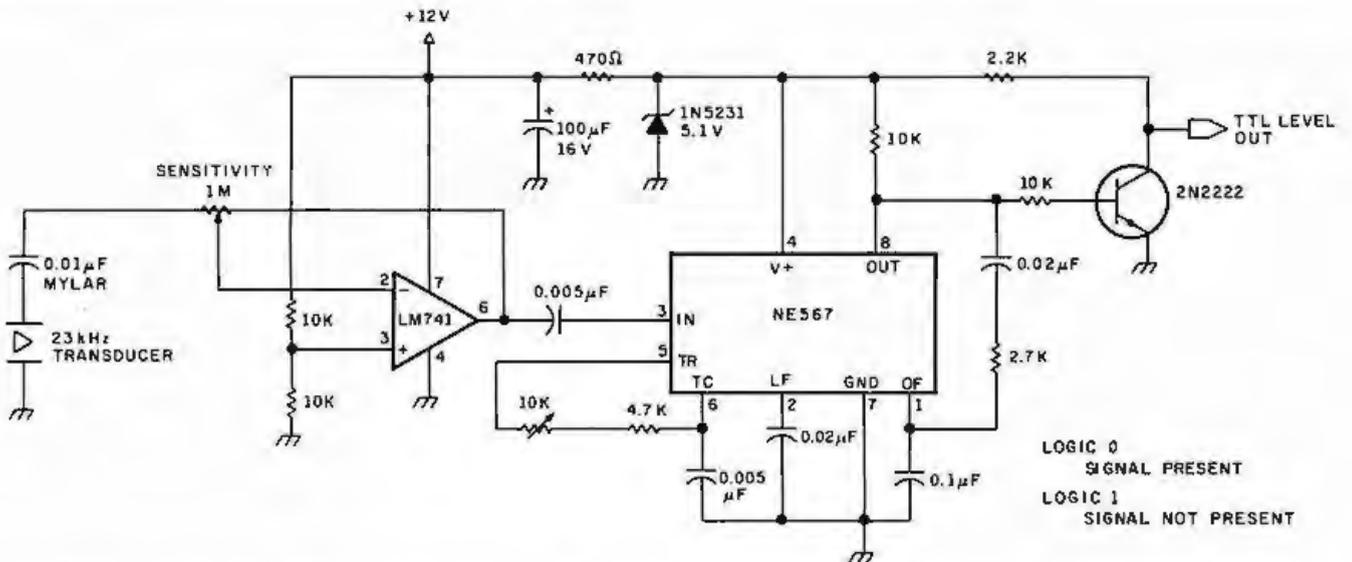


Figure 2: Ultrasonic receiver. This simple receiver has TTL-compatible outputs, and it will work with either transmitter in figure 1.



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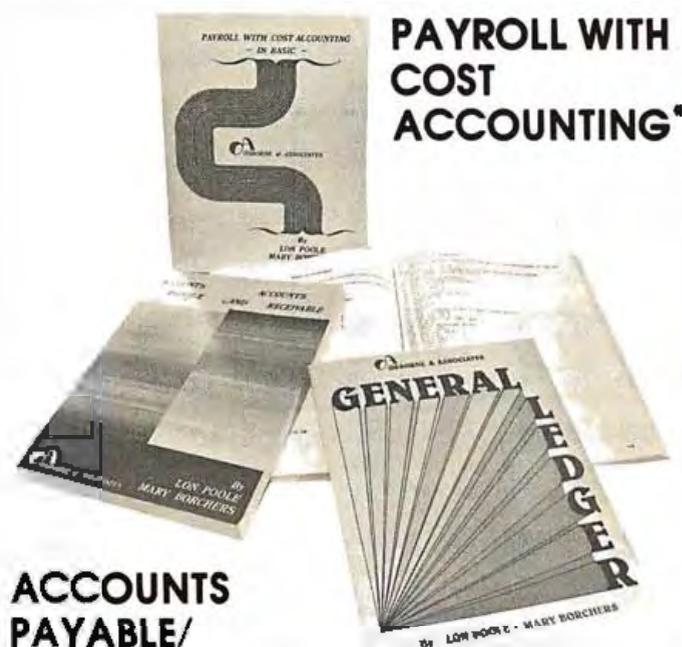
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1124

Text continued from page 266: and the latest designs incorporate an active photosensitive integrated circuit. In fact, Delco Electronics (7 Oakland St, POB 2, Amesbury MA 01913) was offering an under-\$30 kit a while back. In your application, with lights flashing on and off this may not be a reliable approach.

There are many ultrasonic systems on the market, and they range in price from \$50 to \$100. My only criticism of them is that they are prone to false alarms and you may find that the harmonics interfere with the BSR system. If you'd like to try placing one across a doorway or diagonally across a room, you could try the circuits shown in figures 1 and 2. These units operate at 23 kHz. Depending upon the sensitivity setting, they will detect most anything passing through the beam. For small rooms, you won't need much

power, so the circuit of figure 1a should suffice. If you need a range of greater than twenty feet, use the higher-power version shown in figure 1b. The receiver for either circuit is shown in figure 2. By the way, the output is TTL (transistor-transistor logic)-compatible. Normally the signal will be a logic 0 (ie: nothing interrupting the beam between the transmitter and receiver); the signal will go to a logic 1 only when someone walks into the room.

The most effective system for detecting motion uses microwave radiation—similar to police radar and operating on the same X-band frequency. In my experience, these are the best by far. They are relatively false-alarm free and very sensitive. I have them installed throughout my home, and I have found their reliability to be exceptional. Unfortunately, they

are expensive (in the range of \$150 to \$400 for domestic installations). A good unit is the Midex 55 made by Solfan (665 Clyde Ave, Mountain View CA 94043). Solfan's more expensive units have contact-closure outputs which would work well in your application.

The final solution to your problem might be to build a people counter. The circuit in figure 3 (sent to me by William Curlew) might be exactly what you need. It consists of two photodetectors (and two separate light sources) mounted in the doorjamb. Normally the light beam is uninterrupted and the output of the photodetectors is low. As long as there is light on both sensors, the output of IC2b is low. As someone starts through the doorway, one of the sensors goes high, clocking the JK flip-flop into one of two direction states. When the person fully enters the doorway, blocking both

the sensors, a trigger pulse is generated and sent to gates 2c and 2d. Depending upon the state of the flip-flop, the clock pulse will be directed to either the count-up or count-down line of the 4-bit up/down counter, IC5. The counter will increment as people walk into the room and decrement they walk out. A manual reset is provided to start things out correctly. When the 4 outputs are tied to a parallel input port, your computer can read it as often as necessary to determine how many people are left in the room. Since the counting is done in hardware, timing is not critical. It will accommodate only fifteen people in its present form, so don't have too many guests at your parties. Finally, for absolute certainty, you may want to use it with the ultrasonic circuits previously discussed. Steve

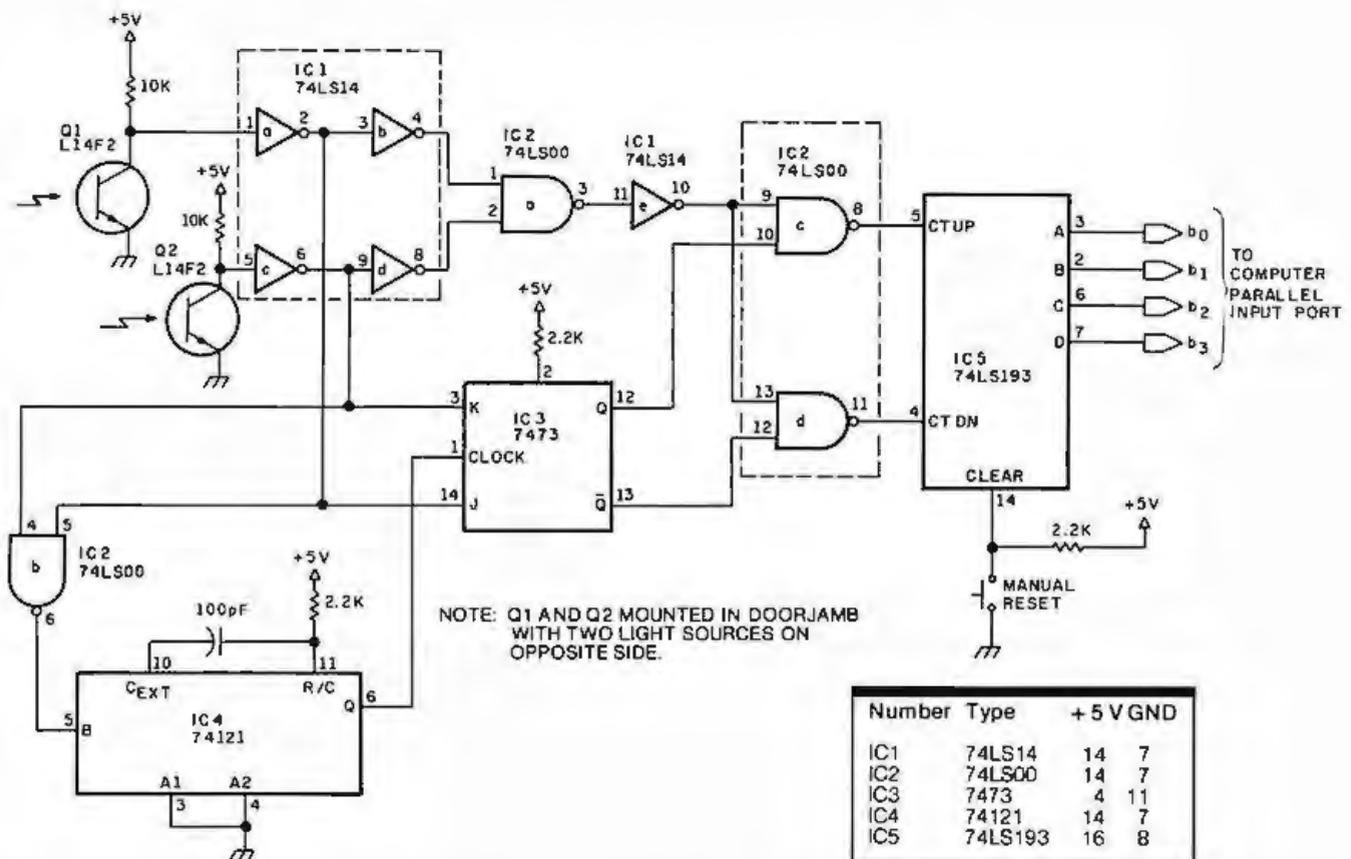


Figure 3: This circuit is capable of optically detecting the passage of people through a doorway and maintaining a count of people in a room. The photo-transistors sense motion through the doorway and cause the count stored in IC5 (a 4-bit binary counter) to either be incremented or decremented, depending upon the direction of passage.

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## Remote Control in Europe

Dear Steve,

Please tell me if the X-10 remote-control system by BSR could be operated on 220 V 50 Hz in Europe. I see from the schematic diagrams and various pictures it is designed to work on 110 V 60 Hz. Do they have a 220 V system? If not, is there any way I could adapt the system to work on a 220 V system.

Please tell me where I can buy the set (ie: common console, cordless controller, appliance module, lamp module, in-wall switch module) using an American Express card; maybe from Sears as you said in your article. If so, please let me know the address of Sears; for that matter, any reliable dealer who accepts American Express. I'll be grateful for the two answers. Next time you are in Europe drop in and see us. We have a wood stove too, and I hope to connect it to the

central heating system.  
**Rangith Amitirigala**  
Brugg, Switzerland

*Up to this point the X-10 system has been available only in the American version (115 VAC 60 Hz). The custom LSI (large-scale integration) device used in the American units, surprisingly enough, can work on either 50 or 60 Hz. The polarity set on pin 13 of the command-console integrated circuit selects either of the two operating frequencies. These consoles cannot, however, be easily converted from 115 V to 220 V operation without considerable component changes.*

*A call to BSR (USA) Ltd in New Jersey produced some fruitful answers to your question. Even though BSR is working on a European version of the X-10, another company has just announced availability of a 220 V 50 Hz unit. I suggest that you contact this firm for price and delivery. The*

source is: Busch-Jaeger Elektro GmbH, 5880 Ludenscheid, Freisenberg, Post Fach 1280, West Germany (BRD).

*As for Sears Roebuck and Company, it is my understanding that the firm accepts only its own credit card. Rather than worry about which stores will accept your credit card, you may find it easier to go your local bank (in Switzerland) and arrange for a letter of credit or bank draft when ordering from an American company.*  
Steve

## Operational Amplifiers

I have been using the AD284J isolation operational-amplifier system that you described in "Mind Over Matter" (June 1979 BYTE, page 49) as an EKG (electrocardiogram) monitor, in conjunction with a surplus chart recorder. Can you recommend some books that will

help me to learn more about operational amplifiers?  
**Matsutoshi Uchiyama**  
Tokyo, Japan

*I am glad you are gaining experience with the circuit. As far as expanding your mind a little, I suggest the following books:*

- Operational Amplifiers—Design and Applications, Jerald G Graeme, Gene E Tobey, and Lawrence P Huelsman, McGraw-Hill Book Company, New York NY 1971.
- Applications of Operational Amplifiers—Third Generation Techniques, Jerald G Graeme, McGraw-Hill Book Company, New York NY 1973.
- Handbook of Operational Amplifier Circuit Design, David F Stout and Milton Kaufman, McGraw-Hill Book Company, New York NY, 1976.

*I hope these help.*  
Steve

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## Beyond "Cyclops"

Dear Steve,

I consider your series of articles the best collection of homebrew-type construction ideas and projects available to the personal-computer experimenter. Your article "Self-Refreshing LED Graphics Display" (October 1979 BYTE, page 58) has prompted me to write you.

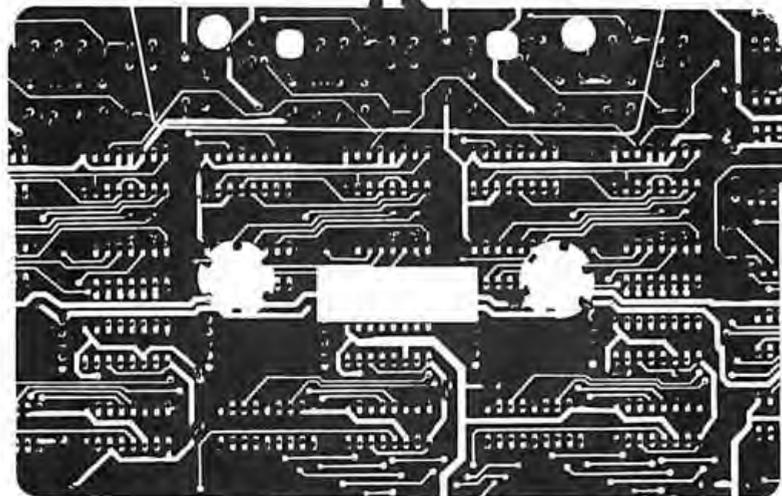
I'd like to propose a project to you. I understand that a construction project called "Cyclops" appeared in *Popular Electronics* that actually used a dynamic-memory integrated circuit to act as a "pseudo-image sensor." Can this unique idea be extended to larger-area memory devices? The 4 K-byte circuit would make a nice 64-by-64 element array.

**Jesse Newton**

*Thanks for the pat on the back. Sometimes late at night I need it.*

*I remember that article*

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well, and I have wanted to try exactly what you suggest. I've waited because I want fairly high resolution. Perhaps with the new 32 K and 64 K bit devices I will try it. Give me a little time.

The real problem I have is that there are so many good article ideas. I still want to put a computer in a car, do something with solar heat, remote control, and robotics. As long as you haven't been dissatisfied with everything so far, I trust that I'll find something interesting in the meantime.  
Steve

#### Across-the-Sea File

Dear Steve,

I read with great interest your article "Computerize a Home" (January 1980 BYTE, page 28), and I am interested in the BSR X-10 system.

I contacted the Commercial Section of the US Embassy here and also my employer's purchasing agent in New York, but neither could find me the address of

the BSR Company. I would appreciate it if you could tell me the manufacturer's address.

Thank you,  
Z Lapidot  
Rehovot, Israel

The address for BSR is: BSR (USA) Ltd, Rt 303, Blauvelt NY 10913, telephone: (914) 358-6060. There are many stocking distributors for its products including: The Software Exchange, 6 South St, Milford NH 03055.

BSR is an English company, and there may be outlets closer to you than those listed here.  
Steve

#### Point-to-Point

Dear Steve,

My compliments for a fine set of articles over the years. Only recently have I had the time to try some of the projects you write about. I am planning to build the DVM (digital voltmeter) from your article in the January 1978 BYTE ("Add More Zing to

the Cocktail," page 37).

I have contacted the printed-circuit board manufacturer that you mentioned in your article, but it no longer has boards available for that particular project. I do have all the components, and would like to avoid the tedium of hand-wiring the project. Do you have any boards available for a reasonable price?

I plan to use this circuit as part of a solar-energy-collector measurement system (among other things). I'm also trying to work out a method to manage energy consumption around the house.  
Frank J Pakulski

A lot of people have built and are using the DVM interface you mention. (Please note a typographical error in table 1 of that article. On IC1 pin 24 is +5 V, pin 13 is ground, and pin 12 is -5 V.) I'm sorry that the company that once sold the components no longer supplies them. I have noticed

that companies such as Jameco sell the MC14433 DVM chip, but not the printed-circuit board.

Recently, I have been arranging for boards and kits on some of my articles. This time the sources are more closely regulated and the boards and parts will be available far into the future.  
Steve

#### In-Depth Information Center

Dear Steve,

I would like you to recommend some texts that would introduce me to computer hardware, from basic switching theory through the actual architecture of a computer. I'm tired of superficial prose intended for the general consumer. I need some more in-depth information that is found only in engineering texts. You know, something that presents the computer from the electronics engineer's point of view in a well-structured manner. What do you suggest? As a postscript, I would also like to learn about Pascal.

Daniel R Shook

You ask an extremely difficult question. I have talked to other computer enthusiasts and it seems that (given the wide variety of texts and computer books being published) no two can agree on what is best. I have felt that there is a void in this area, and, as a matter of fact, I have just written a book on building a Z80 computer system from scratch. It's above the introductory level, but not just for engineers—similar to my articles. It should be published in early 1981.

In the meantime, I suggest you join the McGraw-Hill Electronic & Control Engineers book club. Many of its monthly selections are introductory texts written for engineers.

A good book on Pascal is Pascal User Manual and Report—Second Edition, by Jensen and Wirth from Springer-Verlag.  
Steve ■

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\*Creative Computing, Aug. 1980.

\*\*Popular Mechanics, Aug. 1980.

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Text continued from page 82:

subroutine name, length, and the subroutine instructions. Thus, our load-subroutine primitive can be represented as:

LSUB N,L,D<sub>0</sub>..D<sub>n-1</sub>

where:

- N = subroutine name or number
- L = subroutine length
- D<sub>i</sub> = subroutine instructions

For example, the primitive:

LSUB CLIP,5,D<sub>0</sub>..D<sub>4</sub>

loads a subroutine named CLIP with the given five instructions.

In order to maintain a sense of symmetry with these primitives, we need to include a primitive to read back a given subroutine. Although this feature does not affect the displayed image, it does aid the host in debugging and keeping track of the current status of the display. Thus, we require a read-subroutine primitive, which can be represented as:

RSUB N

where:

N = subroutine name or number

For example, the primitive:

RSUB CLIP

reads the instructions of the subroutine CLIP and presents the data to the host.

We have also assumed the existence of a programmable symbol generator. In order to support this feature, there is the need for some method of loading the generator. We either need to load an entirely new font definition in the symbol generator or alter only certain symbols: thus we must provide the option of loading the entire set or only one element. We can define each symbol by providing data which represents either the vectors that make up the symbol or by defining a bit pattern that forms the image of the symbol. In either case, our load-symbol primitive can be represented as:

LSYM M,(A,)D<sub>0</sub>..D<sub>n</sub>

where:

- M = mode (All symbols or a Single symbol)
- A = symbol code (optional: for single symbol only)
- D<sub>i</sub> = data mask defining the symbol

For example, the primitive:

LSYM S,80,D<sub>0</sub>..

loads the symbol numbered 80 with the given data mask.

Symmetrically, we must include a primitive to read back the data describing a single or all symbols. This feature is necessary to be able to produce hard copies of the displayed image. The host must know, if an image is to be plotted, how the current font is defined. We use the same justification as above to support the option of reading all or only selected symbols. Mnemonically, our read-symbol primitive can be represented as:

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RSYM M,(A)

where:

- M = mode (All symbols or a Single symbol)
- A = symbol code (optional: for single symbol only)

For example, the primitive:

RSYM A

reads back the entire font definition to the host.

In order to fully support a requirement for hard copy, two final primitives have to be provided. First, since we have assumed the existence of a color-look-up table, we must have some manner of reading back the values of the table to the host. Otherwise, the host would have to keep track of the current color definitions. This primitive thus reduces the host's bookkeeping and allows information on the actual displayed colors to be read back. For the same reasons as we described for the load-color-memory primitive, we must support the same options of reading back either the entire table, one entire parameter, or all parameters for one color code. Mnemonically, we can represent our read-color-memory primitive as:

RCRAM R,M,(A)

where:

- R = reference (Intensity, Hue, or Saturation color memory, or All)
- M = mode (Single address or All addresses)
- A = address (optional: for single address only)

For example, the primitive:

RCRAM I,A

reads back the contents of the entire intensity color memory.

Finally, we must be able to read back values of the pixel data itself. This feature is necessary not only for the support of hard copy, but allows the host to interrogate the display to read back the values of pixels at specified points in the image. We use the same justification as for the load-pixel primitive to support the various options of reference (full-frame, viewport, or X,Y). Mnemonically,

our read-pixel primitive can be represented as:

RPIX R

where:

- R = reference (Full-frame, Viewport, or X,Y)

For example, the primitive:

RPIX F

reads back the contents of the entire display-frame buffer.

This completes our set of graphics

(255, 255)

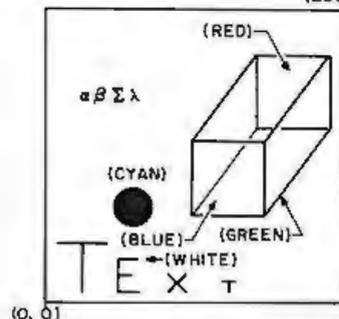


Figure 5: A sample of the images produced by Micrograph using the primitives of listing 1.

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primitives for a color raster-scan display. The graphics primitives are summarized in table 2. Note that this list does not include primitive instructions for operations such as circle or arc generation. Such features can be generated by existing primitives (using the vector-drawing primitive). Furthermore, circle and arc primitives are difficult to generalize and cannot easily support any more complex curves: their utility is therefore very limited for the cost of their implementation in terms of support hardware and display-processor software. Furthermore, features such as transformations are not included at this level since they presuppose a definite image structure that cannot be known by the display processor. Other

*Text continued on page 292*

**Listing 1:** This arrangement of primitives developed for Micrograph was used to produce the images in figure 5.

```

MOV 20,10 (T)
VEC SHORT_REL,WHITE,20,30
MOV 5,30 (T)
VEC SHORT_REL,WHITE,25,30
MOV 30,10 (E)
VEC SHORT_REL,WHITE,30,20
MOV 30,10 (E)
VEC SHORT_REL,WHITE,40,10
MOV 30,15 (E)
VEC SHORT_REL,WHITE,40,15
MOV 30,20 (E)
VEC SHORT_REL,WHITE,40,20
MOV 50,10 (X)
VEC SHORT_REL,WHITE,60,20
MOV 50,20 (X)
VEC SHORT_REL,WHITE,60,10
MOV 70,10 (T)
VEC SHORT_REL,WHITE,70,15
MOV 65,15 (T)
VEC SHORT_REL,WHITE,75,15
LREG VPORT,30,45,40,60 (rectangle
around circle)
LPIX VPORT,CYAN,0..CYAN,149
LREG VPORT,120,60,200,120 (part of
cube)
LPIX VPORT,BLUE
LREG VPORT,170,250,230 (part of
cube)
LPIX VPORT,RED
MOV 120,60
VEC SHORT_REL,GREEN,170,170 (part
of cube)
MOV 200,120
VEC SHORT_REL,GREEN,250,230 (part
of cube)
MOV 200,60
VEC SHORT_REL,GREEN,250,230 (part
of cube)
MOV 120,120
VEC SHORT_REL,GREEN,170,250 (part
of cube)
MOV 20,200
SYM 4,α,β,Σ,λ (from user-defined
font)
    
```

5 types of primitives, 37 instructions, 300 parameters

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**ED (ed)** — Text Editor: Used to write and edit plain text programs and modify any ASCII data file. Search, substitute, search on the fly, right margin, number-in-line position, back space, global change, macro commands. Ed is your standard CP/M command editor.

**ASM (as)** — 8080 Assembler: Takes standard 8080 instructions and translates. Conditional assembly. HEX file generation. Assembles strings, multi disk file transfer.

**FD (fd)** — File Transfer (Interchange Program): For transfer between disk and optical devices. Software for reading, concatenation, subtraction, file extraction, data conversion, file numbering and much more.

**SYSTEM (st)** — Batch (E, H, D, F, ASM and associated parameters) into user defined processes.

**DDT (ddt)** — Dynamic Debugging Tool: 32-bit assembly language interface monitor. Real time between break-point pauses. Full memory refresh, display and alteration at any time. Single step, disassemble, assembly, the list view of RAM. If you want device controllers, DDT is indispensable.

**STAT (st)** — Status: A version of report to physical devices, disk drive parameters, storage space, files etc.

**LOAD (ld)** — Convert 8080 HEX files (out put of ASM) into machine executable code. Programs are then executed by typing the program name.

**MSYCHK (ck)** — Reconfigure user system to a new machine type.

**SYSTEM (st)** — Create new systems create.

**DDAT (dd)** — Multi-purpose Disk Drive routines. Logically, every disk drive is represented by any optional and single density, double density, single side, double side, as well as standard optical disk writing. An optional selection allows full stepping disk rotation stepping. It conveniently reads non-interactive program executables.

An additional feature permits system re-configuration to disk capacity. This allows double density drives to operate with no additional software needed.

**COPY (cp)** — Diskette duplication and verification.

**X500 (x)** — Extension to power of 500000. It includes automatic file input to programs.

**FORMAT (fm)** — Prepare diskette for use with CP/M 2.2.

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<b>Z80</b> — 8086 Assembler for Z80 microcontroller. \$55/\$35	ACCOUNTS RECEIVABLE \$305/\$225
<b>COMPILER SYSTEMS CBASIC 2/INT/04</b>	PAYROLL \$635/\$325
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	OS/INT \$25/\$15
	WAP \$15/\$10
	<b>SHUGART HARDWARE</b> (no warranty, direct connection to front disk) \$15 x 400/110 \$4500
	16 x 110/110 \$4950
	<b>LINE PRINTER</b> — multi-line, multi-page, up to 332 cps; 1000 cps; 1000 cps; 175 cps; 175 cps; 175 cps. \$795
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**MICROLEDGER**

This General Ledger system performs the essential functions of dual entry bookkeeping and matches revenues and expenses.

- MICROLEDGER includes the following programs:
  - LEDGER 1 - builds and maintains the CHART OF ACCOUNTS file. This file contains both current and accumulated totals for each account.
  - LEDGER 2 - builds and updates the JOURNAL TRANSACTION file.
  - LEDGER 3 - lists both the JOURNAL file and the CHART OF ACCOUNTS.
  - LEDGER 4 - computes the TRIAL BALANCE and executes POSTING of journal transactions into the CHART OF ACCOUNTS. An AUDIT TRIAL of all transaction is output.
  - LEDGER 5 - produces the PROFIT AND LOSS STATEMENT.
  - LEDGER 6 - produces the BALANCE SHEET. Assets, liabilities and owners' equities are shown by account and by totals. .... \$140.00

**MICROPAY**

- An Accounts Payable system, MICROPAY includes the following program & functions:
  - PAY 1 - initializes both Transaction and Master files, then begins the Accounts Payable process by inputting and adding records in the Transaction file.
  - PAY 2 - allows for changes and deletions of Transaction and Master records.
  - PAY 3 - reports outstanding Accounts Payables in four categories; under 30 days, 31-50 days, 61-90 days, and over 90 days.
  - PAY 4 - reports all outstanding Accounts Payables for a single customer or for all customers, and computes Cash Requirements.
  - PAY 5 - reports all outstanding Accounts Payables for a single date or for a range of dates and computes the Cash Requirements.
  - PAY 6 - lists both the Transactions and Master files.
  - PAY 7 - prints checks and accumulates and journalizes Accounts Payables. This program simultaneously creates entries for the MICROLEDGER file. .... \$140.00

**MICROREC**

- An Accounts Receivable system, MICROREC includes the following programs and functions:
  - REC 1 - initializes Accounts Receivable files, adds A/R record and prints invoices.
  - REC 2 - accepts receipt of customer payments and changes or deletions of A/R Transaction or Master file records.
  - REC 3 - reports outstanding Accounts Receivables in four categories; under 30 days, 31-60 days, 61-90days, and over 90 days.
  - REC 4 - reports all outstanding Accounts Receivables for a single customer, or for all customers and computes Cash Projections.
  - REC 5 - produces reports for all outstanding Accounts Receivables for a single date or for a range of dates and computes Cash projections.
  - REC 6 - lists Transaction and Master files and accumulates and journalizes Accounts Receivables, creating JOURNAL entries which communicate with the MICROLEDGER JOURNAL file. .... \$140.00

**MICROINV**

- This Inventory Control system presents a general method of Inventory Control and produces several important reports. Its program includes:
  - INV 1 - initializes Transaction and Master files and adds and updates Transaction and Master records.
  - INV 2 - handles inventory issued or received, creating inventory records. This program also accumulates and journalizes transactions, producing JOURNAL entries which communicate with the MICROLEDGER file.
  - INV 3 - lists both Transaction and Master files.
  - INV 4 - produces the STOCK STATUS REPORT, showing the standard inventory stock data and stock valuation, and the ABC ANALYSIS breaking down the inventory into groups by frequency of usage.
  - INV 5 - gives a JOB COST REPORT/MATERIALS, showing allocation of materials used year-to-date by each job or work code. (This is complemented by the Job Cost Report/Personnel in the MICROPERS program.)
  - INV 6 - computes and provides the E.O.Q. (Economic Order Quantities) .... \$140.00

**MICROPERS**

- This is a Payroll/Personnel program whose functions include:
  - PERS 1 - initializes the Master file and allows for entry and updates of Master records.
  - PERS 2 - initializes the Payroll file and allows for entry and updates of payroll records.
  - PERS 3 - lists an Employee Master Record or the entire Employee Master file; lists a single Payroll Record or the entire Payroll file.
  - PERS 4 - computes Payroll and prints the PAYROLL REGISTER. Prints PAYCHECKS and creates JOURNAL entries to be fed into the MICROLEDGER JOURNAL file.
  - PERS 5 - produces the JOB COST REPORT/PERSONNEL, computes the quarterly 94 1 bank deposit, and the Annual W-2 run. .... \$140.00

All COMPUMAX programs available in machine readable format (diskette form) for the following machines:

TRS-80™ Model I	Micropolis 1053/11
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PET	CBASIC under CP/M
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**FROM ADVENTURE INTERNATIONAL (By Scott Adams)**

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2. **PIRATE'S ADVENTURE** - "Yo ho ho and a bottle of rum!" You'll meet up with the pirate and his daffy bird along with many strange sights as you attempt to go from your London flat to Treasure Island. Can you recover Long John Silver's lost treasures? Happy Sailing, matey .....
3. **MISSION IMPOSSIBLE ADVENTURE** - Good morning, your mission is to... and so it starts. Will you be able to complete your mission in time? Or is the world's first automated nuclear reactor doomed? This one's well named. It's hard, there is no magic, but plenty of suspense. Good luck .....
4. **VOODOO CASTLE** - Count Cristo has had a fiendish curse put on him by his enemies. He lies, with you his only hope. Will you be able to rescue him or is he forever doomed? Beware the Voodoo Man .....

5. **THE COUNT** - You wake up in a large brass bed in a castle somewhere in Transylvania. Who are you, what are you doing here, and WHY did the postman deliver a bottle of blood? You'll love this Adventure, in fact, you might say it's Love at First Byte .....
  6. **STRANGE ODYSSEY** - Marooned at the edge of the galaxy, you've stumbled on the ruins of an ancient alien civilization complete with fabulous treasures and unearthly technologies. Can you collect the treasures and return or will you end up marooned forever? .....
  7. **MYSTERY FUN HOUSE** - Can you find your way completely through the strangest Fun House in existence, or will you always be kicked out when the park closes? .....
  8. **PYRAMID OF DOOM** - An Egyptian Treasure Hunt leads you into the dark recesses of a recently uncovered Pyramid. Will you recover all the treasures or more likely will you join its denizens for that long eternal sleep? .....
  9. **GHOST TOWN** - Explore a deserted western mining town in search of 13 treasures. From rattlesnakes to runaway horses, this Adventure's got them all! Just remember, Pardner, they don't call them Ghost Towns for nothin'. (Also includes new bonus scoring system!) .... \$14.95 Per Adventure
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- DMS Features:**
- File Creation and Maintenance:
    - Fields may be alphanumeric, numeric, integer, floating point, or fixed decimal with commas.
    - Fields may be COMPUTED FIELDS. DMS will compute any field within a record, using constants or other fields in the same record. Functions include add, subtract, multiply, divide, and raise exponential powers.
    - Records are easily located, using the SCAN feature. SCAN for records with a field over, below, or between a range of values.
    - Records are easily added and updated. DMS "prompts" you with questions
    - Multi-diskette capabilities for larger files - up to 85,000 characters per file!
    - Sort the records into almost any order, using up to 10 fields as "keys". So you can sort for customer numbers; within zip code, for instance.
    - Delete records, "compact" files, and backup files on data diskettes easily
  - Report Features:**
    - Print reports with records in any order.
    - Select fields to be printed.
    - Print mailing labels.
    - Numeric totals and subtotals can be specified when a value in an unrelated field in the same record changes. For example, sort, subtotal, and print according to department, or month, or customer number, or model number.

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**Listing 2: The first third of the firmware for Micrograph control, written for the Z80 microprocessor used in the prototype. The remaining portions of the firmware will be included in the next two issues of BYTE, along with hardware construction details (Part 2, December 1980 BYTE), and software (Part 3, January 1981 BYTE).**

```

1  MICROGRAPH INTERFACE SYSTEM 1
2  P A T
3
4  MICROGRAPH 1.0 *****
5
6  DEVELOPED BY GRAY BOOTH
7
8  MICROGRAPH IS A FIRMWARE CONTROLLED MICROPROCESSOR
9  BASED COLOR GRAPHICS DISPLAY SYSTEM, BUILT AT A
10 SINGLE BOARD DISPLAY PROCESSOR, WHICH INTERFACES
11 TO A STANDARD UNMODIFIED COLOR TELEVISION. THE USER
12 SEES MICROGRAPH AS A 256 X 256 PIXEL SYSTEM. 8 BITS
13 PER PIXEL. THIS SYSTEM IS CAPABLE TO AN EQUAL OR LOWER
14 RESOLUTION DISPLAY. GRAPHICS PRIMITIVES ARE AVAILABLE
15 TO ALLOW THE USER TO CREATE GRAPHICS DISPLAYS.
16 MICROGRAPH INTERFACES TO A HOST COMPUTER VIA THREE
17 8 BIT I/O PORTS. FURTHER INFORMATION IS AVAILABLE
18 IN THE MICROGRAPH REFERENCE MANUAL.
19
20 ORG 0          START AT ADDRESS 0
21 MICROG: DT     DISABLE INTERRUPTS
22          JP     MAIN      JUMP TO MAIN
23
24 *****
25 GLOBAL DEFINITIONS, CONSTANTS AND STRUCTURES*****
26 *****
27
28 ; STRUCTURES *****
29
30 ; STRUCTURES PROVIDES STORAGE FOR ALL FIRMWARE
31 ; VARIABLES AND STRUCTURES. DEFAULT VALUES ARE PROVIDED
32 ; IN THIS SECTION, WHICH IS STORED IN EPROM. STRUCTURES
33 ; ARE MOVED TO RAM DURING INITIALIZATION, AND REFERENCED
34 ; VIA THE OFFSETS DESCRIBED IN DEFINITIONS. NOTE THAT
35 ; THE FIRST SEVERAL BYTES OF RAM ARE RESERVED FOR THE
36 ; GRAPHICS AND MICROPROCESSOR STACKS.
37
38 ESTRUCT: EQU $          ;START OF STRUCTURES
39 EDDR: EQU $            ;GRAPHICS DISPLAY REG
40 EDDR0: DEFB 0          ;X
41 EDDR1: DEFB 0          ;Y
42 EDDR2: DEFB 255       ;PRIMARY COLOR
43 EDDR3: DEFB 0          ;SECONDARY COLOR
44 EDDR4: DEFB 0          ;FRAME COUNT
45 EDDR5: DEFB 00000000H ;VECTOR MODE
46 EDDR6: DEFB 0          ;VIEWPORT 0 LEFT X
47 EDDR7: DEFB 0          ;VIEWPORT 0 LEFT Y
48 EDDR8: DEFB 255       ;VIEWPORT 0 RIGHT X
49 EDDR9: DEFB 255       ;VIEWPORT 0 RIGHT Y
50 EDDR10: DEFB 0         ;VIEWPORT 1 LEFT X
51 EDDR11: DEFB 0         ;VIEWPORT 1 LEFT Y
52 EDDR12: DEFB 255       ;VIEWPORT 1 RIGHT X
53 EDDR13: DEFB 255       ;VIEWPORT 1 RIGHT Y
54 EDDR14: DEFB 00001000H ;DISPLAY FORMAT
55 EDDR15: DEFB 10000000H ;STATUS
56 ESLINK: EQU $          ;GRAPHICS SUB LINKAGE
57 EL00: DEFW USER       ;SUBROUTINE 00
58 EL01: DEFW USER       ;SUBROUTINE 01
59 EL02: DEFW USER       ;SUBROUTINE 02
60 EL03: DEFW USER       ;SUBROUTINE 03
61 EL04: DEFW USER       ;SUBROUTINE 04
62 EL05: DEFW USER       ;SUBROUTINE 05
63 EL06: DEFW USER       ;SUBROUTINE 06
64 EL07: DEFW USER       ;SUBROUTINE 07
65 EL10: DEFW GUSER      ;SUBROUTINE 10
66 EL11: DEFW GUSER      ;SUBROUTINE 11

```

```

67 EL12: DEFW GUSER      ;SUBROUTINE 12
68 EL13: DEFW GUSER      ;SUBROUTINE 13
69 EL14: DEFW GUSER      ;SUBROUTINE 14
70 EL15: DEFW GUSER      ;SUBROUTINE 15
71 EL16: DEFW GUSER      ;SUBROUTINE 16
72 EL17: DEFW GUSER      ;SUBROUTINE 17
73 ESLONG: EQU $          ;GRAPHICS SUB LENGTH
74 ESH0: DEFB $          ;SUBROUTINE 00
75 ESO1: DEFB $          ;SUBROUTINE 01
76 ESO2: DEFB $          ;SUBROUTINE 02
77 ESO3: DEFB $          ;SUBROUTINE 03
78 ESO4: DEFB $          ;SUBROUTINE 04
79 ESO5: DEFB $          ;SUBROUTINE 05
80 ESO6: DEFB $          ;SUBROUTINE 06
81 ESO7: DEFB $          ;SUBROUTINE 07
82 ESO8: DEFB $          ;SUBROUTINE 10
83 ES11: DEFB $          ;SUBROUTINE 11
84 ES12: DEFB $          ;SUBROUTINE 12
85 ES13: DEFB $          ;SUBROUTINE 13
86 ES14: DEFB $          ;SUBROUTINE 14
87 ES15: DEFB $          ;SUBROUTINE 15
88 ES16: DEFB $          ;SUBROUTINE 16
89 ES17: DEFB $          ;SUBROUTINE 17
90 ESPTR: DEFB 0         ;GRAPHICS SUB POINTER
91 ESOPF: DEFB 0         ;GRAPHICS SUB OFFSET
92 ESOP: DEFB 0          ;GRAPHICS STACK POINTER
93 ESVP: DEFB 0          ;CURRENT VIEWPORT REFERENCE
94 EM: DEFB 0            ;VECTOR DRAWING TEMP
95 EMM: DEFB 0          ;VECTOR DRAWING TEMP
96 ERM: DEFB 0          ;VECTOR DRAWING TEMP
97 ERY: DEFB 0          ;VECTOR DRAWING TEMP
98 ERY: DEFB 0          ;VECTOR DRAWING TEMP
99 ECOLOR: DEFB 0       ;VECTOR COLOR STORAGE
100 EYERR: DEFB 0        ;ERROR SERVICE TEMP
101 ENPL: DEFB 10000000H ;FRAME SERVICE
102
103 ; NON MASKABLE INTERRUPT TRAP *****
104
105 ; A TRAP TO THIS LOCATION IN MEMORY OCCURS UPON RECEIPT
106 ; OF A NON MASKABLE INTERRUPT. THIS SECTION FORCES A
107 ; JUMP TO THE ERROR SERVICE ROUTINE, XERR.
108
109
110
111
112 ; CONSTANTS *****
113
114 ; CONSTANTS PROVIDES STORAGE FOR ALL FIRMWARE CONSTANTS
115 ; WHICH ARE STORED IN EPROM.
116
117 CONST: EQU $          ;START OF CONSTANTS
118 IVECT: EQU $          ;START OF INTERRUPT VEC
119 INTO: DEFW FRAME      ; NAME SERVICE
120 INI: DEFW INPUT       ;INPUT SERVICE
121 INT2: DEFW OUTPUT     ;OUTPUT SERVICE
122 PENTER: EQU $         ;PRIMITIVE ENTRY POINTS
123
124 DEFW CALLS           ;CALLS ENTRY
125 DEFW LCRAM           ;LCRAM ENTRY
126 DEFW LPTX           ;LPTX ENTRY
127 DEFW LREG           ;LREG ENTRY
128 DEFW LSUB           ;LSUB ENTRY
129 DEFW LSYN           ;LSYN ENTRY
130 DEFW MOV            ;MOV ENTRY
131 DEFW RCRAM          ;RCRAM ENTRY
132 DEFW RETN           ;RETN ENTRY
133 DEFW RPTX           ;RPTX ENTRY
134 DEFW RREG           ;RREG ENTRY
135 DEFW RSUB           ;RSUB ENTRY
136 DEFW RSYN           ;RSYN ENTRY
137 DEFW SYM            ;SYM ENTRY
138 DEFW VEC            ;VEC ENTRY
139 DEFW WAIT           ;WAIT ENTRY

```

# YOUR MODEL II CAN HAVE SNAPP!



## SNAPP II EXTENDED BASIC

A family of enhancements to the Model II BASIC interpreter. Part of the package originated with the best of APPARAT, INC.'s thoughts in implementing NEWDOS BASIC. The system is written entirely in machine language for SUPER FAST execution. The extensions are fully integrated into Model II BASIC and require NO user memory, and NO user disk space. The package is made up of the following five modules, each of which may be purchased separately:

**XBASIC** - Six single keystroke commands to list the first, last, previous, next, or current program line, or to edit the current line. Ten single character abbreviations for frequently used commands: AUTO, CLS, DELETE, EDIT, KILL, LIST, MERGE, NEW, LIST, and SYSTEM. \$25

**XREF** - A powerful cross-reference facility with output to display and/or printer. Trace a variable through the code. Determine easily if a variable is in use. \$40

**XDUMP** - Permits the programmer to display and/or print the value of any or all program variables. Identifies the variable type for all variables. Each element of any array is listed separately. \$40

**XRENUM** - An enhanced program line renumbering facility which allows specification of an upper limit of the block of lines to be renumbered, supports relocation of renumbered blocks of code, and supports duplication of blocks of code. \$40

**XFIND** - Permits quick and easy location of specified strings or keywords within the program text. \$30

**SAVE** - on the purchase of the entire package. \$140



## CONVERT

This remarkable utility converts "V" format files (the sequential format used by the SHACKS COBAL and BASIC Compilers) to the "F" format files (the sequential file format used by the BASIC Interpreter and BASCOM), and vice versa. Without this product, programs written for the interpreter will have to be RE-KEYED to be used by the SHACKS Compiler BASIC. \$75.00



## SKRUNCH

A SUPER FAST TRSDOS UTILITY. Compresses your BASIC programs to an absolute minimum. Typically saves 30-40% space, even for programs without REM statements! Also results in 7-10% improvement in execution speed. \$35



## SBASIC

Model I and Model II Program in a high-level, full structured BASIC! The BEST of the BASIC pre-processors. PERFORM named subroutines. CONDITIONAL case structures. WHILE loops. UNTIL loops. And much more. Forget about line numbers. Model II version is compiled, and SUPER FAST. From Ultimate Computer Systems. Model I \$50 Model II \$75



## DOSFIX

A collection of patches to TRSDOS and BASIC to enhance their usability and function. Includes our well-known BREAK7E patches to keep the break key from being used accidentally. FREE WITH ANY MODEL II SOFTWARE PACKAGE.



## FRIEND

### FOUR NEW TRSDOS COMMANDS!

**SHOW** - A much better multi-disk directory display. Let's you see only those files you want, and includes date of last update.

**MOVE** - A much better file copying command. Copy/Move whole groups of files, renaming them at the same time. If desired, with just 1 command!

**ERASE** - Better than KILL, better than PURGE.

**PRINT** - Print BASIC programs from disk, whether saved in ASCII or compressed. All 4 DOS commands allow fast processing of one, or complete groups of files, based on generic naming and wild card specifications. Enhanced functions too numerous to fully describe here.

**EXAMPLES:**  
**SHOW PAY\*/BAS\***

Directory display of all 'BAS' files on all diskettes which begin with 'PAY'.

**MOVE PAY\*/BAS:1 TO =/OLD:3**

Save current versions of payroll programs to drive 3, changing extensions to 'OLD'.

**MOVE OLD\*/? TO NEW =/? :1**

Copy all files on drive 0 which begin with 'OLD', regardless of extension, to drive 1, changing the first 3 letters of the filename to 'NEW', but retaining the same file extension. Save time!

Reduce frustration!  
Eliminate ERROR 33! \$75



## HOSTII / TERMI

Allows 'remote control' of a Model II from another Model II, or any ASCII terminal. If terminal is a Model II, accurate screen positioning (PRINT @) is fully supported! Requires NO user memory! This system is designed to provide software support to our customer locations without ever leaving the office. \$50



## BUGZAP

A powerful utility oriented toward the machine language programmer. Display/Modify/Print/Memory/Disk sectors. Use this to help you learn more about the internals of the Model II. \$50



## MASTER / SLAVE

This software package was designed to support the transferring of files from one Model II to another, via direct connection or modem/phone line connection. ALL kinds of files, and baud rates up to 9600 are fully supported. Transfer files in either direction, even with the SLAVE Model II UNATTENDED! \$150



## SPOOLER - Model I and Model II

Our workhorse! This package, available for Model I, in the TRSDOS/NEWDOS or NEWDOS 80 versions, or for the Model II, greatly enhances system performance when running typical business applications. Many applications have been benchmarked to run nearly TWICE AS FAST with the SPOOLER installed. Installs in minutes, and no changes are required to your programs. Preferred Model II versions require NO user memory. Optional features for the Model II version only: Serial printer support, and DISK SPOOLING support. The DISK SPOOLING support is particularly recommended for word processing applications. \$100

**SERIAL PRINTER OPTION** \$50  
**DISK SPOOLING OPTION** \$50



## ROUTE

Causes LPRINT data to be sent to the video screen! A great help in writing and debugging programs when no printer is available, you have a slow printer, or you are just in a hurry. Can be turned on and off from within your BASIC program. Requires NO user memory. \$25



## SCREEN

Supports the copying of the full video screen to the printer. Can be invoked by the operator with a keystroke, or from your program with a USR call. Requires NO user memory. \$25



## SAVE

Retrieve the resident BASIC program following an accidental SYSTEM, or a system crash. DON'T BE WITHOUT THIS ONE. YOU NEVER KNOW WHEN YOU WILL NEED IT! \$35



## TERMS OF SALE:

Credit card customers, add 3% C.O.D. customers add \$3. Ohio residents add 4 1/2% sales tax. Shipments normally made the same day we receive your order.



## OUR GUARANTEE:

If your diskette arrives damaged, we will replace it without charge. If you ever accidentally damage it, we will replace it for a \$10 handling charge. For a period of one year, we will provide you with any enhancements or updates for a \$10 handling charge. For a period of one year, if errors are discovered in the programs, they will be corrected without charge. In the event we cannot correct an error, you may return the program material for a refund.



8160 Corporate Park Dr.  
Cincinnati, Ohio 45242

Ohio residents call collect

(513) 891-4496

Call Toll Free

1-800-543-4628

Most products will soon be available for the Model I. CALL FOR DETAILS!



## Listing 2 continued:

```

141 : DEFINITIONS: *****
141 :
142 : DEFINITIONS PROVIDES GLOBAL DEFINITIONS OF VARIOUS
143 : STRUCTURES AND VARIABLES.
144 :
145 DEFTM: EQU $                :START OF DEFTM
146 RESTART: EQU 0              :RESTART ADDRESS
147 PROTIN: EQU 4096            :BOTTOM OF PRIVATE RAM
148 NSTACK: EQU PROTIN+63      :BOTTOM OF MICRO STACK
149 NSTACK4: EQU NSTACK+44     :BOTTOM OF GRAPH STACK
150 STRUCT: EQU RESTART+1      :START OF STRUCTURES
151 RELOC: EQU -STRUCT         :RELOCATION CONSTANT
152 GDR: EQU RELOC+GDR        :GRAPHICS DISPLAY REG
153 GDR0: EQU RELOC+GDR0      :X
154 GDR1: EQU RELOC+GDR1      :Y
155 GDR2: EQU RELOC+GDR2      :PRIMARY COLOR
156 GDR3: EQU RELOC+GDR3      :SECONDARY COLOR
157 GDR4: EQU RELOC+GDR4      :FRAME COUNT
158 GDR5: EQU RELOC+GDR5      :VECTOR MODE
159 GDR6: EQU RELOC+GDR6      :VIEWPORT 0 LEFT X
160 GDR7: EQU RELOC+GDR7      :VIEWPORT 0 LEFT Y
161 GDR8: EQU RELOC+GDR8      :VIEWPORT 0 RIGHT X
162 GDR9: EQU RELOC+GDR9      :VIEWPORT 0 RIGHT Y
163 GDR10: EQU RELOC+GDR10    :VIEWPORT 1 LEFT X
164 GDR11: EQU RELOC+GDR11    :VIEWPORT 1 LEFT Y
165 GDR12: EQU RELOC+GDR12    :VIEWPORT 1 RIGHT X
166 GDR13: EQU RELOC+GDR13    :VIEWPORT 1 RIGHT Y
167 GDR14: EQU RELOC+GDR14    :DISPLAY FORMAT
168 GDR15: EQU RELOC+GDR15    :STATUS
169 SLINK: EQU RELOC+SLINK     :GRAPHICS SUB LINKAGE
170 L01: EQU RELOC+L01         :SUBROUTINE 01
171 L02: EQU RELOC+L02         :SUBROUTINE 02
172 L03: EQU RELOC+L03         :SUBROUTINE 03
173 L04: EQU RELOC+L04         :SUBROUTINE 04
174 L05: EQU RELOC+L05         :SUBROUTINE 05
175 L06: EQU RELOC+L06         :SUBROUTINE 06
176 L07: EQU RELOC+L07         :SUBROUTINE 07
177 L10: EQU RELOC+L10         :SUBROUTINE 10
178 L11: EQU RELOC+L11         :SUBROUTINE 11
179 L12: EQU RELOC+L12         :SUBROUTINE 12
180 L13: EQU RELOC+L13         :SUBROUTINE 13
181 L14: EQU RELOC+L14         :SUBROUTINE 14
182 L15: EQU RELOC+L15         :SUBROUTINE 15
183 L16: EQU RELOC+L16         :SUBROUTINE 16
184 L17: EQU RELOC+L17         :SUBROUTINE 17
185 SLONG: EQU RELOC+SLONG     :GRAPHICS SUB LENGTH
186 S00: EQU RELOC+S00         :SUBROUTINE 00
187 S01: EQU RELOC+S01         :SUBROUTINE 01
188 S02: EQU RELOC+S02         :SUBROUTINE 02
189 S03: EQU RELOC+S03         :SUBROUTINE 03
190 S04: EQU RELOC+S04         :SUBROUTINE 04
191 S05: EQU RELOC+S05         :SUBROUTINE 05
192 S06: EQU RELOC+S06         :SUBROUTINE 06
193 S07: EQU RELOC+S07         :SUBROUTINE 07
194 S10: EQU RELOC+S10         :SUBROUTINE 10
195 S11: EQU RELOC+S11         :SUBROUTINE 11
196 S12: EQU RELOC+S12         :SUBROUTINE 12
197 S13: EQU RELOC+S13         :SUBROUTINE 13
198 S14: EQU RELOC+S14         :SUBROUTINE 14
199 S15: EQU RELOC+S15         :SUBROUTINE 15
200 S16: EQU RELOC+S16         :SUBROUTINE 16
201 S17: EQU RELOC+S17         :SUBROUTINE 17
202 SPTR: EQU RELOC+SPTR       :GRAPHICS SUB POINTER
203 SOFF: EQU RELOC+SOFF       :GRAPHICS SUB OFFSET
204 GPC: EQU RELOC+GPC         :GRAPHICS STACK POINTER
205 REF: EQU RELOC+REF         :CURRENT VIEWPORT REF
206 M: EQU RELOC+M            :VECTOR DRAWING TEMP
207 NM: EQU RELOC+NM          :VECTOR DRAWING TEMP
208 MN: EQU RELOC+MN          :VECTOR DRAWING TEMP
209 SX: EQU RELOC+SX          :VECTOR DRAWING TEMP
210 SY: EQU RELOC+SY          :VECTOR DRAWING TEMP
211 COLOR: EQU RELOC+COLOR     :VECTOR COLOR STORAGE
212 XFRNT: EQU RELOC+XFRNT     :ERROR SERVICE FLAG
213
214 MBL: EQU RELOC+MBL         :FRAME SERVICE
215 FREE: EQU STRUCT+MBL+1    :START OF FREE RAM
216 SYTAB: EQU 5120           :START OF SYMBOL TABLE
217 TTOP: EQU 2143            :TOP OF PRIVATE RAM
218 CR0: EQU 2140             :COLOR RAM 0
219 CR1: EQU 2142             :COLOR RAM 1
220 CR2: EQU 2140             :COLOR RAM 2
221 RBOTTOM: EQU 8150         :START OF PRIVATE RAM
222 RTOP: EQU 1415           :RESET TOP SYSTEM 1
223 :
224 *****
225 MAIN PROGRAM BLOCK *****
226 *****
227 :
228 : MAIN *****
229 :
230 : MAIN IS THE DRIVER FOR MICROGRAPH, WITH INITIALIZING
231 : OF MAIN CALLS INIT, PITCH AND EXEC OF WHICH DO
232 : WORK TO PROCESS THE GRAPHICS PRIMITIVES.
233 :
234 : CALLS: INIT
235 : PITCH
236 : EXEC
237 :
238 : CALLED BY: NOT APPLICABLE
239 :
240 : REGISTERS: SP (STACK POINTER)
241 :
242 : I/O: NONE
243 :
244 : STRUCTURES: NONE
245 :
246 MAIN: LD SP,NSTACK          :INITIALIZE SP
247 CALL INIT                  :INITIALIZE THE SYSTEM
248 LOOP: CALL PITCH           :GET A PRIMITIVE
249 OR LOOP                   :RETURN A PRIMITIVE
250 :                          :PRINT IMMEDIATELY
251 :
252 *****
253 INTERRUPT SERVICE ROUTINES *****
254 *****
255 :
256 XERR *****
257 :
258 XERR SERVICES AN ERROR CONDITION. XERR IS CALLED UPON
259 : A TRAP TO THE NON-MASKABLE INTERRUPT VECTOR.
260 : XERR ALLOWS A SYSTEM RESET, REGISTER DUMP, OR MEMORY
261 : DUMP VIA THE DIAGNOSTIC DIRECTIVES.
262 :
263 : CALLS: SENDY
264 :
265 : CALLED BY: NON-MASKABLE INTERRUPT
266 :
267 : REGISTERS: A (DUMP)
268 : B (DUMP)
269 : C (DUMP)
270 : D (DUMP)
271 : E (DUMP)
272 : H (DUMP)
273 : I (DUMP)
274 : IX (DUMP)
275 : IY (DUMP)
276 : SP (DUMP)
277 :
278 : I/O: PORT 2 (STATUS)
279 : PORT 4 (INPUT)
280 :
281 : STRUCTURES: GDR15 (STATUS)
282 :
283 XERR: EI                    :ENABLE INTERRUPTS
284 PUSH AF                   :SAVE A AND F
285 SET D,(IX*GDR15)          :SET ERROR
286 SET I,(IX*GDR15)          :SET ERROR
287 LD A,(IX*GDR15)           :GET THE STATUS

```

## OS-9™ LEVEL TWO MULTIUSER OPERATING SYSTEM

**T** rue multitasking, multiuser OS for timesharing or real-time control applications.

- Sophisticated memory management permits use of over one megabyte.
  - Versatile, easy-to-use input/output supports multiple devices.
  - UNIX™-like file structure including hierarchical directories, pipes, filters, and byte-addressable random access files.
  - Provides log-on password protection and user file security.
  - Can run on small, inexpensive systems with floppy disks and as little as 32K memory.
- \$495.00\*

## OS-9™ LEVEL ONE OPERATING SYSTEM

**A** multitasking real-time operating system for software development, process control and smaller multi-user applications.

- Versatile input/output system can support multiple devices using interrupt-driven, DMA, or program-controlled data transfer. Users can easily add additional I/O devices.
  - Tape or disk-based versions available.
  - Disk versions support UNIX™-like hierarchical directory structure and byte-addressable random-access files.
  - Memory management for single address-space (up to 64K).
- Disk version \$150.00\*  
 Tape version \$95.00

## BASIC®™ PROGRAMMING LANGUAGE SYSTEM

**E** xtended BASIC language compiler/interpreter with integrated text editor and debug package. Runs standard BASIC programs or minimally-modified PASCAL programs.

- Permits multiple named program modules having local variables and identifiers. Modules are reentrant, position independent and ROMable.
- Additional control statements for structured programming: IF ... THEN ... ELSE, FOR ... NEXT, REPEAT ... UNTIL, WHILE ... DO, LOOP ...

## INTRODUCING

# 6809 SOFTWARE POWER TOOLS

BY MICROWARE®

ENDLOOP, EXITIF ... ENDEXIT.

- Allows user-defined data types and complex data structures. Five built-in data types: byte, integer, 9 digit floating-point, string and boolean.
  - Outperforms any other BASIC on any 8-bit MPU.
  - Available on ROM, disk or cassette tape. Runs under OS-9™ Level One or Level Two.
- Disk or tape \$195.00\*

## MICROSOFT 6809 BASIC

**S** tandard Microsoft BASIC optimized for the 6809 and OS-9™.

- Four data types: integer, string, single precision and double precision floating point.
  - Program trace and edit capabilities.
  - Automatic line numbering and renumbering.
  - Supports random and sequential file I/O. Full PRINT USING for formatted output.
- Disk or tape \$250.00

## OS-9™ TEXT EDITOR

**M** inimum-keystroke macro text editor useful for text preparation or interactive word processing.

- User-defined macros with parameters permit virtually unlimited command expansion. Macros can be saved, loaded

and edited.

- Buffer, line and character oriented commands.
  - Search, change and extend operations.
  - Permits multiple input/output files.
- Disk or tape \$75.00  
 ROM set (2716) \$90.00

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Compact Motorola compatible assembler for machine language program development.

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  - Facilities for generation of OS-9™ memory modules and system calls.
  - Formatted listings include syntax and context error checking.
  - Runs on OS-9™ Level One or Level Two.
- Disk or tape \$75.00  
 ROM set (2716) \$90.00

## OS-9™ INTERACTIVE DEBUGGER

**F** acilitates testing and debugging of machine- language programs.

- Includes common "monitor" functions: memory examine/change, breakpoints, display/change registers, etc.
  - Calculator mode evaluates arithmetic expressions in hex, decimal or binary.
  - Access to system commands.
  - Available on ROM, disk or cassette tape.
- Disk or tape \$35.00  
 ROM (2716) \$50.00

BASIC ® is a trademark of Motorola. OS-9 is a trademark of Motorola and Microware®, UNIX is a trademark of Bell Telephone Laboratories.

Most software is available on ROM, diskette and tape in versions for many popular 6809 computers. Source listings and yearly maintenance/update service are sold separately for most programs.

\*Specify manufacturer and type of CPU and I/O controllers. Contact Microware® for specific availability.

## MICROWARE®

Microware Systems Corp., Dept. B1  
5835 Grand Avenue  
Des Moines, Iowa 50304  
(515) 279-8844

## Listing 2 continued:

```

00A9 D302 288      OUT (2),A      ;DISPLAY THE STATUS
00AB DDCB0F66 289 XERR0: BIT 4,(IX+GDR15) ;WAIT FOR DIRECTIVE
00AF 28FA 290      JR 2,XERR0    ;JUMP UNTIL RECEIVED
00B1 0B04 291      IN A,(4)      ;GET THE DATA
00B3 DDCB0FA6 292      RES 4,(IX+GDR15) ;RESET THE STATUS
00B7 F5 293      PUSH AF      ;SAVE A AND F
00B9 0D7E0F 294      LD A,(IX+GDR15) ;GET THE STATUS
00BB D302 295      OUT (2),A    ;OUTPUT THE STATUS
00BD F1 296      POP AF       ;RESTORE A AND F
00BL 0B7F 297      BIT 7,A      ;TEST FOR RESET
00CD C20000 298      JP NZ,RESTART ;RESTART IF SET
00CF 0B77 299      BIT 6,A      ;TEST FOR DIRECTIVE
00D5 204F 300      JR NZ,XERR1    ;JUMP IF SET
00D7 F1 301      POP AF       ;RESTORE A AND F
00D9 F5 302      PUSH AF      ;SAVE A COPY OF A AND F
00DB 0D910A 303      CALL SENDBY ;SEND A
00DD 70 304      LA A,B      ;GET B
00DF 0D910A 305      CALL SENDBY ;SEND B
00E1 70 306      LD A,C      ;GET C
00E3 0D910A 307      CALL SENDBY ;SEND C
00E5 7A 308      LD A,D      ;GET D
00E7 0D910A 309      CALL SENDBY ;SEND D
00E9 7B 310      LA A,E      ;GET E
00EB 0D910A 311      CALL SENDBY ;SEND E
00ED 7C 312      LD A,H      ;GET H
00EF 0D910A 313      CALL SENDBY ;SEND H
00F1 7D 314      LD A,L      ;GET L
00F3 0D910A 315      CALL SENDBY ;SEND L
00F5 0D22CA10 316      LD (STRUCT+XERR1),IX ;GET IX
00F7 0D7E4A 317      LD A,(IX+XERR1) ;GET LOW BYTE
00F9 0D910A 318      CALL SENDBY ;SEND IT
00FB 0D7E4B 319      LD A,(IX+XERR1+1) ;GET HIGH BYTE
00FD 0D910A 320      CALL SENDBY ;SEND IT
00FF 0D22CA10 321      LD (STRUCT+XERR1),IY ;GET IY
0101 0D7E4A 322      LD A,(IX+XERR1) ;GET LOW BYTE
0103 0D910A 323      CALL SENDBY ;SEND IT
0105 0D7E4B 324      LD A,(IX+XERR1+1) ;GET HIGH BYTE
0107 0D910A 325      CALL SENDBY ;SEND IT
0109 09 326      EXX          ;SAVE PRIMARY REGISTERS
010B 2100 327      LD L,0      ;CLEAR POINTER
010D 2600 328      LD H,0      ;CLEAR POINTER
010F 39 329      ADD HL,SP    ;GET THE STACK POINTER
0111 7D 330      LD A,L      ;GET THE LOW BYTE
0113 0D910A 331      CALL SENDBY ;SEND IT
0115 7C 332      LD A,H      ;GET THE HIGH BYTE
0117 0D910A 333      CALL SENDBY ;SEND IT
0119 09 334      EXX          ;RESTORE PRIMARY REGS
011B F1 335      POP AF       ;RESTORE A AND F
011D 1095 336      JR XERR0    ;DO IT AGAIN
011F F1 337      POP AF       ;POP A AND F
0121 0B 338      EX AF,AF'    ;SAVE A AND F
0123 09 339      EXX          ;SAVE PRIMARY REGISTERS
0125 DDCB0F66 340 XERR2: BIT 4,(IX+GDR15) ;TEST THE INPUT
0127 28FA 341      JR 2,XERR2    ;JUMP IF NOT SET
0129 0B04 342      IN A,(4)      ;GET THE DATA
012B 6F 343      LD L,A      ;SAVE THE LOW ADDRESS
012D DDCB0FA6 344      RES 4,(IX+GDR15) ;RESET THE FLAG
012F 0D7E0F 345      LD A,(IX+GDR15) ;GET THE STATUS
0131 D302 346      OUT (2),A    ;SEND THE STATUS
0133 DDCB0F66 347 XERR3: BIT 4,(IX+GDR15) ;TEST THE INPUT
0135 28FA 348      JR 2,XERR3    ;JUMP IF NOT SET
0137 0B04 349      IN A,(4)      ;GET THE DATA
0139 67 350      LD H,A      ;SAVE THE HIGH ADDRESS
013B DDCB0FA6 351      RES 4,(IX+GDR15) ;RESET THE FLAG
013D 0D7E0F 352      LD A,(IX+GDR15) ;GET THE STATUS
013F D302 353      OUT (2),A    ;SEND THE STATUS
0141 7E 354      LD A,(HL)     ;GET THE MEMORY DATA
0143 0D910A 355      CALL SENDBY ;SEND THE DATA
0145 09 356      EXX          ;RESTORE PRIMARY REGS
0147 0B 357      EX AF,AF'    ;RESTORE A AND F
0149 03ABD0 358      JP XERR0    ;DO IT AGAIN
014B 359      ;
014D 360      ;
014F 361      ;
0151 362      ; FRAME IS THE INTERRUPT SERVICE ROUTINE FOR A FRAME
363 ; COUNT INTERRUPT (FIRST PRIORITY, MASKABLE INTERRUPT).
364 ; FRAME FIRST SETS THE FRAME INTERRUPT FLAG, INCREMENTS
365 ; THE FRAME COUNT, CALLS NULL, THE FRAME SERVICE
366 ; ROUTINE IN RAM, AND THEN RESETS THE FRAME INTERRUPT
367 ; FLAG. NOTE THAT THE OUTPUT TO THE DISPLAY PORT FORCES
368 ; A RESET OF THE INTERRUPT FOR THE FRAME INTERRUPT.
369 ; SINCE THE INTERRUPT IS PRODUCED ON THIS PORT.
370 ;
371 ; CALLS          NULL
372 ;
373 ; CALLED BY     FIRST PRIORITY MASKABLE INTERRUPT
374 ;
375 ; REGISTERS     A      (TEMPORARY)
376 ;               F      (TEMPORARY)
377 ;               IX      (INDEX)
378 ;
379 ; I/O           PORT 0 (DISPLAY)
380 ;               PORT 2 (STATUS)
381 ;
382 ; STRUCTURES    GDR4  (FRAME COUNT)
383 ;               GDR14 (DISPLAY FORMAT)
384 ;               GDR15 (STATUS)
385 ;
386 FRAME: PUSH AF      ;SAVE A AND F
387 EI                 ;ENABLE INTERRUPTS
388 SET 2,(IX+GDR15)  ;SET FRAME INTERRUPT
389 LD A,(IX+GDR15)  ;GET GDR15
390 OUT (2),A        ;UPDATE THE STATUS
391 INC (IX+GDR4)    ;INCREMENT FRAME COUNT
392 CALL STRUCT+NULL ;CALL NULL IN RAM
393 LD A,(IX+GDR14)  ;GET THE DISPLAY FORMAT
394 OUT (0),A        ;SEND IT
395 RES 2,(IX+GDR15) ;RESET FRAME INTERRUPT
396 LD A,(IX+GDR15) ;GET THE STATUS
397 OUT (2),A        ;UPDATE THE STATUS
398 POP AF           ;RESTORE A AND F
399 RETI              ;RETURN FROM INTERRUPT
400 ;
401 ; INPUT *****
402 ;
403 ; INPUT IS THE INTERRUPT SERVICE ROUTINE FOR AN INPUT
404 ; INTERRUPT (SECOND PRIORITY, MASKABLE INTERRUPT).
405 ; INPUT SIMPLY SETS THE INPUT INTERRUPT FLAG IN GDR15.
406 ;
407 ; CALLS          NONE
408 ;
409 ; CALLED BY     SECOND PRIORITY MASKABLE INTERRUPT
410 ;
411 ; REGISTERS     A      (TEMPORARY)
412 ;               F      (TEMPORARY)
413 ;               IX      (INDEX)
414 ;
415 ; I/O           PORT 2 (STATUS)
416 ;
417 ; STRUCTURES    GDR15 (STATUS)
418 ;
419 INPUT: PUSH AF     ;SAVE A AND F
420 EI                 ;ENABLE INTERRUPTS
421 SET 4,(IX+GDR15)  ;SET INPUT INTERRUPT
422 LD A,(IX+GDR15)  ;GET GDR15
423 OUT (2),A        ;UPDATE THE STATUS
424 POP AF           ;RESTORE A AND F
425 RETI              ;RETURN FROM INTERRUPT
426 ;
427 ; OUTPUT *****
428 ;
429 ; OUTPUT IS THE INTERRUPT SERVICE ROUTINE FOR AN OUTPUT
430 ; INTERRUPT (THIRD PRIORITY, MASKABLE INTERRUPT).
431 ; OUTPUT SIMPLY RESETS THE OUTPUT INTERRUPT FLAG IN
432 ; GDR15.
433 ;
434 ; CALLS          NONE
435 ;
436 ; CALLED BY     THIRD PRIORITY MASKABLE INTERRUPT
437 ;

```



# META TECHNOLOGIES

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### FILE BOX

DISKETTE STORAGE SYSTEM

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Single Sided, Single Density, Soft-Sector'd  
5 1/4-inch. (for TRS-80™) Mini-floppy

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Meta Technologies strikes again . . . at the competition! These are factory fresh, absolutely first quality (no seconds!) mini-floppies. They are complete with envelopes, labels and write-protect tabs in a shrink-wrapped box.

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In 1980 alone, MTC has sold nearly a third of a million dollars worth of brand-name diskettes. If anyone knows quality, we do. And these are quality diskettes. The catch? They are in a plain white box. You're not paying for fancy printing, fancy labels or fancy names on the packaging. We don't even put our own label on the package (labels cost money). At this introductory price (our regular price will be \$21.95 per box of 10) we cannot offer quantity or dealer discounts.

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### TRS-80™ PRODUCTS



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- 35-track . . . . . \$69.95
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- MICROSOFT™ BASIC DECODED & OTHER MYSTERIES for the TRS-80™ . . . . . \$29.95

## THANK YOU

for 1980 . . .

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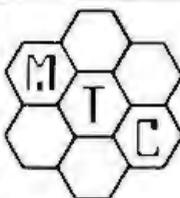
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Listing 2 continued:

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430 : REGISTERS      A      (TEMPORARY)
431 :                I      (TEMPORARY)
440 :                IX     (INDEX)
441 :
442 : I/O             PORT 2 (STATUS)
443 :
444 : STRUCTURES     GDR15  (STATUS)
445 :
0176 : F5             446 OUTPUT: PUSH AF          ;SAVE A AND F
0177 : F8             447 EI              ;ENABLE INTERRUPTS
0178 : DDCBOFF*E     448 RES 3,(IX+GDR15)    ;RESET OUTPUT INTERRUPT
0179 : DD/EOF        449 LD A,(IX+GDR15)    ;GET GDR15
017F : B302          450 OUT (2),A          ;UPDATE THE STATUS
0191 : F1             451 POP AF           ;RESTORE A AND F
0182 : ED4D          452 RET              ;RETURN FROM INTERRUPT
453 :
454 : *****
455 : PROCESS DRIVERS*****
456 : *****
457 :
458 : INIT *****
459 :
460 : INIT INITIALIZES MICROGRAPH, THE INPUT/OUTPUT PORTS
461 : ARE FIRST SET UP, THEN MEMORY IS CLEARED. INIT THEN
462 : LOADS THE RAM WITH THE STRUCTURES, THEN SET THE
463 : INTERRUPTS.
464 :
465 : CALLS          NONE
466 :
467 : CALLED BY     MAIN
468 :
469 : REGISTERS     A      (TEMPORARY)
470 :                B      (TEMPORARY)
471 :                C      (TEMPORARY)
472 :                D      (TEMPORARY)
473 :                L      (TEMPORARY)
474 :                H      (POINTER)
475 :                IX     (INDEX)
476 :                IY     (INDEX)
477 :                I      (INTERRUPT VECTOR)
478 :
479 : I/O           ALL PORTS
480 :
481 : STRUCTURES   ALL STRUCTURES
482 :
0184 : 3E0F          484 INIT: LD A,00001111B ;LOAD NODE 2 MASK
0186 : D301          485 OUT (1),A          ;SET UP DISPLAY
0188 : D303          486 OUT (2),A          ;SET UP STATUS
018A : D307          487 OUT (7),A          ;SET UP OUTPUT
018C : 3141          488 LD A,01001111B    ;LOAD NODE 1 MASK
018E : D305          489 OUT (5),A          ;SET UP INPUT
0190 : 3128          490 LD A,INT0          ;GET FIRST VECTOR
0192 : D301          491 OUT (1),A          ;SET UP FRAME INTERRUPT
0194 : 3E6A          492 LD A,INT1          ;GET SECOND VECTOR
0196 : D305          493 OUT (5),A          ;SET UP INPUT INTERRUPT
0198 : 3E6C          494 LD A,INT2          ;GET THIRD INTERRUPT
019A : D307          495 OUT (7),A          ;SET UP OUTPUT INT
019C : 3E09          496 LD A,00000111B    ;DISABLE INTERRUPTS
019E : D303          497 OUT (3),A          ;SET STATUS
01A0 : 3E07          498 LD A,100001111B   ;ENABLE INTERRUPTS
01A2 : D301          499 OUT (1),A          ;SET DISPLAY
01A4 : D305          500 OUT (5),A          ;SET INPUT
01A6 : D307          501 OUT (7),A          ;SET OUTPUT
01A8 : 3E80          502 LD A,10000000B    ;SET STATUS
01AA : D302          503 OUT (2),A          ;SET STATUS
01AC : D021801D     504 LD IX,STRUCT      ;SET UP IX
01AD : 00360000      505 LD (IX+D),0        ;CLEAR FIRST WORD
01B4 : 21E010       506 LD HL,STRUCT       ;POINT TO STRUCT
01B7 : 11E110       507 LD DE,STRUCT+1     ;POINT TO NEXT STRUCT
01B8 : 034000       508 LD BC,1*RET-STRUCT ;SET UP COUNT
01B9 : ED80          509 LDIR              ;CLEAR PRIVATE RAM
01BF : 210400       510 LD HL,STRUCT       ;POINT TO STRUCTURES
01C2 : 11E010       511 LD DE,STRUCT       ;POINT TO STRUCT
01C5 : 016000       512 LD BC,1*PULL-ESTRUCT+1 ;GET THE COUNT

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01C8 : ED80          513 LDIR              ;LOAD STRUCTURES
01CA : 210020       514 LD HL,RBOTTOM      ;POINT TO RBOTTOM
01CC : 3600          515 LD (HL),0          ;CLEAR FIRST LOCATION
01CE : 110120       516 LD DE,RBOTTOM+1    ;POINT TO NEXT LOCATION
01D0 : 010018       517 LD BC,RTOP-RBOTTOM+1 ;GET THE COUNT
01D2 : ED80          518 LDIR              ;CLEAR REFRESH RAM
01D4 : DDCBOFF*E     519 RES 7,(IX+GDR15)   ;CLEAR INIT STATUS
01D6 : DD/EOF        520 LD A,(IX+GDR15)    ;GET GDR15
01D8 : D302          521 OUT (2),A          ;UPDATE STATUS
01DA : 3E00          522 LD A,0             ;CLEAR A
01DC : ED47          523 LD I,A            ;SET UP INTERRUPT VECTOR
01DE : ED5E          524 IM 2             ;SET INTERRUPT MODE 2
01E0 : F0           525 EI              ;ENABLE INTERRUPTS
01E2 : DD/EOF        526 LD A,(IX+GDR14)    ;SET DISPLAY MASK
01E4 : D300          527 OUT (0),A          ;SET DISPLAY MODE
01E6 : C9           528 RET              ;RETURN
529 :
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Listing 2 continued:

```

0212 CB23 589 SLA E ;MULTIPLY BY TWO
0213 1600 590 LD D,0 ;CLEAR POINTER
0214 FD21F010 591 LD IY,STRUCT+SLINK ;LOAD SLINK ADDRESS
0214 FD19 592 ADD IY,DE ;ADD THE OFFSET
0214 FD6E00 593 LD L,(IY+0) ;GET LOW BYTE OF ENTRY
021F FD6601 594 LD H,(IY+1) ;GET HIGH BYTE OF ENTRY
0222 005E41 595 LD E,(IX+SOFF) ;GET OFFSET
0225 1600 596 LD D,0 ;CLEAR POINTER
0227 003441 597 INC (IX+SOFF) ;INCREMENT OFFSET
022A 19 598 ADD HL,DE ;ADD OFFSET
022B 7E 599 LD A,(HL) ;GET DATA FROM SUB
022C 1DE1 600 POP IY ;RESTORE IY
022E E1 601 POP HL ;RESTORE HL
022F 01 602 POP DE ;RESTORE DE
0230 F5 603 PUSH AF ;SAVE A AND F
0231 DDC80FB6 604 RES 5,(IX+GDR15) ;RESET EXECUTE FLAG
0235 0D7E0F 605 LD A,(IX+GDR15) ;GET GDR15
0238 0502 606 OUT (2),A ;UPDATE THE STATUS
023A FB 607 EI ;ENABLE THE INTERRUPTS
023E 11 608 POP AF ;RESTORE A AND F
023C 09 609 RET ;RETURN
610 ;
611 ; EXEC *****
612 ;
613 ; EXEC IS THE FIRST STEP IN EXECUTING A GRAPHICS
614 ; PRIMITIVE. EXECUTE FIRST SETS THE EXECUTE FLAG, THEN
615 ; CALLS PRIMAT, WHICH JUMPS TO THE PROPER PRIM.
616 ; AFTER A RETURN FROM THE PRIMITIVE ITSELF, EXEC
617 ; RESETS THE EXECUTE FLAG AND IN LRMS.
618 ;
619 ; CALLS PRINT
620 ;
621 ; CALLED BY MAIN
622 ;
623 ; REGISTERS A (TEMPORARY)
624 ; F (TEMPORARY)
625 ; IX (INDEX)
626 ;
627 ; I/O POINT 2 (STATUS)
628 ;
629 ; STRUCTURES GDR15 (STATUS)
630 ;
0220 F5 631 EXEC: PUSH AF ;SAVE A AND F
023C DDC80FB6 632 SET 5,(IX+GDR15) ;SET EXECUTE FLAG
0242 0D7E0F 633 LD A,(IX+GDR15) ;GET GDR15
0245 0302 634 OUT (2),A ;UPDATE THE STATUS
0247 F1 635 POP AF ;RESTORE A AND F
0248 0D5502 636 CALL PRIMAT ;CALL PRIMAT
024E DDC80FAE 637 RES 5,(IX+GDR15) ;RESET EXECUTE FLAG
024F 0D7E0F 638 LD A,(IX+GDR15) ;GET THE STATUS
0252 0302 639 OUT (2),A ;UPDATE THE STATUS
0254 09 640 RET ;RETURN
641 ;
642 ;*****
643 ;GRAPHICS PRIMITIVES*****
644 ;*****
645 ;
646 ; PRIMAT *****
647 ;
648 ; PRIMAT IS THE SECOND STEP IN EXECUTING A PRIMITIVE.
649 ; PRIMAT FIRST DETERMINES THE PRIMITIVE NUMBER FROM THE
650 ; OP CODE IN REGISTER A, AND PUTS A POINTER TO THIS
651 ; ADDRESS IN IY. HL IS THEN LOADED WITH THE SUBROUTINE
652 ; ADDRESS ITSELF, THEN PRIMAT JUMPS TO THIS LOCATION.
653 ; NOTE THAT A RETURN FROM A PRIMITIVE SUBROUTINE
654 ; ACTUALLY RETURNS TO EXEC.
655 ;
656 ; CALLS NONE
657 ;
658 ; CALLED BY EXEC
659 ;
660 ; REGISTERS A (PRIMITIVE OR CODE)
661 ; D (POINTER)
662 ; E (POINTER)
663 ; H (POINTER)

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664 ; L (POINTER)
665 ; IY (INDEX)
666 ;
667 ; I/O NONE
668 ;
669 ; STRUCTURES POINTER (PRIMITIVE ENTRY POINT)
670 ;
0220 5F 671 INRHL: LD L,A ;SAVE A COPY OF VALUE
0226 0038 672 SRL E ;SHIFT THE OP
0228 0E26 673 SRL E ; CODE RIGHT FOUR
022A 0E38 674 SRL E ; BITS TO MAINTAIN
022C 0E38 675 SRL E ; THE OFFSET
022E 0023 676 SLA E ;MULTIPLY BY TWO
0230 1600 677 LD D,0 ;CLEAR THE POINTER
0232 FD216E00 678 LD IY,PRIMAT ;LOAD PRIMER ADDRESS
0234 FD19 679 ADD IY,DE ;ADD THE OFFSET IN HL
0236 FD6E00 680 LD L,(IY+0) ;LOAD LOW BYTE OF SUB
0238 FD6601 681 LD H,(IY+1) ;LOAD HIGH BYTE OF SUB
023A 19 682 JP (HL) ;JUMP TO SUBROUTINE
683 ;
684 ; CALLS *****
685 ;
686 ; CALLS CALLS A MICROCOMPUTER OR GRAPHICS SUBROUTINE.
687 ; CALLS FIRST DETERMINES WHAT TYPE OF SUBROUTINE IS
688 ; BEING CALLED, IF IT IS A MICROCOMPUTER SUBROUTINE,
689 ; CALLS CALLS THE PROPER SUBROUTINE AS LINKED BY
690 ; SLINK, OTHERWISE, CALLS PUSHES SPTR AND SOFF ON THE
691 ; GRAPHICS SUBROUTINE STACK, AND LOADS THE NEW VALUES
692 ; FOR SPTR AND SOFF. FUTURE DATA FROM FLCH THEN COMES
693 ; FROM THIS GRAPHICS SUBROUTINE UNTIL A RETN IS
694 ; EXECUTED.
695 ;
696 ; CALLS USER (INDIRECTLY, BY DEFAULT)
697 ; GUSER (INDIRECTLY, BY DEFAULT)
698 ; USER SUB(INDIRECTLY)
699 ;
700 ; CALLED BY PRIMAT (INDIRECTLY)
701 ;
702 ; REGISTERS A (PRIMITIVE OR CODE)
703 ; B (TEMPORARY)
704 ; D (TEMPORARY)
705 ; E (TEMPORARY)
706 ; H (POINTER)
707 ; L (POINTER)
708 ; IX (INDEX)
709 ;
710 ; I/O NONE
711 ;
712 ; STRUCTURES GPC (GRAPHICS STACK POINTER)
713 ; GSTACK (GRAPHICS STACK)
714 ; SOFF (GRAPHICS SUBROUTINE OFFSET)
715 ; SLINK (GRAPHICS SUBROUTINE LINKAGE)
716 ; SPTR (GRAPHICS SUBROUTINE POINTER)
717 ;
0221 0E5F 718 CALLS: BIT 3,A ;TEST BIT 3 OF CODE
0271 2014 719 JR NZ,CALLS1 ;JUMP IF GRAPHICS SUB
0273 FD21F010 720 LD IY,STRUCT+SLINK ;GET LINK BASE
0277 E607 721 AND 0000011B ;MASK ALL BUT SUB
0279 0E27 722 SLA A ;MULTIPLY BY TWO
027B 5F 723 LD E,A ;SAVE A IN E
027C 1600 724 LD D,0 ;CLEAR POINTER
027E F019 725 ADD IY,DE ;ADD OFFSET TO IY
0280 FD6E00 726 LD L,(IY+0) ;GET LOW ADDRESS
0283 FD6601 727 LD H,(IY+1) ;GET HIGH ADDRESS
0284 E9 728 JP (HL) ;JUMP TO SUBROUTINE
0287 217F10 729 CALLS1: LD HL,GSTACK ;LOAD GSTACK ADDRESS
028A 0D5E40 730 LD I,(IX+GPC) ;GET GPC
028C 1600 731 LD D,0 ;CLEAR POINTER
028E 0E0F 732 OR A ;RESET THE CARRY
0290 ED52 733 SBC HL,DE ;SUBTRACT POINTER
0292 0D4440 734 LD B,(IX+SPTR) ;LOAD SPTR
0295 70 735 LD (HL),B ;PUT SPTR ON GSTACK
0296 0D4441 736 LD B,(IX+SOFF) ;LOAD SOFF
0298 2B 737 DEC HL ;UPDATE THE POINTER
029A 70 738 LD (HL),B ;PUT SOFF ON GSTACK

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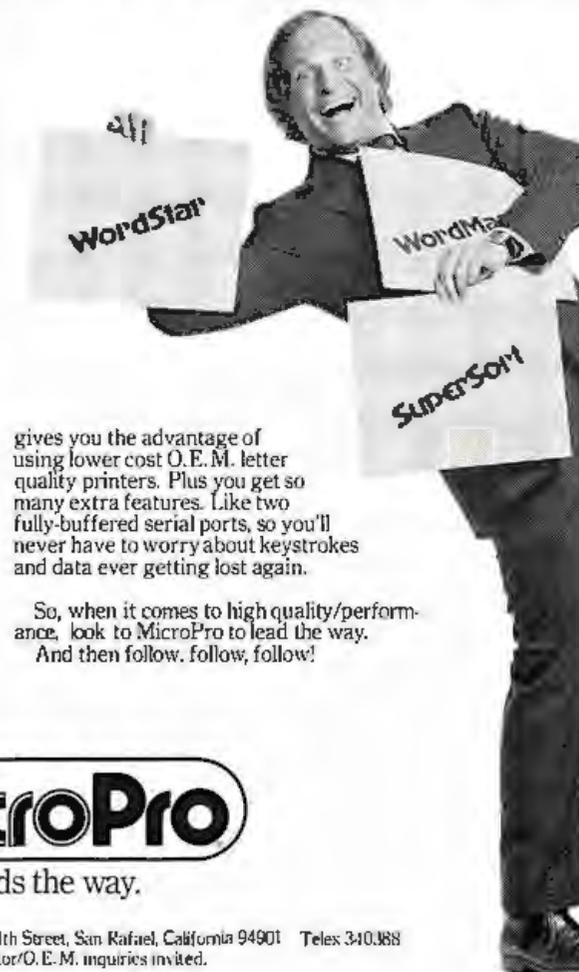
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Listing 2 continued:

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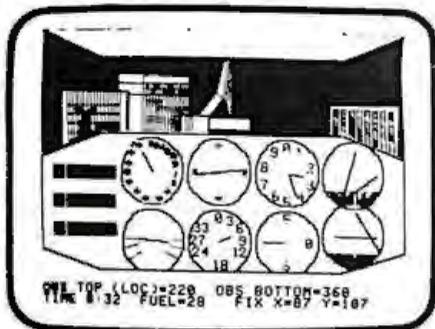
0296 820F 749 007F 00001110  ;AND ALL BUT ONE
0298 002740 740 LD (IX+SPTR),A ;UPDATE SPTR
02A0 00364100 741 LD (IX+OFFT),0 ;UPDATE OFFT
02A4 003442 742 INC (IX+GPR) ;INCREMENT GPC
02A7 003442 743 INC (IX+GPR) ;INCREMENT GPC
02AA 07 744 RET ;RETURN
745 ;
746 ; LCRAM *****
747 ;
748 ; LCRAM LOADS THE COLOR RAMS. LCRAM FIRST DETERMINES IF
749 ; A SINGLE OR ALL COLOR RAMS ARE TO BE LOADED. IF A
750 ; SINGLE COLOR RAM IS TO BE LOADED, THE ENTIRE RAM OR
751 ; A SINGLE ADDRESS OF THAT RAM IS TO BE LOADED.
752 ; OTHERWISE, ALL THREE COLOR RAMS ARE EITHER ENTIRELY
753 ; LOADED, OR A SINGLE ADDRESS IN ALL THREE IS LOADED.
754 ;
755 ; CALLS FETCH
756 ; GETBLK
757 ;
758 ; CALLED BY PRMAT (INDIRECTLY)
759 ;
760 ; REGISTERS A (PRIMITIVE OF CODE)
761 ; B (COUNTER)
762 ; D (TEMPORARY)
763 ; E (TEMPORARY)
764 ; H (POINTER)
765 ; L (POINTER)
766 ; IX (INDEX)
767 ;
768 ; I/O NONE
769 ;
770 ; STRUCTURES CR0 (COLOR RAM 0)
771 ; CR1 (COLOR RAM 1)
772 ; CR2 (COLOR RAM 2)
773 ;
02AB CB47 774 LCRAM: BIT 0,A ;TEST SINGLE BIT
02AD 2820 775 JR Z,LCRAM1 ;JUMP IF SINGLE
02AF FE10 776 CF 00011100B ;TEST FOR ALL
02B1 2007 777 JR NZ,LCRAM0 ;JUMP IF NOT ALL
02B3 0630 778 LD B,48 ;SET COUNT OF 48 BYTES
02B5 21001C 779 LD HL,CR0 ;SET START ADDRESS
02B8 0D9A08 780 CALL GETBLK ;CALL GETBLK
02BB 07 781 RET ;RETURN
02BD 0610 782 LCRAM0: LD B,16 ;SET COUNT OF 16 BYTES
02BE E60E 783 AND 00001100B ;MASK OFF #PCODE
02C0 CB27 784 SRA A ;SHIFT OFFSET
02C2 CB27 785 SRA A ;SHIFT OFFSET
02C4 6F 786 LD L,A ;SAVE OFFSET
02C5 2600 787 LD H,0 ;CLEAR POINTER
02C7 11001C 788 LD DE,CR0 ;GET START ADDRESS
02CA 17 789 ADD HL,DE ;ADD TO OFFSET
02CB 0D9A08 790 CALL GETBLK ;CALL GETBLK
02CE 07 791 RET ;RETURN
02CF FE10 792 LCRAM1: CF 00011100B ;TEST FOR ALL
02D1 2027 793 JR NZ,LCRAM2 ;JUMP IF NOT ALL
02D3 0DE001 794 CALL FETCH ;GET OFFSET
02D6 E60F 795 AND 00001111B ;MASK ALL BUT OFFSET
02D8 6F 796 LD L,A ;SAVE OFFSET
02D9 2600 797 LD H,0 ;CLEAR POINTER
02DB 11001C 798 LD DE,CR0 ;GET START ADDRESS
02DE 17 799 ADD HL,DE ;ADD TO OFFSET
02E0 50 800 LD E,L ;RESTORE LOW BYTE
02E1 54 801 LD H,H ;RESTORE HIGH BYTE
02E3 FD210000 802 LD IX,0 ;CLEAR INDEX
02E5 FD19 803 ADD IX,DE ;MOVE POINTER TO INDEX
02E7 0DE001 804 CALL FETCH ;GET DATA
02EA FD7700 805 LD (IX+0),A ;LOAD DATA IN CR0
02ED 0E0000 806 CALL FETCH ;GET DATA
02F0 FD7710 807 LD (IX+1),A ;LOAD DATA IN CR1
02F2 0DE001 808 CALL FETCH ;GET DATA
02F6 FD7720 809 LD (IX+2),A ;LOAD DATA IN CR2
02F9 07 810 RET ;RETURN
02FA 0601 811 LCRAM2: LD B,1 ;SET COUNT OF 1 BYTE
02FC L600 812 AND 00001100B ;MASK ALL BUT OFFSET
02FE CB27 813 SRA A ;SHIFT OFFSET

```

```

0300 CB27 814 SRA A ;SHIFT OFFSET
0302 47 815 LD L,A ;SAVE A IN L
0303 2600 816 LD H,0 ;CLEAR POINTER
0305 0DE001 817 CALL FETCH ;GET OFFSET
0308 E60F 818 AND 00001111B ;MASK ALL BUT OFFSET
030A 95 819 ADD A,L ;ADD OFFSET
030B 6F 820 LD L,A ;SAVE OFFSET
030C 11001C 821 LD DE,CR0 ;GET START ADDRESS
030F 17 822 ADD HL,DE ;ADD OFFSET
0310 0D9A08 823 CALL GETBLK ;GET DATA
0313 07 824 RET ;
825 ; LPIX *****
826 ;
827 ;
828 ; LPIX LOADS PIXEL DATA ACCORDING TO THE GIVEN
829 ; REFERENCE. LPIX CAN LOAD EITHER FULL FRAME, ONE
830 ; PIXEL AT XY, OR AN ENTIRE VIEWPORT. THE PIXELS ARE
831 ; LOADED IN EITHER THE PRIMARY COLOR, THE SECONDARY
832 ; COLOR, OR AS SPECIFIED IN THE DATA WHICH FOLLOWS.
833 ; LPIX FIRST CHECKS TO SEE IF ONLY A SINGLE POINT IS
834 ; LOADED. IF SO, LPIX LOADS THE APPROPRIATE COLOR.
835 ; OTHERWISE, LPIX SETS A FLAG IF THERE IS A FULL FRAME
836 ; LOAD REQUESTED. NEXT, LPIX DETERMINES WHAT COLOR IS
837 ; REQUESTED. IF THE COLOR DOES NOT FOLLOW, A FLAG IS
838 ; SET, AND THE APPROPRIATE COLOR IS LOADED FROM THE
839 ; GRAPHICS DISPLAY REGISTERS. NEXT, LPIX CLEARS BOTH
840 ; X AND Y, AND PROCEEDS TO LOAD THE PIXELS FROM
841 ; THE ORIGIN OF THE DISPLAY TO THE TOP, ONE LINE AT
842 ; A TIME. CLIP IS CALLED IF THERE IS A VIEWPORT
843 ; REFERENCE TO SEE IF THAT POINT WILL ACTUALLY BE
844 ; LOADED. LPIX IS COMPLETED WHEN X AND Y RECYCLE TO THE
845 ; ORIGIN.
846 ;
847 ; CALLS FETCH
848 ; CASE
849 ; CLIP
850 ; POKE
851 ;
852 ; CALLED BY PRMAT (INDIRECTLY)
853 ;
854 ; REGISTERS A (PRIMITIVE OF CODE, TEMPORARY)
855 ; B (CASE)
856 ; C (CLIP SUCCESS FLAG)
857 ; D (FULL FRAME FLAG)
858 ; E (COLOR FOLLOWS FLAG)
859 ; IX (INDEX)
860 ;
861 ; I/O NONE
862 ;
863 ; STRUCTURES GR00 (X)
864 ; GR01 (Y)
865 ; GR02 (PRIMARY COLOR)
866 ; GR03 (SECONDARY COLOR)
867 ; REF (REFERENCE)
868 ;
0314 1E00 869 LPIX: LD E,0 ;CLEAR COLOR FOLLOWS
0316 1600 870 LD 0,0 ;CLEAR FULL FRAME
0318 E60F 871 AND 00001111B ;CLEAR OF CODE
031A 007743 872 LD (IX+REF),A ;SAVE REFERENCE
031D 0DC0433E 873 SRA (IX+REF) ;ADJUST REFERENCE
0321 0DC0433E 874 SRA (IX+REF) ;ADJUST REFERENCE
0325 0E5F 875 BIT Z,A ;TEST REFERENCE
0327 2821 876 JR Z,LPIX4 ;JUMP IF VIEWPORT REF
0329 0E57 877 BIT Z,A ;TEST REFERENCE
032B 2819 878 JR Z,LPIX3 ;JUMP IF FULL FRAME
032D 0E4F 879 BIT 1,A ;TEST COLOR FOLLOWS
032F 200E 880 JR NZ,LPIX1 ;JUMP IF COLOR FOLLOWS
0331 0E47 881 BIT 0,A ;TEST COLOR TYPE
0333 2805 882 JR Z,LPIX0 ;JUMP IF PRIMARY COLOR
0335 0D7E03 883 LD A,(IX+GR03) ;LOAD SECONDARY COLOR
0338 1808 884 JR LPIX2 ;JUMP AROUND FETCH
033A 0D7E02 885 LPIX0: LD A,(IX+GR02) ;LOAD PRIMARY COLOR
033D 1803 886 JR LPIX2 ;JUMP AROUND FETCH
033F 0E001 887 LPIX1: CALL FETCH ;GET THE COLOR DATA
0342 0D390A 888 LPIX2: CALL POKE ;POKE THE COLOR AT X,Y

```



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5. **PRINTER DRIVER.** Simply hit CTRL P for direct output to Centronics printer.
6. **REIVAL ROUTINE.** If NEW or CLOAD are typed, or RESET is hit by mistake, your program may be recovered! This is a safety device.

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- RUNSTOP stops execution until any other key is hit.
- CLEAR clears screen then sends a CR. Hit CLEAR to start on new page.
- CTRL characters such as ESC, LF and CLEAR don't return "SN ERROR".
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MNEMONIC NAME

CALL	call subroutine
LCRAM	load color memory
LPIX	load pixel
LREG	load register
LSUB	load subroutine
LSYM	load symbol
MOV	move
RCRAM	read color memory
RET	return
RPIX	read pixel
RREG	read register
RSUB	read subroutine
RSYM	read symbol
SYM	display symbol
VEC	draw a vector
WAIT	wait

Table 2: Quick reference guide to the primitives defined for Micrograph. Although the minimum set of instructions need only include a point-positioning primitive and a vector-drawing primitive, added flexibility of extra functions is used to remove processing burden from the host system.

Text continued from page 278:

features, such as clipping and anti-aliasing, can be readily implemented at the primitive level without the addition of other instructions. Such features can be treated as system parameters, selectable through the load-register primitive. In figure 5, a sample of the images produced by these primitives is shown. (Also see listing 1.)

One last item that must be discussed is error processing. For any implementation of the primitives, the display processor must be able to detect, report, and possibly recover from errors such as invalid primitives or an error in a called user subroutine. Of course, this error processing is highly implementation-dependent, but does not affect the structures of our primitives. However, several of these primitives can be used to aid the host computer in error processing, such as the read-register and read-pixel primitives.

So far the characteristics of interactive computer-graphics systems have been examined, focusing on a comparison of the features of calligraphic and raster-scan display processors. A set of primitive instructions for the control of a color raster-scan display processor have been developed.

Next month, Part 2 of this article will concern the hardware design of Micrograph, a microprocessor-based peripheral which implements these primitives. ■

Listing 2 continued:

```

0345 09          889      RET          :RETURN
0346 1601       890      LFIX3: LD 0,1      :SET FULL FRAME FLAG
0348 1803       891      JR LFIX6      :JUMP AROUND CASE
034A CD4007     892      LFIX4: CALL CASE  :FIND VIEWPORT CASE
034D 00360000   893      LFIX5: LD (IX+GDR0),0  :CLEAR X
0351 00360100   894      LD (IX+GDR1),0  :CLEAR Y
0355 0E4F       895      BIT 1,A        :TEST COLOR FOLLOWS
0357 200E       896      JR NZ,LFIX7    :JUMP IF COLOR FOLLOWS
0359 1E01       897      LD E,1        :SET COLOR FLAG
035B 0E47       898      BIT 0,A        :TEST COLOR TYPE
035D 2005       899      JR Z,LFIX6    :JUMP IF PRIMARY COLOR
035F 007E03     900      LD A,(IX+GDR3)  :LOAD SECONDARY COLOR
0362 1803       901      JR LFIX7      :JUMP TO LOOP
0364 007E02     902      LFIX6: LD A,(IX+GDR2)  :LOAD PRIMARY COLOR
0367 0E43       903      LFIX7: BIT 0,E        :TEST COLOR FOLLOWS
0369 2003       904      JR NZ,LFIX8    :JUMP IF COLOR PRESENT
036B 0E0001     905      CALL FETCH    :GET DATA
036E 0E42       906      LFIX8: BIT 0,D        :TEST FULL FRAME
0370 2007       907      JR NZ,LFIX9    :JUMP IF FULL FRAME
0372 0DEF07     908      CALL CLIP    :CHECK FOR CLIP
0375 0E41       909      BIT 0,C        :TEST SUCCESS
0377 2003       910      JR Z,LFIX10   :JUMP IF CLIPPED
0379 0D390A     911      LFIX9: CALL F0KE  :FORK THE DATA
037C 063400     912      LFIX10: INC (IX+GDR0)  :INCREMENT X
037E 30E6       913      JR NZ,LFIX7    :JUMP IF X NOT ZERO
0381 003401     914      INC (IX+GDR1)  :INCREMENT Y
0383 30E1       915      JR NZ,LFIX7    :JUMP IF Y NOT ZERO
0386 09          916      RET          :RETURN
917 ;
918 ; LREG *****
919 ;
920 ; LREG LOADS A GRAPHIC DISPLAY REGISTER. IF GDR15 IS
921 ; SPECIFIED, A RESET OCCURS, SINCE THIS IS ESSENTIALLY
922 ; A READ ONLY REGISTER. OTHERWISE, LREG SETS A POINTER
923 ; TO THE APPROPRIATE REGISTER AND READS IN THE DATA.
924 ;
925 ; CALLS          FETCH
926 ;
927 ; CALLED BY      PRIMAL (INDIRECTLY)
928 ;
929 ; REGISTERS     A (PRIMITIVE OF CODE, TEMPORARY)
930 ;               D (TEMPORARY)

```

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Feeling Listless

The performance of a program in the Technical Forum "Some More on Performance Evaluation," by Carl Helmers (July 1980 BYTE, page 216) suffered from one error of substitution and one error of omission.

Listing 1 on page 217, a program submitted by Charles Porter, should contain two lines as follows:

```

105 IF X = L THEN 120
110 IF A(X) = 0 THEN 100
    ELSE 90

```

Thanks to Martin Berman of Teaneck, New Jersey, for pointing this out. ■

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# A General Interpolating Graphics Package for the TRS-80

---

D K Cohen and Devon Crowe  
Bell Technical Operations Corp  
1050 E Valencia Rd  
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---

If you've ever tried creating graph displays with the Radio Shack TRS-80, then you know that the task can be time-consuming. If you haven't tried, you can look forward to the fact that axes must be generated and labelled, and data must be plotted using the awkward screen coordinates of Level II BASIC. After all this has been done, the resulting graph usually is not continuous, but has annoying *holes* in it. But don't despair, because with our simple package that may be implemented as a subroutine plotting X, Y coordinate relations or geometric figures is easy.

In order to use this plotting package effectively, we suggest that you work through each example given. After implementing this package, TRS-80 users should be able to plot any analytic function or set of  $x$  and corresponding  $y$  values efficiently. This package will allow you to draw axes in the correct quadrant(s) and label them with chosen titles. Tic marks displayed at user-determined intervals, and maximum and minimum values displayed at the correct positions on the graph are also easy to accomplish.

## Basic Plotting

The plotting package is divided into two subroutines. The interpolating subroutine (see listing 1)

---

With this package, TRS-80 users should be able to plot any analytic function.

---

plots the function (or coordinate pairs), interpolating between the points to produce a continuous curve. The resulting curve may be easily displayed at any position of the screen by changing at most four parameters. The program takes care of all scaling problems, and parameters are specified through the use of additional BASIC statements inserted at the front of the subroutine.

To begin this demonstration, suppose you desire to plot the cost of heating a home as a function of the monthly period, displayed in the upper right-hand corner of the screen.

(This is done to leave space for other information you may desire to display.) In order to have the graph confined to the desired position, you must specify a *viewport*. For this plotting routine, consider the screen to be divided into one hundred horizontal units and forty vertical units. The bottom left corner corresponds to the screen coordinate (0,0). (See figure 1.) To display the graph in the right-hand corner, the horizontal coordinates should be from 50 to 100, and the vertical coordinates should be from 20 to 40. Thus, to set this viewport, the reader must specify the four variables, Z1, Z2, W1, W2. For this example the viewport variables should be set as follows:

Z1 = 100  
Z2 = 50  
W1 = 40  
W2 = 20

The next step is to set up the  $x$  and corresponding  $y$  arrays. For example, if during the month of January the heating cost was \$80, the first  $x$  element would be 1 (for the month) and



the y element would be 80 (for the cost). Table 1 is a hypothetical set of data to be graphed. The arrays that will contain the data are AX and AY. Thus, for this example, the following BASIC statements should be inserted at the beginning of the subroutine:

```
FOR I=1 TO 12
READ AX(I)
READ AY(I)
NEXT I
DATA 1,80,2,90,3,75,4,50,5,
      45,6,45,7,50,8,80,
      9,70,10,65,11,70,12,80
```

The next variables specify the dimension of the arrays to be graphed. In this example, the minimum dimension TI is 1, the maximum dimension TA is 12, and the separation between the array points IN to be plotted is 1. (For example, if you wanted to plot the cost of heating for every other month, IN would be 2.) Therefore, you must include the following BASIC statements:

```
TI = 1
TA = 12
IN = 1
```

The final variable to be specified, S1, determines the *resolution*, or how well the points are connected in the graph. The value of S1 needed to fully connect all the points depends strongly on the size of the viewport and the number of array points to be plotted. A little experimentation with S1 is necessary to obtain the desired effect. For this demonstration: S1=0.01. After specifying the parameters above, the user is now ready to run the program.

After execution, the results should be as presented in figure 2. To change the viewport, simply change the values in the viewport variables. Figure 3 shows the result when the viewport variables are as follows:

```
Z1 = 100
Z2 = 0
W1 = 40
W2 = 0
```

If you desire to plot the cost of heating for every other month, simply change IN to 2. The results of this change are shown in figure 4.

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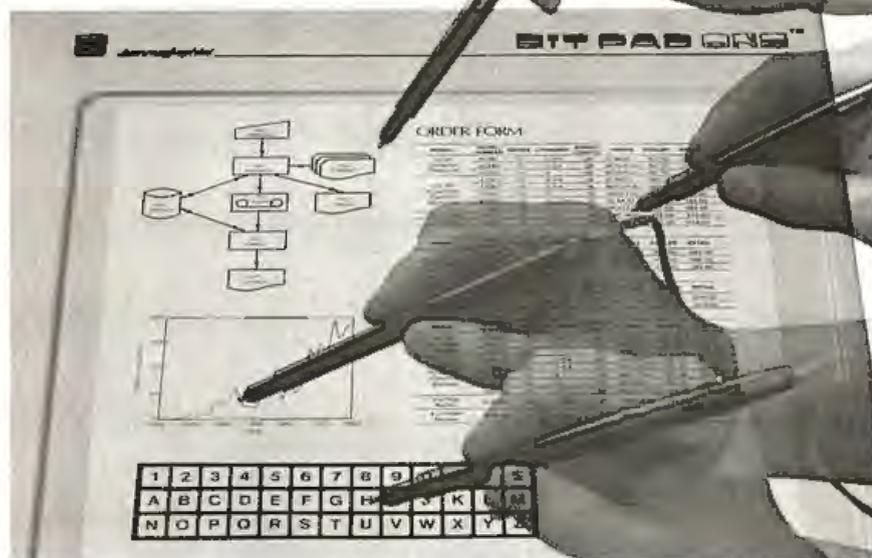
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### Adding Axes

At this point, it would be nice to have the axes drawn and labeled. This can be done by specifying four axis parameters for use by the axis-drawing subroutine in listing 2. The first two parameters to be defined are the string variables AX\$ and AY\$, which define the x axis and the y axis labels respectively. For this example the x axis should be labeled "month" and the y axis should be labeled "cost." Thus, the two BASIC statements that must be executed are:

```
AX$ = "MONTH"
AY$ = "COST"
```

The final two parameters specify the separation of the tic marks on the axes. In the example, set C1 (the x-axis tic-mark-separation variable) to 1 for a tic mark every month. Set C2 (the y-axis tic-mark-separation variable) to 5 for a tic mark at every \$5.00 increment. Thus, the following BASIC statements must be executed:

```
C1 = 1
C2 = 5
```

After execution, the results should be  
*Text continued on page 310*

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Listing 1: The interpolating subroutine. Written in TRS-80 Level II BASIC, this routine plots points on the screen from an array specified by the user. BASIC statements are inserted before the routine is run to create the desired array and, thus, the desired image.

```

10000 Z2 = Z2 + 25
10005 W2 = W2 + 5
10010 IF Z2 > Z1 THEN Z3 = Z2 ELSE GOTO 10025
10015 Z2 = Z1
10020 Z1 = Z3
10025 IF W2 > W1 THEN W3 = W2 ELSE GOTO 10040
10030 W2 = W1
10035 W1 = W3
10040 Y1 = -.10E38
10045 Y2 = 1.0E38
10050 X1 = Y1
10055 X2 = Y2
10060 FOR I = TI TO TA STEP IN
10065 IF Y1 < AY(I) THEN Y1 = AY(I)
10070 IF Y2 > AY(I) THEN Y2 = AY(I)
10075 IF X1 < AX(I) THEN X1 = AX(I)
10080 IF X2 > AX(I) THEN X2 = AX(I)
10085 NEXT I
10090 IF Y1 = Y2 THEN Y1 = 1.001 * Y1
10095 IF X1 = X2 THEN X1 = 1.001 * X1
10100 A = (X1 - X2) / (Z1 - Z2)
10105 B = (Y1 - Y2) / (W1 - W2)
10110 FOR I = TI TO TA STEP IN
10115 SET((Z2 + (AX(I) - X2) / A), (47 - ((AY(I) - Y2) / B + W2)))
10120 Q = I + IN
10125 IF Q > TA GOTO 10165
10130 IF AX(I) > AX(Q) THEN SS = -S1 ELSE SS = S1
10135 FOR J = AX(I) TO AX(Q) STEP SS
10140 IF AX(I) = AX(Q) THEN AX(Q) = 1.001 * AX(Q) + .0000001
10145 Y3 = ((AY(Q) - AY(I)) / (AX(Q) - AX(I))) * (J - AX(I)) + AY(I)
10150 SET((Z2 + (J - X2) / A), (47 - ((Y3 - Y2) / B + W2)))
10155 NEXT J
10160 NEXT I
10165 RETURN
    
```

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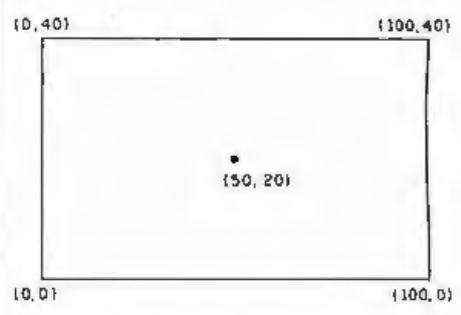


Figure 1: The TRS-80 video monitor screen is partitioned into one hundred units horizontally and forty units vertically. The bottom left corner of the screen corresponds to the coordinates (0,0). Coordinates are also used to specify viewports in which the plot is to be displayed.

Month	Cost(\$)
1	80
2	90
3	75
4	50
5	45
6	45
7	50
8	80
9	70
10	65
11	70
12	80

Table 1: This hypothetical set of data represents the heating costs incurred in a house. Plotted as in figure 2, the information may be limited to one area of the screen or may use the whole screen, as in figure 3.

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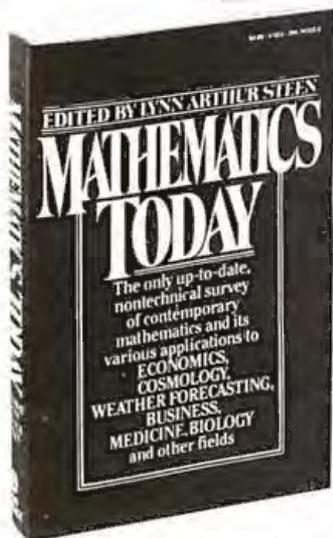


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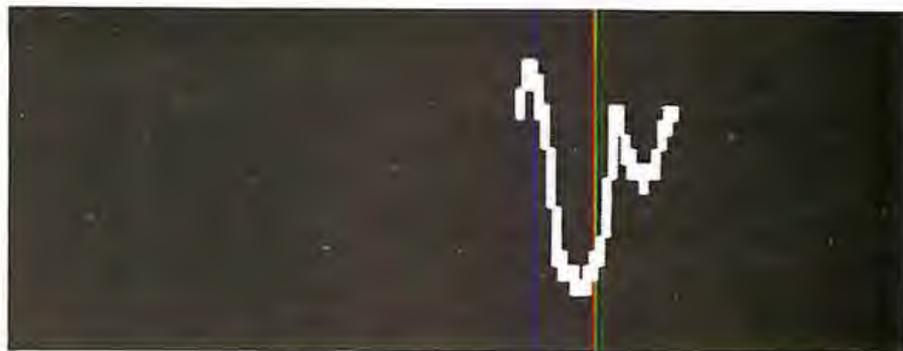


Figure 2: The information of table 1 is plotted as shown here. The size and location of the viewport used were specified by limiting the display area to the bounds of 50 to 100 and 20 to 40.

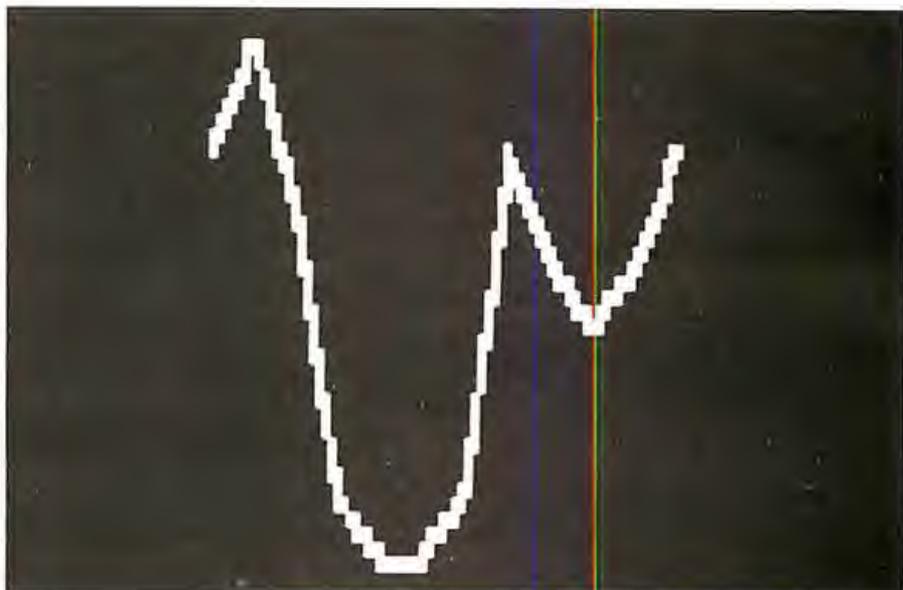


Figure 3: The information of table 1 is plotted again, with the viewport bounds set at 0 to 100 and 0 to 40 (whole screen).

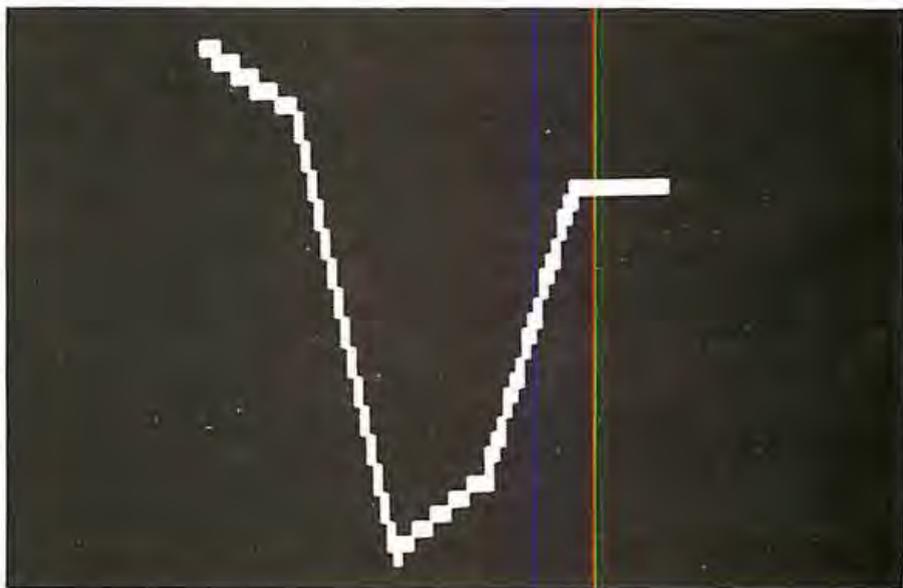


Figure 4: The information, as in table 1, may be condensed by changing the IN variable. The integer value specified allows the program to plot a reduced number of values from the array. Also, varying the S1 parameter may help to close gaps that occur between plotting points.

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- 22 = PRINT CASH FLOW FORECAST
- 23 = ENTER/UPDATE PAYROLL (NOT YET AVAILABLE)
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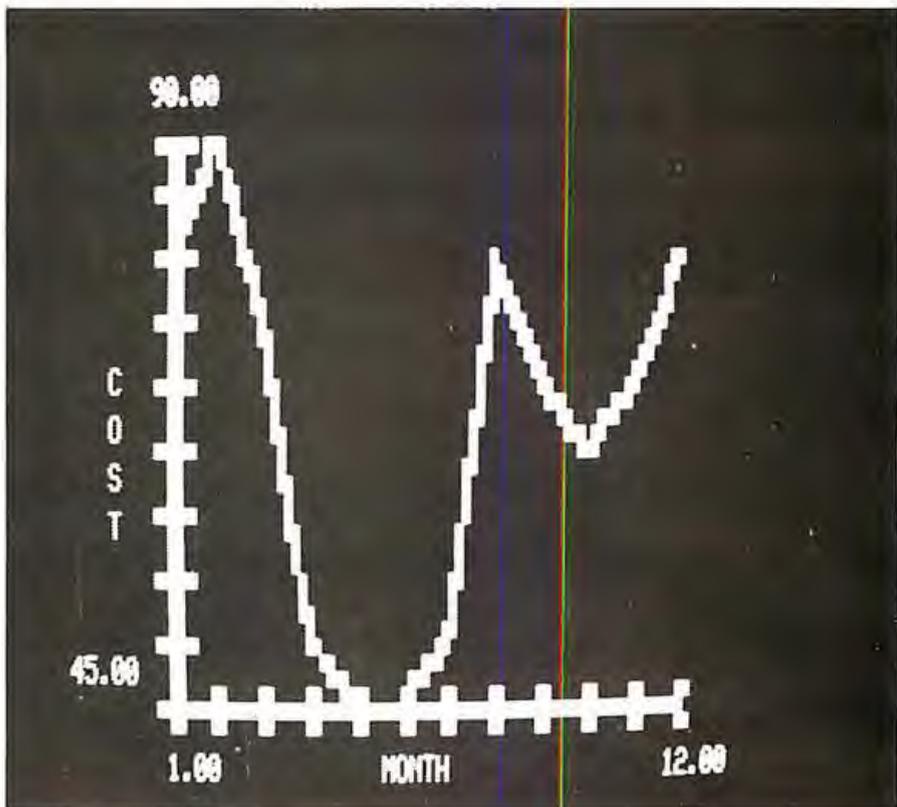


Figure 5: The axis-plotting subroutine provides for labeling and scaling of the display. The user only needs to specify increments for each scale.

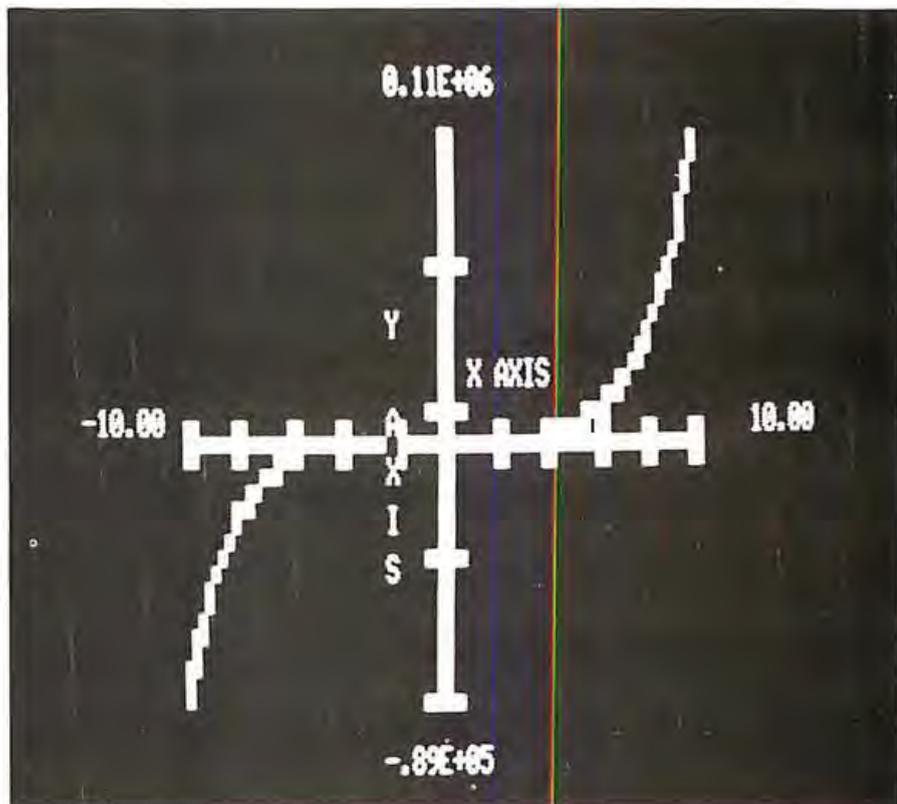


Figure 6: Analytic functions such as this may be plotted by transforming the function into an array. Usually, a short BASIC routine may be inserted before the plotting routines, depending on the complexity of the desired display.

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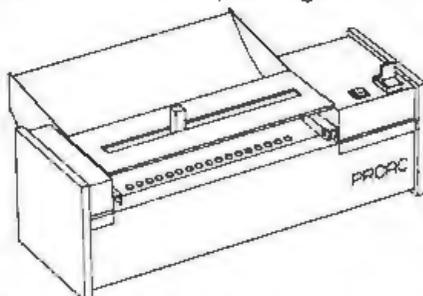
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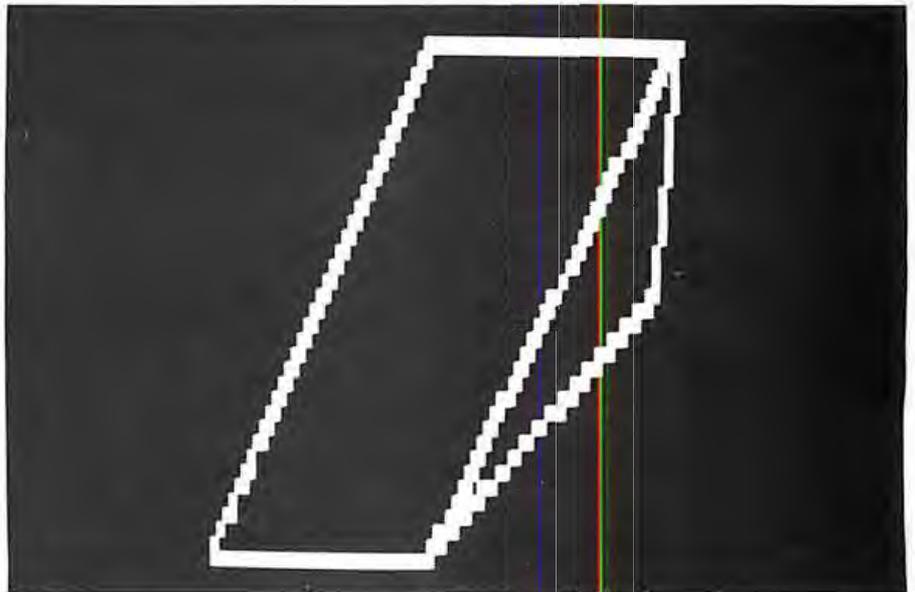
7a

```

W1 = 40      AY(1)=0
W2 = 0       AY(2)=1
Z1 = 100     AY(3)=2
Z2 = 0       AY(4)=2
S1 = .005    AY(5)=0
              AY(6)=0
              AY(7)=2

AX(1)=1      TI=1
AX(2)=2      TA=7
AX(3)=2.1    IN=1
AX(4)=1
AX(5)=0
AX(6)=1
AX(7)=2.1    GOSUB 10000

```



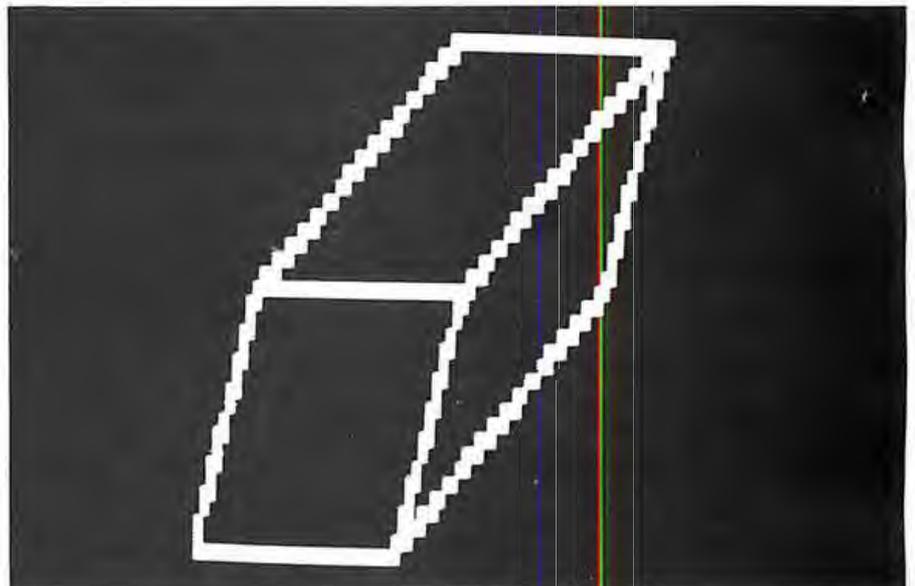
7b

```

W1 = 40      AY(1)=0
W2 = 0       AY(2)=0
Z1 = 100     AY(3)=1
Z2 = 0       AY(4)=2
S1 = .005    AY(5)=2
              AY(6)=1
              AY(7)=0
              AY(8)=1
              AY(9)=1
              AY(10)=0
              AY(11)=1
              AY(12)=2

AX(1)=0      TI=1
AX(2)=1      TA=12
AX(3)=2      IN=1
AX(4)=2.3
AX(5)=1.3
AX(6)=0.3
AX(7)=0
AX(8)=0.3
AX(9)=1.3
AX(10)=1
AX(11)=1.3
AX(12)=2.3  GOSUB 10000

```



7c

```

W1 = 40      AY(1)=1
W2 = 0       AY(2)=0
Z1 = 100     AY(3)=0
Z2 = 0       AY(4)=1
S1 = .005    AY(5)=.3
              AY(6)=0
              AY(7)=0
              AY(8)=.4
              AY(9)=.4
              AY(10)=.58
              AY(11)=.91

AX(1)=.5      TI=1
AX(2)=0       TA=11
AX(3)=1       IN=1
AX(4)=.5
AX(5)=1.3
AX(6)=1
AX(7)=0
AX(8)=.2
AX(9)=.8
AX(10)=.98
AX(11)=.6    GOSUB 10000

```

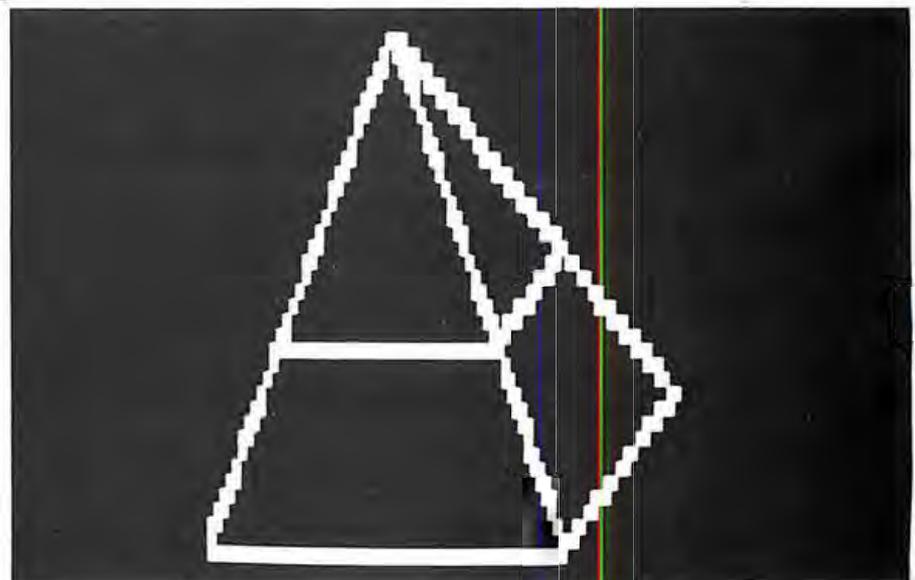


Figure 7: Three-dimensional displays are also achieved through the transformation to an array.



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**Listing 2:** The axis-creating subroutine shown here produces properly scaled axes, complete with tic marks and labels, from a set of values specified by inserting BASIC statements.

```

20000 IF X1 <= 0 AND X2 <= 0 THEN A1 = Z1 ELSE A1 = Z2
20005 IF X1 >= 0 AND X2 <= 0 THEN A1 = Z2 - X2/A
20010 FOR I1 = 0 TO 1
20015 FOR J1 = W2 TO W1
20020 SET ((A1 + I1), (47 - J1))
20025 NEXT J1
20030 NEXT I1
20035 IF Y1 <= 0 AND Y2 <= 0 THEN B1 = 47 - W1 ELSE B1 = 47 - W2
20040 IF Y1 >= 0 AND Y2 <= 0 THEN B1 = 47 - W2 + Y2/B
20045 FOR I3 = Z2 TO Z1
20050 SET(I3, B1)
20055 NEXT I3
20060 FOR I5 = 1 TO 3 STEP 2
20065 FOR J5 = 0 TO 1
20070 FOR K5 = X2 TO X1 STEP C1
20075 SET(((K5 - X2)/A + Z2 + J5), (B1 - I5 + 2))
20080 NEXT K5
20085 NEXT J5
20090 NEXT I5
20095 FOR I6 = 0 TO 4 STEP 2
20100 FOR J6 = 2 TO 3
20105 FOR K6 = Y2 TO Y1 STEP C2
20110 SET((A1 + J6 - I6), (47 - ((K6 - Y2)/B + W2)))
20115 NEXT K6
20120 NEXT J6
20125 NEXT I6
20130 IF B1 < > 47 - W2 GOTO 20145
20135 IF A1 = Z2 - X2/A THEN P1 = -64 ELSE P1 = 64
20140 IF A1 = Z2 THEN P2 = -4 ELSE P2 = 4
20145 IF B1 < > 47 - W1 GOTO 20160
20150 IF A1 = Z2 - X2/A THEN F1 = 64 ELSE P1 = -64
20155 IF A1 = Z2 THEN P2 = -4 ELSE P2 = 4
20160 IF B1 < > 47 - W2 + Y2/B GOTO 20175
20165 P1 = -64
20170 IF A1 = Z2 THEN P2 = 4 ELSE P2 = -4
20175 Z3 = LEN(AX$)
20180 Z4 = (Z1 + Z2)/2
20185 I7 = 0
20190 FOR I7 = 3 TO 45 STEP 3
20195 IF B1 < I7 GOTO 20210
20200 I7 = I7 + 64
20205 NEXT I7
20210 Z5 = Z4/2 + I7 - Z3/2
20215 IF A1 = Z2 - X2/A AND B1 = 47 - W2 + Y2/B THEN DU = 5 ELSE DU = 0
20220 PRINT @ Z5 + P1 + DU, AX$,
20225 W3 = LEN(AY$)
20230 FOR I8 = 1 TO W3
20235 F$(I8) = MID$(AY$, I8, 1)
20240 NEXT I8
20245 W4 = (W1 + W2)/2
20250 I6 = 0
20255 FOR K8 = 3 TO 45 STEP 3
20260 IF 47 - W4 < K8 GOTO 20275
20265 I8 = I8 + 64
20270 NEXT K8
20275 W5 = I8 + A1/2 - (INT(W3/2) - 1) * 64
20280 L8 = 0
20285 FOR M8 = W5 TO (W5 + (W3 - 1) * 64) STEP 64
20290 L8 = L8 + 1
20295 PRINT @ M6 + P2, F$(L8);
20300 NEXT M8
20305 F1(1) = 47 - W1
20310 F1(2) = 47 - W2
20315 F1(3) = B1
20320 F1(4) = B1
20325 F3(1) = A1/2
20330 F3(2) = A1/2
20335 F3(3) = Z1/2
20340 F3(4) = Z2/2
20345 FOR I9 = 1 TO 4
20350 J9 = 0
20355 FOR K9 = 3 TO 45 STEP 3
20360 IF F1(I9) < K9 GOTO 20375

```

Listing 2 continued on page 310



Listing 2 continued:

```

20365 I9=J9+64
20370 NEXT K9
20375 F2(I9)=J9+F3(I9)
20380 NEXT I9
20385 IF ABS(Y1)>1E4 OR ABS(Y1)<1E-2 THEN D1$="#.##|(|(|"
      ELSE D1$="#####"
20390 IF ABS(Y2)>1E4 OR ABS(Y2)<1E-2 THEN D2$="#.##|(|(|"
      ELSE D2$="#####"
20395 IF ABS(X1)>1E4 OR ABS(X1)<1E-2 THEN D3$="#.##|(|(|"
      ELSE D3$="#####"
20400 IF ABS(X2)>1E4 OR ABS(X2)<1E-2 THEN D4$="#.##|(|(|"
      ELSE D4$="#####"
20405 IF B1 < > 47 - W2 + Y2/B GOTO 20435
20410 D1=1
20415 D2=-9
20420 D3=-68
20425 D4=60
20430 GOTO 20505
20435 IF B1 < > 47 - W1 GOTO 20475
20440 D1=-68
20445 D2=-68
20450 D4=60
20455 IF A1=Z1 THEN D3=65
20460 IF A1=Z2 THEN D3=54
20465 IF A1=Z2-X2/A THEN D3=-68
20470 GOTO 20505
20475 D1=60
20480 D2=60
20485 D3=-68
20490 IF A1=Z2 THEN D4=-74
20495 IF A1=Z1 THEN D4=-62
20500 IF A1=Z2-X2/A THEN D4=60
20505 PRINT @ F2(1)+D3,USING D1$,Y1;
20510 PRINT @ F2(2)+D4,USING D2$,Y2;
20515 PRINT @ F2(3)+D1,USING D3$,X1;
20520 PRINT @ F2(4)+D2,USING D4$,X2;
20525 RETURN
  
```

All scaling and other mundane functions are taken care of in the subroutine.

Text continued from page 298:

displayed as in figure 5. This is for a graph of the cost of heating for every month displayed in the total viewport.

Clearly, it is easy to plot any set of data that can be represented in array form. Remember that all scaling and other mundane functions are taken care of in the subroutines. You don't need to be concerned or irritated by the gyrations needed to create displays on the TRS-80.

### Analytic Functions

In order to plot any analytic function, be prepared to transform the function into array form. An example of this is best demonstrated in the plotting of the function:

$$Y = X^5 + X^4 - X^3$$

This is for X taking on values from -10 to 10. In order for this to occur the following BASIC initialization routine is needed:

```

FOR I=-10 TO 10
AX(I+10)=I
AY(I+10)=I5+I4-I3
NEXT I
TI=0
TA=20
IN=1
AX$="X AXIS"
AY$="Y AXIS"
C1=2
C2=49750
  
```

The result should appear as shown in figure 6. Note that the correct quadrants are displayed.

Another feature provided by this graphics package is the ability to create *three-dimensional* graphs. Figures 7a, b, and c give several examples of this, along with the array values used. The displayed figures are not necessarily functions, but may have more than one y value for each value of x.

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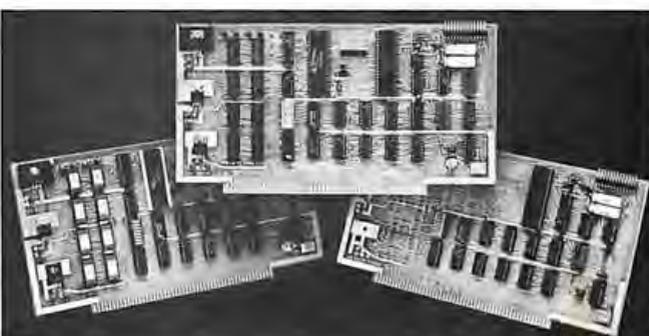


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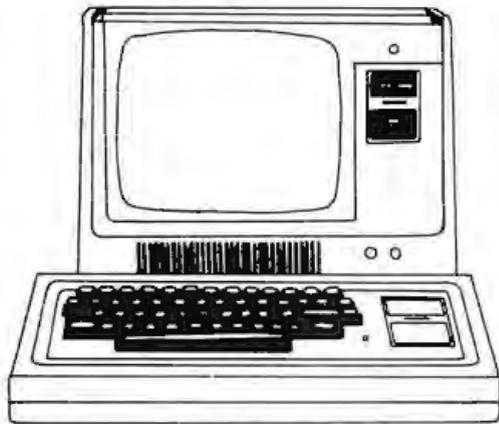
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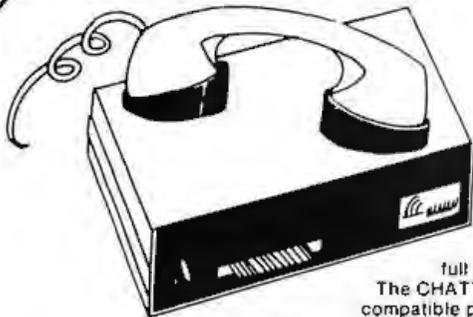
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*November-February*

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*November 6*

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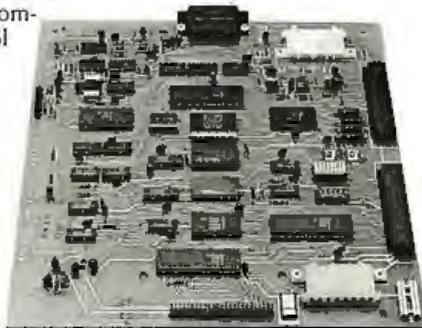


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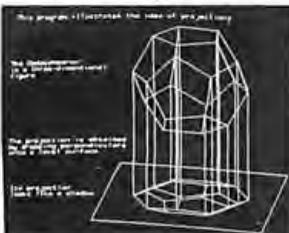
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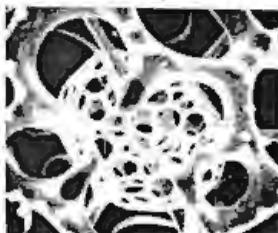
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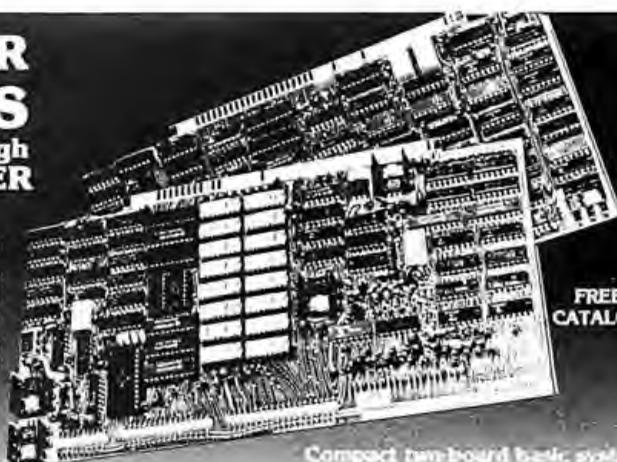


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November 12

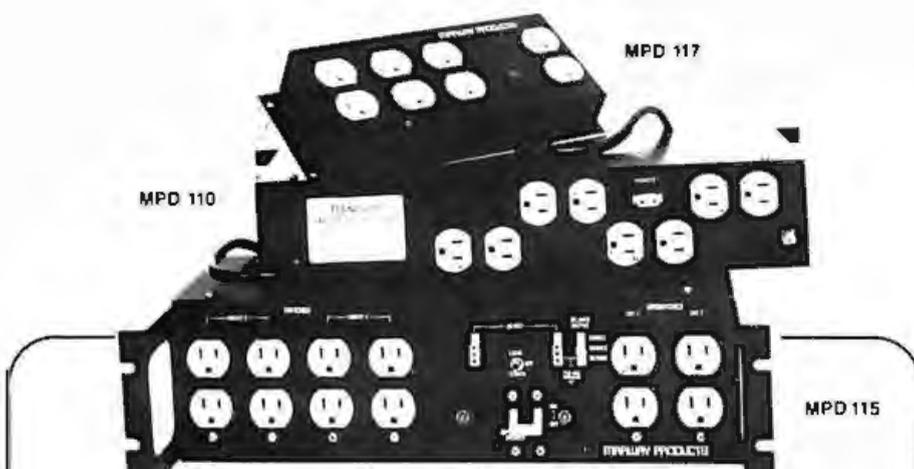
**National Conference on the Use of On-Line Computers in Psychology,** St Louis MO. This conference is for computer users in psychology and related disciplines. These users will consider the use of computers in research, clinical practice, and teaching. Tutorial sessions will be included. Contact Dr Dominic Massaro, Program in Experimental Psychology, University of California, Santa Cruz CA 95064.

November 13-16

**The 1980 International Computer Music Conference,** Queens College, Flushing NY. This conference is for persons interested in computer applications in music. Conference activities include presentation of papers, concerts, workshops, panel discussions, meetings of special interest groups, demonstrations, and an exhibition of computer music equipment. For information, contact Dr Hubert S Howe Jr, Director 1980 International Computer Music Conference, Queens College, Flushing NY 11367, (212) 520-7342.

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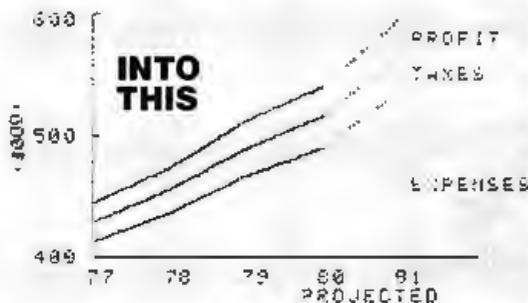
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November 18-20

The Third Industrial Revolu-

tion, McCormick Place, Chicago IL. This show is an exposition and conference devoted to development by manufacturing companies of systems for information management. Information may be obtained from Banner & Grief Ltd, 110 E 42nd St, New York NY 10017, (212) 687-7730.

November 19-21

Comdex, Las Vegas Convention Center, Las Vegas NV. Comdex is a conference and exposition for independent sellers of small-computer

and word-processing systems, peripherals, media, and supplies. Address inquiries to The Interface Group, 160 Speen St, Framingham MA 01701, (800) 225-4620.

November 20-21

Western Educational Computing Conference, San Diego CA. This conference will feature papers and seminars on the use of computing in higher education for instruction, administration, and research. Contact Ron Langley, Director,

Computer Center, California State University, Long Beach, 1250 Bellflower Blvd, Long Beach CA 90840, (213) 498-5459.

November 20-23

Northeast Computer Show, Hynes Auditorium, Boston MA. This exposition is open to the general public. The admission will be \$5. Contact National Computer Shows, 824 Boylston St, Chestnut Hill MA 02167, (617) 739-2000.

November 21-23

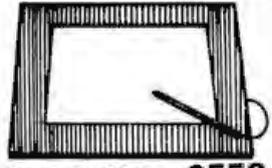
National Home Entertainment Show, New York Coliseum, New York NY. Exhibits will cover video, photography, audio, games, and home computers. Seminars and demonstrations will be featured in this show. Contact United Business Publications Inc, 475 Park Ave South, New York NY 10016, (212) 725-2300.

November 24-25

Computer Equipment Registration, George Washington University, Washington DC. This course will review the FCC's Part 15 rules dealing with RF (radio frequency) emissions by computers. Technical considerations governing the classifications for computers, peripherals, and other related devices will be described. Contact the GWU Continuing Engineering Education Program, Washington DC 20052, (800) 424-9773.

November 25-27

Semiconductor International '80, Metropole Convention Centre, Brighton, England. This exhibition is devoted completely to production of semiconductor components, and displays will cover all areas of technology. A technical conference program will cover mask-making procedures, VLSI (very large-scale integration), crystal growth technology, thin film technology, bonding, memory testing, and more. Contact Kiver Communications SA, 171/185 Ewell Rd, Surbiton, Surrey, KT6 6AX, England.

		
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In the OFF-LINE mode, the EP-2A-87 will program, verify, test buffer, and load the buffer from the EPROM socket. During the programming cycle, the EPROM is checked before programming to insure that it is erased and after programming it automatically verifies that programming is correct. Power requirements are 115 VAC 50/60 Hertz at 15 watts.

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EP 2A-87-2	Programmer with 4K buffer	600.00
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PM 1	Personality module, programs 2708	26.00
PM 2	Personality module, programs 2732	31.00
PM 3	Personality module, programs TMS 2716	26.00
PM 4	Personality module, programs TMS 2532	31.00
PM 5	Personality module, programs 2716, TMS 2516	16.00
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PM 7	Personality module, programs 2758, TMS 2508	16.00
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December 2-5

**The Eleventh International Conference of the Computer Measurement Group,** Sheraton-Boston Hotel, Boston MA. This conference is entitled "Computer Performance Evaluation in the 80s." Contact Judith G Abilock, Price Waterhouse and Company, Office of Government Services, 1801 K St NW, Washington DC 20006, (202) 296-0800.

December 3-5

**The 1980 Winter Simulation Conference,** Orlando Marriott, Orlando FL. This conference will feature papers, panel discussions, tutorials, and review sessions on discrete and combined simulations. Contact Professor Tuncer I Ören, Chairman, Department of Computer Science, University of Ottawa, Ottawa, Ontario K1N 9B4, Canada, (613) 231-5420.

December 3-5

**Implementing Computer-Based Human Resource**

**Systems,** New York NY.

This is a seminar for planning, organizing, and implementing a comprehensive system for the human resources area. It will demonstrate ways to set up a useful personnel record-keeping system. The course fee is \$695. For information, contact The University of Chicago, Center for Continuing Education, MC Seminar Division, 1307 E 60th St, Chicago IL 60637, (800) 223-7450.

December 4

**California Computer Shows,**

**Hyatt-Palo Alto,** Palo Alto CA. Show hours are from 1 to 7 PM. OEM (original equipment manufacturers) and end-user computer and peripheral products will be exhibited and demonstrated by over sixty companies. Contact Norm De Nardi Enterprises, 95 Main St, Los Altos CA 94022, (415) 941-8440.

December 10

**1980 Computer Networking Symposium,** Gaithersburg MD. The symposium is sponsored by the IEEE Computer Society, Technical Committee on Computer Communications, and the Institute for Computer Sciences and Technology of the National Bureau of Standards. The focus is on office automation, office system components, and the computer networks required to interconnect them. For information, contact Executive Secretary, POB 639, Silver Spring MD 20901, (301) 439-7007.



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## January 1981

January 7-9

**The Fourteenth International Symposium on Minicomputers and Microcomputers,** Hotel del Coronado, San Diego CA. The scope of the symposium will cover technology, hardware, software, engineering, languages, systems architecture, operating systems, numerical methods, computer networks, and other aspects of computing. Contact the Secretary, MIMI '81 San Diego, POB 2481, Anaheim CA 92804.

January 13-15

**Communications Networks 1981,** Albert Thomas Convention Center, Houston TX. This show will feature exhibits and seminars covering network policy and management for US and international users and carriers; network architecture, software, and hardware; new developments; information appliances; and more. This conference is aimed at communications professionals, carrier, service and

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hardware vendors who are interested in combining voice, data, and message systems applications. Contact Communications Networks '81, c/o The Conference Company, 60 Austin St, Newton MA 02160, (617) 964-4550.

January 14-19

**42nd National Audio-Visual Convention and Exhibit**, Dallas Convention Center, Dallas TX. Over 300 manufacturers and producers of audio-visual, video and microcomputer hardware and software will be exhibiting their products. Seminars will cover marketing and production of audio-visual items. For more information, contact the National Audio-Visual Association, 3150 Spring St, Fairfax VA 22031, (703) 273-7200.

January 16-17

**Microcomputer Conference**, Arizona State University, Tempe AZ. The goal of this

microcomputer conference is to introduce educators to the applications of computers in the classroom. The emphasis of the conference is to provide an awareness of microcomputers and their impact on society. For further information, contact Dr Gary G Bitter, Arizona State University, Payne 203, Tempe AZ 85281.

January 27-29

**Advanced Semiconductor Equipment Exposition**, San Jose Convention Center, San Jose CA. Over 100 exhibitors will feature equipment at this trade show. The show's emphasis is on new products and emerging technology in the semiconductor processing and production fields. Contact Cartledge & Associates, 491 Macara Ave, Suite 1014, Sunnyvale CA 94086, (408) 245-6870.

January 28-31

**The Third IMMM/Data Comm International Japan**

**Exposition**, Harumi Exposition Center, South Hall, Tokyo, Japan. Over 15,000 scientists, design engineers, technical managers, applications engineers, and other specialists are expected to attend this show. Internepon Japan/Semiconductor International is held concurrently. A conference program will include talks on microcomputer-controlled data communications systems, peripheral interfacing, software management, and more. Contact Industrial and Scientific Conference Management Inc, 222 W Adams St, Chicago IL 60606, (312) 263-4866. ■



Correspondence on  
Correspondence

Thank you, BYTE, for

running the enlarged, corrected oscilloscope photographs in BYTE's Bugs on page 182 of the June 1980 issue. BYTE readers may wish to label these pictures in order to be sure of their correspondence with the original photographs on page 66 of the article, "A Computer-Controlled Light Dimmer" (January 1980 BYTE). The picture labels should be matched as follows:

Original Article (January)	Pictures in BYTE's Bugs (June)
00	a
40	b
80	c
C0	d
FF	e

Thank you again for your time and concern in publishing the corrections in BYTE's Bugs.

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## Incorrect STOIC Price

An incorrect price was reported in John James's article "What is FORTH?" in the August 1980 BYTE. On page 134, middle column, Mr James reported that the language STOIC was available from the CP/M User's Group (1651 Third Ave, New York NY 10028) for \$20. The membership fee of \$4 has been replaced by a one-time catalog fee of \$6, making the total \$22, not \$20 (\$8 each for two floppy disks plus \$6 for the catalog). Also, the above price is valid for the United States, Canada, and Mexico only. The price for all other countries is \$12 per disk, making a total of \$30 (\$12 each for two floppy disks plus \$6 for the catalog). The Group is filling orders that were received with insufficient funds, but they (and we at BYTE) request that the receivers of such orders pay the appropriate difference in price. ■

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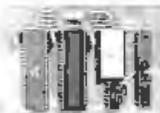
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  - Latched output and input with handshaking logic
  - TTL and CMOS compatible

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## The muSIMP/muMATH-79 Symbolic Math System

Gregg Williams  
Editor

Computers are very literal minded: ask one to add  $1/2$  and  $1/3$  and it will probably give you 0.833333 or some close approximation. Ask for  $40!$  (ie: 40 factorial) and you will get an answer like 8.1592E47, if you receive a reply at all. But what if you wanted the answer  $5/6$  for the first problem and an exact answer to the second problem, all forty-eight digits of it? Computers express everything in numbers, not symbols: that's the problem.

A software package called muMATH-79, created by the Soft Warehouse of Honolulu, Hawaii, does just what you want and more. The muMATH-79 package, billed as a *symbolic math system*, is to algebraic problem solving what the pocket calculator is to arithmetic problem solving. Like a pocket calculator, it cannot solve problems on its own, but muMATH-79 can be an invaluable tool in terms of increasing the accuracy and the complexity of the problems that can be solved by a person.

muMATH-79 is a modular system. It can be used for any one or a combination of the following: 611-digit arithmetic; matrix manipulation; algebraic manipulation and equation solving; logarithmic and trigonometric manipulation; integration and differentiation.

### Arithmetic and Algebra

muMATH-79 manipulates everything as a string of symbols, so it's no surprise that numbers are stored as strings of digits, with a

given number being up to 611 digits long. Given this situation, muMATH-79 has defined addition, subtraction, multiplication, division, and integral exponentiation as operations that work on two strings of numbers to give a third string as a result.

### Matrix operations in muMATH-79 are fast as well as exact.

When muMATH-79 is running, the computer prompts user input with a question mark and a space. (In our examples, computer-generated output is underlined here to distinguish it from user input.) All commands must be ended in a semicolon, and muMATH-79 precedes its answer with an ampersand and a space. For example, if we type in:

```
? 2150;
```

muMATH-79 replies almost instantly with:

```
@ 1125899906842624
```

Similarly, a request for 40 factorial gets an immediate reply:

```
? 40!;  
@ 81591528324789773434  
561126959611589427200  
0000000
```

We can assign strings (ie: numbers or symbolic expressions) to variable names using a colon:

```
? C1:2150;  
@ 1125899906842624  
? C2:C1-1;  
@ 1125899906842623
```

Also, we can change the radix used to accept and display numbers. For example, to change to binary (also called radix 2 or base 2), we say:

```
? RADIX(2);  
@ 1010
```

and muMATH-79 replies that its base was base 10 (since it is now in base 2, it prints 10 in binary: binary 1010 = decimal 10). To check that we are in base 2:

```
? C1;  
@ 10000000000000000000  
00000000000000000000  
000000000  
? C2;  
@ 11111111111111111111  
11111111111111111111  
111111111
```

Sure enough, C1, being  $2^{50}$ , should be a 1 followed by fifty 0s in binary, and C2 should be fifty 1s.

Also, muMATH-79 is fast. It computed all the above answers in less than 1 second each (running on a Cromemco Z-2D at 4 MHz), and answered 250! (seven lines of numbers) in 31 seconds. (See listing 1.) When a number being computed

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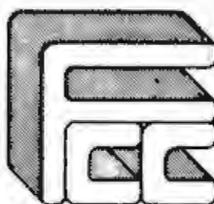
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**Listing 1:** Extended-precision arithmetic in muMATH-79. As shown in the first two examples, muMATH-79 does not convert fractions, but rather reduces them to their lowest terms. As you can see from the 493-digit answer to 250! (250 factorial), muMATH-79 does all its arithmetic exactly. In this and all other listings, underlining denotes computer output.

? 4/20;

@ 1 / 5

? 352/283072;

@ 11 / 8846

? 250!;

@ 3232856260909107732320814552024368470994843717673780666747942427112823  
747555111209488817915371028199450928507353189432926730931712808990822791  
030279071281921676527240189264733218041186261006832925365133678939089569  
935713530175040513178760077247933065402339006164825552248819436572586057  
399222641254832982204849137721776650641276858807153128978777672951913990  
844377478702589172973255150283241787320658188482062478582659808848825548  
8000

exceeds the capacity of the system, muMATH-79 replies with the word FALSE:

? 300!;  
 @ FALSE

muMATH-79 also manipulates symbolic expressions (depending on the values of its control variables, described later). For example:

? 5\*X-3\*Y12+8\*X-4\*Y12  
 @ 13\*X - 7\*Y12

Equations in muMATH-79 are often hard to read. It helps to write them out using pencil and paper; the above was  $5X - 3Y^2 + 8X - 4Y^2$ , which

simplified to  $13X - 7Y^2$ . Variables can be used in expressions, where they add their symbolic content to the expression being evaluated:

? EXPR1:B+4;  
 @ 4 + B  
 ? EXPR2:EXPR1+C+2\*B;  
 @ 4 + 3\*B + C

A variable name is called *bound* if it has a value and *unbound* if it does not. For example, the variable EXPR1, above, is bound because it has the value B+4. There are times, however, when we want a variable to simply be itself. We can change a variable from bound to unbound as follows (using the example of EXPR1):

? EXPR1;  
 @ 4 + B (EXPR1 is bound)  
 ? EXPR1:EXPR1  
 @ EXPR1 (EXPR1 is now unbound)

### Equation Solving

In addition, some equations can be solved. For example, to solve

$$X^3 + 2X^2 - 63X = 0;$$

? SOLVE(X13+2\*X1  
 2-63\*X=0,X);  
 @ {X = 7,  
 X = -9,  
 X = 0}

(muMATH-79 uses the double equal

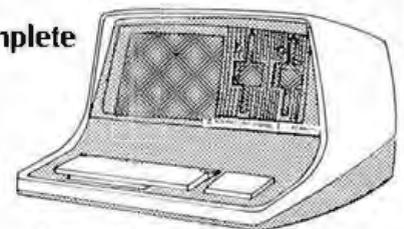
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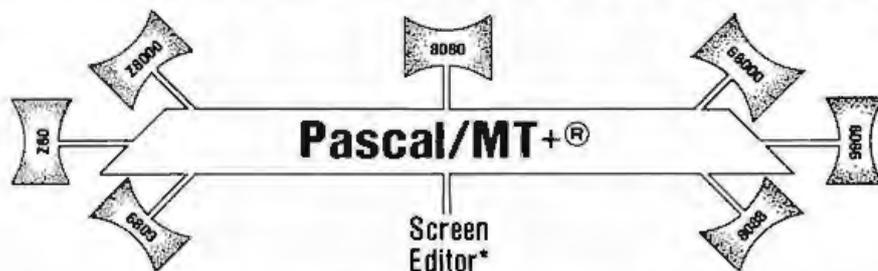


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The most impressive feature of muMATH-79 is its ability to do symbolic differentiation and integration.

sign to distinguish it from the single equal sign, which is used as a Boolean equality operator; the final X in the SOLVE command tells muMATH-79 to solve for the variable X.)

It is also aware of imaginary and complex numbers and uses the variable #I to represent the imaginary number i:

```
? SOLVE(XI2+1=0,X);
@ {X = -#I,
   X = #I}
```

However, muMATH-79 is not intelligent; it cannot solve equations of order 3 or higher. (The example with the X<sup>3</sup> polynomial is seen by muMATH-79 as being of order 2, with a zero factor added.) Factoring is hard even for people, but muMATH-79 can aid you in factoring a higher-order polynomial.

### Trigonometric and Logarithmic Manipulation

With the addition of these packages to the muMATH-79 system, the user can manipulate logarithmic and trigonometric expressions. Manipulation of these expressions varies with the values of certain control variables.

For example, if the trigonometric expansion variable TRGEXPD is 0:

```
? SIN(5*Y);
@ SIN(5*Y)
```

But if TRGEXPD is -6 (denoting expansion of multiple-angle sine and cosine functions):

```
? SIN(5*Y);
@ -12*COS(Y)I2*SIN(Y)
+ 16*COS(Y)I4*SIN(Y)
+ SIN(Y)
```

The functions available are LN (logarithm to the base e), LOG (logarithms to other bases), SIN, COS, TAN, COT, SEC, and CSC. And muMATH-79 uses the variable #E (for e) and #PI (for π).

### Matrix Manipulations

The math system can also manipulate matrices. Matrices can be multiplied (or divided) by a matrix or a scalar, transposed, inverted, and taken to an integer power. If a matrix is nonsingular (ie: its inverse does not exist), muMATH-79 responds to an attempt to invert it with divide-by-zero error messages. If the matrix can be inverted, the coefficients of its inverse, if nonintegral, are expressed as fractions—that is, the inverse is algebraically exact. For an example of this, see listing 2.

Matrix operations are fast as well as exact. The inversion of matrix H in listing 2 took 5 seconds, and the inversion of a 5-by-5 matrix took 48 seconds. Since matrix entries are symbolic, the entries can be scalars or matrices. This allows the formation of complex data structures that can be manipulated by muMATH-79.

### Differentiation and Integration

The most impressive feature of muMATH-79 is its ability to do symbolic differentiation and integration. For example, if we differentiate 1/X<sup>3</sup> with respect to X, we get -3X<sup>-4</sup>. muMATH-79 accomplishes the task as follows:

```
? DIF(1/XI3,X);
@ -3 / XI4
```

Listing 2: Matrix inversion and multiplication in muMATH-79. Listing 2a shows the creation of the 2 by 2 matrix H. Listing 2b shows the creation of the inverse of H, HINV. Listing 2c shows the multiplication of two compatible matrices using a period (.) as the muMATH-79 matrix multiplication operator.

(2a)

```
? H: {[380, -115/2], [17, 109]};
@ {[380, -115/2],
   [17, 109]}
```

(2b)

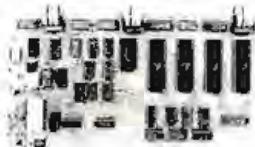
```
? HINV:H^-1;
@ {[218/84795, 23/16959],
   [-34/84795, 152/16959]}
```

(2c)

```
? H.HINV;
@ {[1, 0],
   [0, 1]}
```

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Listing 3: Algebraic integration in muMATH-79. Listing 3a shows the creation of the function FC1, which equals  $X^2 + \ln(X)$ . Listing 3b shows the calculation of the indefinite integral of FC1, while listing 3c shows the calculation of its definite integral from  $e$  to  $2e$ . (See the text for these two equations written in conventional form.)

(3a) ? FC1: X^2+LN(X);

@ X^2 + LN(X)

(3b) ? INT(FC1,X);

@ -X + X\*LN(X) + X^3/3

(3c) ? DEFINT(FC1,X,#E,2\*#E);

@ -2\*#E + 2\*#E\*LN(2\*#E) + 7\*#E^3/3

It works with the resources of whatever packages are loaded into it at the time. For example, if the trigonometric package is loaded, muMATH-79 can do the following:

? DIF(COT(2\*X),X);  
@ -2 \* CSC(2\*X)/2

which translates as:

$$\frac{d}{dx} \cot 2X = -2 \csc^2(2X)$$

Indefinite and definite integrals are also within muMATH's capabilities. The definite integral is calculated by simple substitution of the integral limits into the result of the indefinite integration, in much the same process a person performs. If muMATH-79 cannot do this, it simply returns the indefinite integral. Listing 3 shows its calculation of the following two integrals:

$$\int X^2 + \ln(X) dX = \frac{X^3}{3} + X \ln(X) - X + C$$

and

$$\int_e^{2e} X^2 + \ln(X) dX = \frac{7e^3}{3} + 2e \ln(2e) - 2e$$

### muMATH-79 Control Variables

The package does not exhibit artificial intelligence. (Although with some of its accomplishments, it seems to exhibit it.) Rather, it is a very sophisticated symbol manipulator

that rigorously applies a given set of rules to arrive at a transformed result. But achieving a desired algebraic manipulation is not always an exact process.

For example, consider the trivial example given in figure 1a. If the denominator is distributed over the numerator, the result is the expression in figure 1b. But if we factor the numerator first, the discovered factor of  $(X+1)$  in the numerator cancels the  $(X+1)$  in the denominator, leaving the simplified answer in figure 1c.

muMATH-79 cannot make these decisions; it is a tool, not a problem solver. So certain variables called *control variables* are introduced into its environment. Under human control, these variables are used to tell muMATH-79 what manipulations to make.

(a)  $\frac{X^3 + X^2}{(X+1)}$   
 (b)  $\frac{X^3}{(X+1)} + \frac{X^2}{(X+1)}$   
 (c)  $\frac{X^3 + X^2}{(X+1)} = \frac{X^2(X+1)}{(X+1)} = X^2$

Figure 1: Options in the transformation of an algebraic expression. The simple expression in figure 1a can be transformed to that of figure 1b by distributing the denominator over the terms of the numerator. A more useful transformation, however, is shown in figure 1c. By factoring out a term of  $X^2$  and cancelling out the  $(X+1)$  factor in both numerator and denominator, the expression can be considerably simplified.

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Although an explanation of the intricacies of control variables is beyond the scope of this review, the topic does deserve some explanation. Table 1 is a list of the control variables and their effects on algebraic expressions. Table 2 shows the effect of one control variable, NUMNUM, on expressions. (Most control variables behave similarly,

with positive values causing an expansion of terms to take place and negative values causing a combination of terms to take place.)

### Generating a muMATH-79 System

Because muMATH-79 can potentially use more than 64 K bytes of memory, the system is supplied as a

series of packages that can be combined to create an optimal environment for a given purpose. Figure 2 shows a *dependency diagram* from the muMATH-79 packages as they are supplied. To run a given package, you must load that package and all the packages above it. For example, to manipulate algebraic and logarithmic expressions, you must load the file named MUSIMP79 (which loads MUSMORE automatically), ARITH, ALGEBRA, and LOG, in that order. To solve equations that use logarithmic expressions, you would add to the above the files EQN and SOLVE.

Of course you would like to have all the packages available at once. Unfortunately, due to the large size of the packages, this cannot be done. A 32 K-byte system is necessary to run anything in muMATH-79, but more memory is recommended. It takes 40 K bytes, for example, to run algebra and 48 K bytes to run either calculus or matrix algebra.

A muMATH-79 system is first generated and then saved for future loading into the same system. Each package takes 1 to 5 minutes to load, given a Z80 system running at 4 MHz; loading time will be proportional to the speed of the processor being used.

Another method of loading, called *condensation*, takes from 10 minutes to 1 hour per module to load, but it has the advantage of loading the same module in just over half as much memory. At BYTE Publications Inc, we are running a condensed system in 56 K bytes that includes all the muMATH-79 packages except TRACE, ARRAY, and MATRIX. It took an afternoon to set up the system, but the time was well spent, because all the packages interact with each other. However, problem solution time decreases with increased unused memory. Decreasing the number of packages used would probably cut the solution times of problems, but so far the delays encountered have been hardly objectionable.

### The muSIMP-79 Language

An unexpected benefit of the muMATH-79 package is the inclusion of the muSIMP-79 language. muMATH-79 as supplied is actually a series of source files written in muSIMP-79. Inclusion of the source files allows you the very important

Control Variable	Result with Positive Value	Result with Negative Value
NUMNUM	$A(B+C) - AB + AC$	$AB + AC - A(B+C)$
DENDEN	$\frac{1}{A} \left( \frac{1}{B+C} \right) - \frac{1}{AB+AC}$	$\frac{1}{AB+AC} - \frac{1}{A} \left( \frac{1}{B+C} \right)$
DENNUM	$\frac{B+C}{A} - \frac{B}{A} + \frac{C}{A}$	$\frac{B}{A} + \frac{C}{A} - \frac{B+C}{A}$
NUMDEN	$\frac{A}{B+C} - \frac{1}{\frac{B}{A} + \frac{C}{A}}$	$\frac{1}{\frac{B}{A} + \frac{C}{A}} - \frac{A}{B+C}$
BASEXP	$A^{B+C} - A^B A^C$	$A^B A^C - A^{B+C}$
EXPBAS	$(AB)^C - A^C B^C$	$A^C B^C - (AB)^C$
PWREXP	$(A+B)^2 - A^2 + 2AB + B^2$ $(A+B)^3 - A^3 + 3A^2B + B^3$ (etc)	$(A+B)^2 - \frac{1}{(A^2 + 2AB + B^2)}$ $(A+B)^3 - \frac{1}{A^3 + 3A^2B + 3AB^2 + B^3}$ (etc)

**Table 1:** The effect of control variables on symbolic manipulation within muMATH-79. The values given to these control variables determine how muMATH-79 manipulates algebraic expressions. Other control variables not listed in this table are TRGSQ, TRGEXP, LOGBAS, PBRCH, and LOGEXP, which control trigonometric and logarithmic expressions.

Value of NUMNUM	Transformation	Example
0	do nothing	$3A(B+C)(D+E) - 3A(B+C)(D+E)$
2 and its multiples	distribute constants over sums	$-A(3B + 3C)(D+E)$
3 and its multiples	distribute monomials over sums	$-3(AB + AC)(D+E)$
5 and its multiples	distribute sums over sums	$-3A(D(B+C) + E(B+C))$
6 (= 2*3)	distribute constants and monomials over sums	$-(3AB + 3AC)(D+E)$
10 (= 2*5)	distribute constants and sums over sums	$-A(D(3B + 3C) + E(3B + 3C))$
15 (= 3*5)	distribute monomials and sums over sums	$-3(ABD + ABE + ACD + ACE)$
30 (= 2*3*5)	distribute constants, monomials, and sums over sums	$-3ABD + 3ABE + 3ACD + 3ACE$
-2, -3, -6	same as 2, 3, 6, only factor out instead of distribute	NUMNUM = -3 causes $3AB + 3AC - A(3B + 3C)$

**Table 2:** A detailed example of the effect of the control variable NUMNUM on algebraic expressions. NUMNUM is so named because it controls the distribution or factoring of a numerator expression with the denominator expression containing it. Positive values cause a factor to be distributed across a sum, while negative values cause factoring a common value from a sum.

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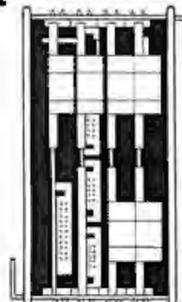
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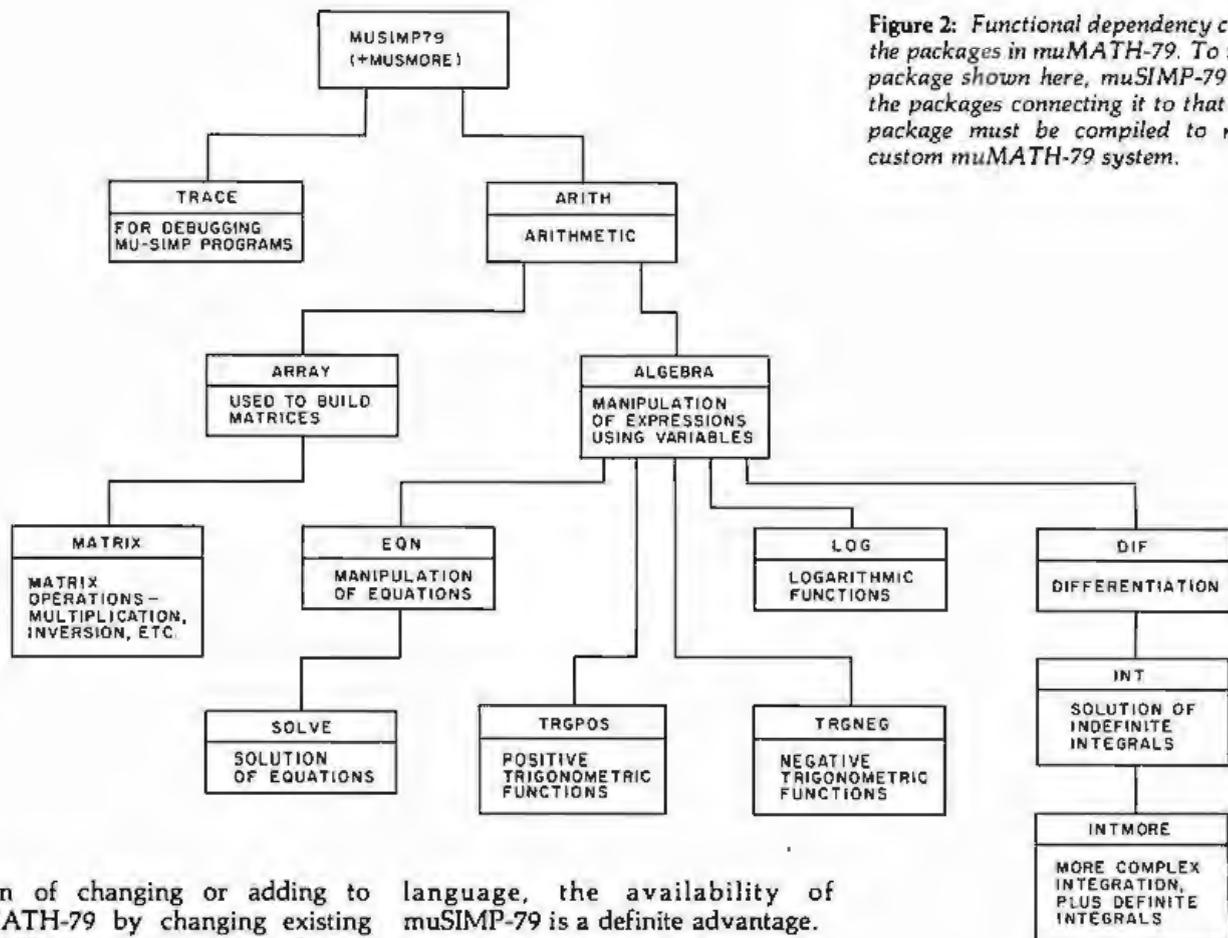


Figure 2: Functional dependency chart for the packages in muMATH-79. To run any package shown here, muSIMP-79 and all the packages connecting it to that desired package must be compiled to make a custom muMATH-79 system.

option of changing or adding to muMATH-79 by changing existing muSIMP-79 programs (ie: packages) or adding your own.

muSIMP-79 is a variation of the well-known list-processing language LISP; it has been adapted for readability and optimized for the manipulation of symbolic expressions. Considering that the entire capabilities of muMATH-79 are based on the use of the muSIMP-79

language, the availability of muSIMP-79 is a definite advantage.

### Documentation

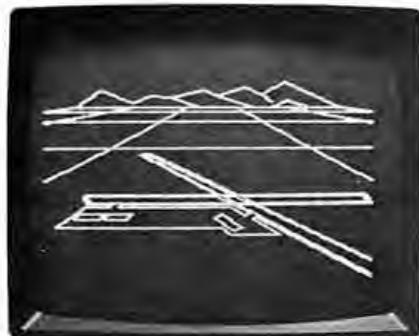
The muSIMP/muMATH-79 Symbolic Math System comes with all its associated files on floppy disk and its printed documentation in a three-ring binder. There are about 175 pages of printed documentation in the reference manual, with tabbed sections marked General Information,

Calculator-Mode Lessons, Programming-Mode Lessons, muSIMP-79, Arithmetic, Algebra, Equation, Matrix, Log and Trig, and Calculus.

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available on the disk in machine-readable form. Included are sections on building, saving, and using a muMATH-79 *environment* (which is the muMATH-79 packages compiled plus all the variable and status assignments completed to date). In addition, ten files (five for each subject) that execute interactively on the host computer cover the topics of using muMATH-79 in what is called *calculator mode* and of programming in muSIMP-79.

The Soft Warehouse prints an occasional newsletter that contains updates, additions, and (very occasionally) corrections to its muSIMP/muMATH-79 and muLISP (another of its products) systems. The people at the Soft Warehouse have been friendly and informative every time I've called them.

### muMATH-79 for the TRS-80

Microsoft Consumer Products of Bellevue, Washington (a sibling company to the Microsoft of Microsoft BASIC fame) is marketing two versions of muSIMP/muMATH-79 for the TRS-80. The first version, equivalent to the one described in this review, will sell for \$250.

A slightly diminished version of the system will be available for \$75—a very reasonable price. Although I have not seen it, the manufacturer informs us that the system will come with two floppy disks (one for 32 K-byte systems, one for 48 K-byte systems) and an abbreviated manual. The floppy disk for the 32 K-byte system will include muSIMP-79, a precompiled module including the arithmetic, algebra, and equation-solution packages, and uncompiled logarithmic and positive and negative trigonometric packages.

The floppy disk for the 48 K-byte

#### At a Glance:

Name of program	muSIMP/muMATH-79
Type of program	language/utility
Manufacturer	The Soft Warehouse POB 11174 Honolulu HI 96828 (808) 734-5801
Price	\$290
Format	5-inch or 8-inch disk
Language used	8080 machine language
Computer needed	an 8080, 8085, or Z80-based computer running CP/M, CDOS, IMDOS, or TRSDOS operating systems
Documentation	175 pages, 8½ by 11 inches, in three-ring binder
Audience	high-school and college students, educators, programming language enthusiasts

TRS-80 system will be the same but will add the differentiation package and most of the integration packages in the compiled module. Both versions have extensions that allow muSIMP to access the TRS-80 graphics.

### Conclusions

● The muSIMP/muMATH-79 Symbolic Math System is a very impressive tool. It fills a gap in the spectrum of problems solvable by a computer.

● Although it cannot work wonders, muSIMP/muMATH-79 can solve many of the problems encountered in algebra, trigonometry, and even calculus classes. (Educators need not fear: muMATH-79 does not provide a solution's derivation, only the final answer.)

● Educators from the high-school level up have used the package as an aid to teaching mathematics. And researchers have used it to keep track

of equations during complex manipulations. Other potential users include: engineers demanding exact numeric solutions of problems and matrices (the fractional answers can be divided out conventionally to give decimal answers of any accuracy); researchers interested in artificial intelligence; college professors studying programming languages, and all those in need of a calculator.

● Although this is no fault of the package, muMATH-79 occasionally behaves in a way that, although correct, leads to unexpected and seemingly mysterious results. (I, for example, was unable to save a compiled package to disk drive B because I had assigned an algebraic value to the variable B.) Some sophistication on the part of the user is necessary in such cases.

● The documentation is good, but a thorough knowledge of the system is gained only by lots of practical experience. ■



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# An 8088 Processor for the S-100 Bus

## Part 3

---

Thomas Woodward Cantrell  
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---

MON88 is a small system monitor for the single-board 8088-based processor described in parts 1 and 2 of this article (September and October 1980 BYTE, pages 43 and 62 respectively).

The current configuration of MON88 implements sixteen commands (expandable to twenty-six) and uses less than 1.5 K bytes of memory. This includes a "large" (approximately 256-byte) video driver required for my hardware environment and lengthy messages (about 128 bytes' worth) that make MON88 easy to use. No attempt was made to optimize the amount of memory used.

Stripping out the video-driver routine (that is, using a hardware *terminal*, rather than software, to create the same effect) and the messages, along with some optimization, can probably reduce code size to 1 K bytes. My plan is to expand the monitor until it fills the 2 K bytes of EPROM (erasable programmable read-only memory) in the 8755A-2 integrated circuit on the processor board. (See table 1 for a quick-reference guide to the MON88 instruction set.)

### MON88 Philosophy

The 8088 incorporates very powerful, mainframe-like architectural features such as segmented memory, pipelining, multi- and co-processing "hooks," etc. One key objective of the 8088 project has been to implement the hardware and software in as simple a fashion as possible. This will allow users familiar with traditional 8-bit processors to ease into an understanding of this powerful new machine.

Following the philosophy of simplicity, my 8088 design embodies what is known as the "small model of computation." This model assumes that a given task can be implemented using one set of segmentation register values:

- one 64 K code segment
- one 64 K data segment
- one 64 K stack segment
- one 64 K extra segment

A key feature of the 8088 is that, for many instructions, certain memory segments are used to determine an absolute memory address. This allows instructions to be implemented in fewer bits, contributing to the extremely

efficient use of memory in the 8088. This is not a restriction because the default segment can be overridden by using a *segment-prefix* for the instruction in question.

In fact, my decision was to initially use only sixteen of the twenty address lines available on the processor board. In this case, all segments (code, data, stack and extra) totally overlap in the 64 K-byte address space of the processor board. This means we need not concern ourselves with what segment is where, and what instructions assume which segments.

### MON88 Organization

The organization of MON88 in memory is shown in figure 1. I will briefly discuss each section. Note that modifications to MON88 for your own environment are discussed later in this article. The following paragraphs describe each section of the monitor.

*Storage allocation and constant definition:* This section defines commonly used constants and specific I/O (input/output) port addresses, etc. In addition, memory allocation is performed for needed buffer and variable space.

*User jump table:* This is the first actual code in MON88 consisting of two MON88 entry points (INIT and START) and three I/O entry points (KEYIN, KEYSTAT and VIDOUT). A user program could terminate by jumping to one of the two MON88 entry points. Similarly, a user program could call one of the I/O entry points. When the I/O is done, the return instruction of each I/O routine will give control back to the user program.

*Segment register and I/O initialization:* The code, data, stack and extra segments (CS, DS, SS and ES) are set overlapping at address 0. Environment-dependent I/O initialization is also performed by this routine.

*Main loop:* This is the overall control routine for MON88. It prints the prompt character and accepts a one-letter command from the console. The appropriate command-routine address is determined and control is transferred from this routine.

*Message storage:* Messages used by various commands are stored here. Note that each message is terminated by a 0.

*Command jump table:* The addresses for the twenty-six possible commands are stored here. Note that

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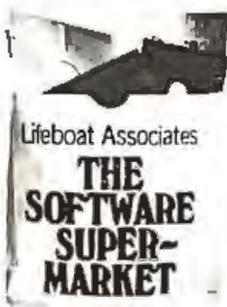
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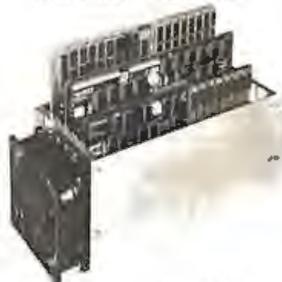
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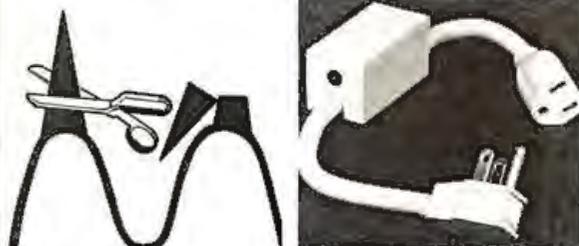
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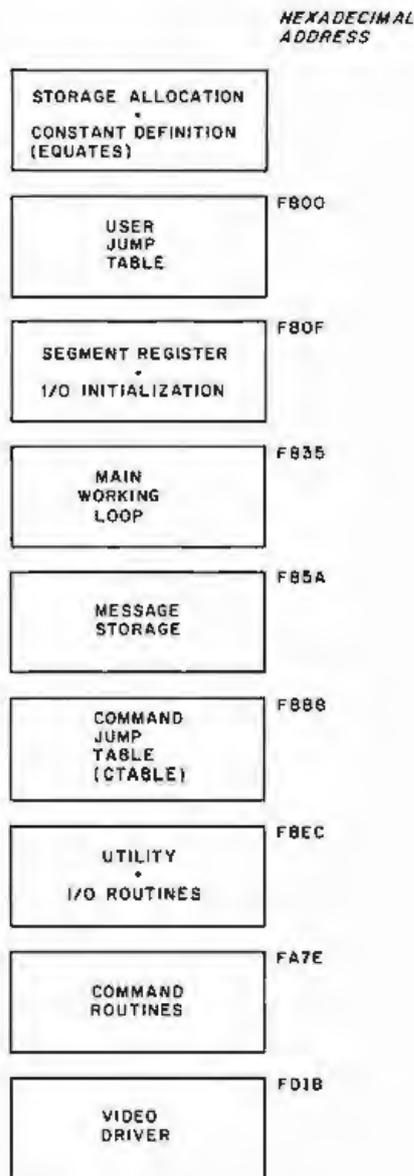


Figure 1: Memory map for the MON88 monitor.

unimplemented commands are given the ERR (error) address.

**Utility and I/O routines:** This and the following (command routines) section make up the bulk of MON88. The utility routines are used by command routines. This allows command routines to be implemented largely as calls to various utility routines (see figure 2). For instance, many commands require the acquisition of a starting and ending address. The utility routine SETUP performs this function. Many of these utility routines may be useful in your own programming efforts.

**Command routines:** These are the routines that actually perform each command. Due to the extensive use of the above utility routines, most commands are easily implemented as a series of subroutines. A good example is the W (CWRITE) cassette-write command, which dumps a block of memory to tape (see listing 1, starting at line 576). Note that of the twelve "instructions" constituting the command, eight are calls to other routines.

The advantage of programming in this manner is that the command routines are easy to write. Should you

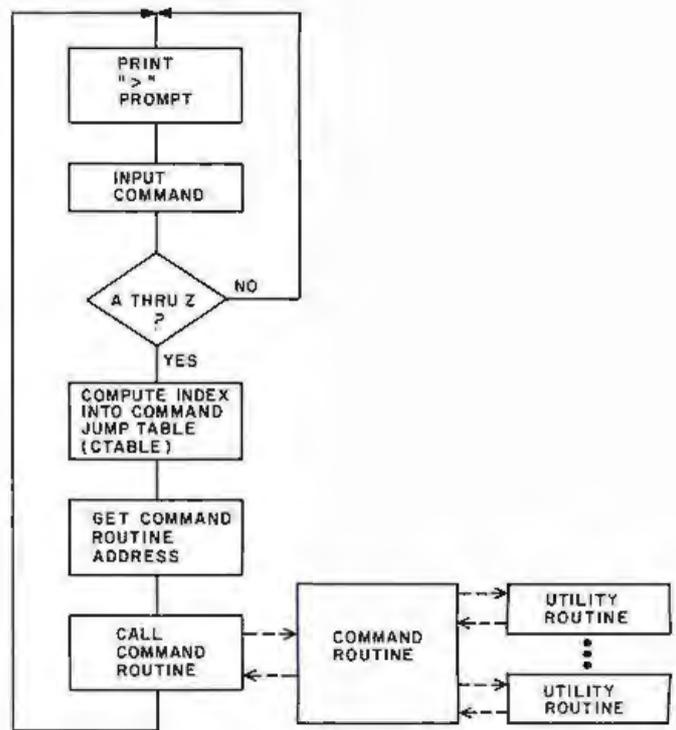


Figure 2: High-level flowchart for MON88 program. In general, the program decodes user input and, if valid, jumps to the appropriate command subroutine. Once the routine is finished, control is passed back to the command-input routine, and the program prints another prompt.

want to add commands, they can probably be implemented largely as a series of calls to already-existing, tested utility routines in MON88. This also saves memory space by eliminating redundant coding of essentially the same routine.

**Video driver:** My hardware requires a relatively lengthy software driver for the video board in my system. I converted this code from 8080 assembly language using Intel's CONV86 code converter. Briefly, the tradeoff is between the performance of the converted code versus a version rewritten for the 8088 and the associated time required for each process. Converted code may be somewhat larger than a rewritten version, but it will probably take only a small fraction of the time to implement as compared to a rewrite. Because the 8088 has a faster clock rate than the 8080, the converted program, even if larger, will probably run faster than the original 8080 version.

### Environment Dependence

The dependence of MON88 on a certain I/O or memory environment has been minimized. The following summarizes the changes you will need to make to adapt MON88 to your own system. Refer to listing 1, starting at line 14.

**Location of MON88:** The statement immediately preceding the EQUATES FOLLOW section sets MON88's origin. For my processor board, the origin is hexadecimal F800:

ORG F800H

Text continued on page 346

# GRAPHIC POSSIBILITIES

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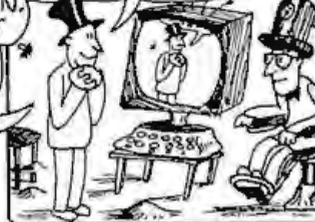
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I'M TRYING!



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IT'S A LIGHTNING BUG!



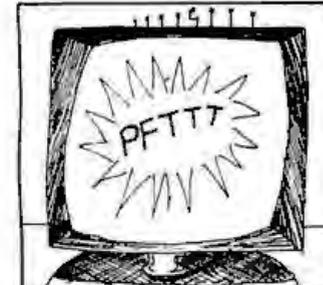
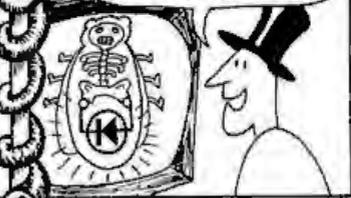
GREAT! PUT HIM UNDER THE MACHINE.



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## Command Summary

### Command syntax definitions:

[addr] = 16-bit address (or data) as four hexadecimal digits

[data] = 8-bit data as two hexadecimal digits

[cr] = carriage return

Note that [addr] and [data] entry routines accept the last four and two digits entered, respectively. For example, using the fill (F) command:

```
F0123456 789ABCD 0123456[cr]
```

is the same as

```
F3456 ABCD 56[cr]
```

Also note that [addr], [data] entries to commands can be separated by a blank or a comma, ie:

```
F3456 ABCD 56[cr]
```

is the same as

```
F3456,ABCD,56[cr]
```

Invalid hexadecimal digits and unimplemented commands always result in an error response. MON88 responds to errors by printing an asterisk (\*), carriage return/line feed sequence and redisplaying the prompt.

All entries to MON88 may be either upper or lower case.

Most commands can be halted temporarily with Control-S, restarted with Control-Q, and aborted with Control-C.

In the following examples, all user input to MON88 is underlined.

### Commands

#### A — Enter ASCII Text into Memory

Allows the direct entry of ASCII text from the keyboard into memory. The command is terminated with a Control-D [ctl-D]. At termination, the address following the last character entered is displayed:

```
A[addr][cr]
```

```
A100[cr]
```

```
This is a test of the 'A' command.[ctl-D]
```

```
@0122
```

```
D100 121[cr]
```

```
0100 54 48 49 53 20 49 53 20 41 20 54 45 53 54 20 4F
```

```
0110 46 20 54 48 45 20 27 41 27 20 43 4F 4D 40 41 4E
```

```
0120 44 2E
```

#### B — Not Implemented

#### C — Compare Cassette Input With Memory

Compares cassette input with the contents of

memory on a byte-by-byte basis. All tape-read operations display the length of the file being read when the header is found. In this case the length is hexadecimal 200 bytes. A heading line is displayed, and if a comparison fails, the address and differing inputs are displayed:

```
C[addr][cr]
```

```
C100[cr]
```

```
ADDR M T DIFF LENGTH (HEXADECIMAL)=0200
```

```
0102 77 76 00000001
```

In this example, the data coming from tape matched the data located starting at hexadecimal address 100 except for address 102, where a 1-bit error was encountered.

#### D — Dump or Display the Contents of Memory

Displays the contents of memory from [addr1] to [addr2] as sixteen hexadecimal values per line:

```
D[addr1] [addr2][cr]
```

```
D0 20[cr]
```

```
0000 01 33 43 56 A3D8 90 90 34 88 ACEE F0 99 5F 70
```

```
0010 86 45 10 3E D4 BB CDEE 42 4E 53 96 9F 88 53 40
```

```
0020 74
```

#### E — Enter Hexadecimal Data From the Keyboard into Memory

After you enter the E command and an address, MON88 will display the current contents of that memory address followed by a "-". The value at that address can be changed by entering a new value. Once a new value has been entered, or if no change to the contents is required, a space is entered. MON88 will then display the contents of the next location followed by a "-". The E command is terminated with a carriage return:

```
E[addr][cr]
```

```
D100 104[cr]
```

```
0100 01 02 03 05 06
```

```
E100[cr]
```

```
0100 01-02 02-03 03-04 05-__ 06-[cr]
```

```
D100 104[cr]
```

```
0100 02 03 04 05 06
```

#### F — Fill a Memory Block With a Constant

Fills a block of memory from [addr1] to [addr2] with a constant value:

```
F[addr1] [addr2] [data][cr]
```

```
F100 104 20[cr]
```

```
D100 104[cr]
```

```
0100 20 20 20 20 20
```

#### G — Go To and Execute a User Program

MON88 will vector to and begin executing a program in memory. Note that if the user program does not modify the contents of the segment registers, a

return instruction at the end of the program will transfer control to MON88. For this example, note that hexadecimal address F800 is the start address of MON88:

```
G[addr][cr]
GF800[cr]
(screen clears)
8088 Monitor [rev 0]
```

#### *H — Compute the Sum and Difference of the 16-Bit Hexadecimal Values*

MON88 will compute and display the sum and difference of two 16-bit arguments:

```
H[addr1] [addr2][cr]
H2000 1010[cr]
SUM DIFF
3010 0FF0
```

#### *I — Input a Byte From an I/O Port*

MON88 will read a byte from an I/O port and display the hexadecimal and binary values. Note that an 8- or 16-bit I/O port address may be specified. If boards in your system decode the upper (A8 thru A15) address lines, use a 16-bit I/O address:

```
I[addr][cr]
```

To input from I/O port hexadecimal 20 in the case that no I/O boards decode the upper eight address lines:

```
I20[cr]
23 00100011
```

To input from I/O port hexadecimal 20 in the case that any I/O boards decode the upper eight address lines for their 8-bit I/O port address:

```
I2020[cr]
23 00100011
```

#### *J — Not Implemented*

#### *K — Toggle Keyboard Upper/Lower Case*

For keyboards with only a "shift lock," the K command will result in teletypewriter-like uppercase capability. In this mode, the letters A thru Z will be automatically shifted to uppercase, while all other keys (ie: the numbers 0 thru 9, etc) will not shift:

```
K[cr]
```

#### *L — Not Implemented*

#### *M — Move a Block of Memory*

This command moves the block of memory between [addr1] and [addr2] (inclusive) to [addr3]. Forward or backward moves are acceptable. Overlapping moves can of course have strange results:

```
M[addr1] [addr2] [addr3][cr]
```

```
D0 F[cr]
0000 01 02 03 04 05 06 07 08 09 0A0B 0C 0D 0E 0F 10
M0 35 [cr]
D0 F [cr]
0000 01 02 03 04 05 01 02 03 04 0A0B 0C 0D 0E 0F 10
```

#### *N — Nondestructive Memory Test*

A block of memory may be nondestructively tested using a read-complement-write-read-recomplement-compare-write algorithm. This provides a quick check for easily detected failures. Failing bits will be noted in hexadecimal and binary along with the failing address. The memory block will be repeatedly tested until a Control-C is entered:

```
N[addr1] [addr2][cr]
N0 2000[cr]
12FF 02 00000010
12FF 02 00000010
12FF 02 00000010
```

```
[Control-C]
```

In this case, location hexadecimal 12FF has a bad bit (D1 on a scale of D0 to D7)

#### *O — Output to a Port*

This command outputs a byte to an I/O port. As in the Input (I) command, 8- or 16-bit I/O port addresses can be used. The same rule for dealing with S-100 I/O devices that decode their 8-bit I/O address on the upper eight address lines is used:

```
O[addr] [data][cr]
O2020 FE[cr]
```

This outputs hexadecimal FE to port hexadecimal 20 (old S-100) or port hexadecimal 2020 (new S-100)

#### *P — Write Continuous Sync Stream to Cassette*

A continuous stream of Tarbell format "sync" characters (hexadecimal E6) will be written to tape. The P command is terminated by pressing any key on the keyboard:

```
P[cr]
```

#### *Q — Not Implemented*

#### *R — Read from Cassette*

A file can be read from tape into memory, starting at [addr]. The length of the file is contained in the file header, so no length or ending address input to the R command is required. When MON88 finds the tape header, the file length will be printed on the console, informing the user that loading has been initiated. In this example, the file length is hexadecimal 200 bytes:

```
R[addr][cr]
R100[cr]
LENGTH (HEXADECIMAL) = 0200
```

S, T, U — Not Implemented

V — Verify the Equality of Two Blocks of Memory

The block of memory from [addr1] to [addr2] will be compared with the block starting at [addr3]. Differences will be noted in hexadecimal and binary:

```
V[addr1] [addr2] [addr3][cr]
V20 3F 100[cr]
SRC M DEST M DIFF
0022 10 0122 11 00000001
0030 3E 0130 3F 00000001
```

In this case, the hexadecimal 20 bytes from hexadecimal addresses 20 to 3F are equal to those at address 100 except for two locations: hexadecimal locations 22 and 122 differ, as do locations 30 and 130.

W — Write to Cassette

The block of memory from [addr1] to [addr2] will be written to tape. MON88 will calculate the length of the block, display it, and write it to the tape header for use by the Read ("R") and Compare ("C") commands:

```
W[addr1] [addr2][cr]
W100 1FF[cr]
LENGTH (HEXADECIMAL) = 100
```

The block of memory from hexadecimal 100 to 1FF is written to tape.

X, Y, Z — Not Implemented

Command	Use
A	Enter ASCII text into memory.
B	Not implemented
C	Compare cassette input with memory.
D	Display memory.
E	Enter hexadecimal data into memory.
F	Fill memory with a constant.
G	Go To and execute user program.
H	Hexadecimal math.
I	Input from an I/O port.
J	Not implemented.
K	Toggle keyboard upper/lowercase.
L	Not implemented.
M	Move memory.
N	Nondestructive memory test.
O	Output to an I/O port.
P	Put a continuous 'sync' stream to tape.
Q	Not implemented.
R	Read a file from cassette.
S,T,U	Not implemented.
V	Verify equality of two memory blocks.
W	Write a file to cassette.
X,Y,Z	Not implemented.

Table 1: A quick reference guide to MON88 commands. Note that only sixteen of the possible twenty-six commands are implemented. While a stripped version of the present monitor can reside in 1 K bytes of memory, there is provision on the processor board for 2 K bytes of EPROM.

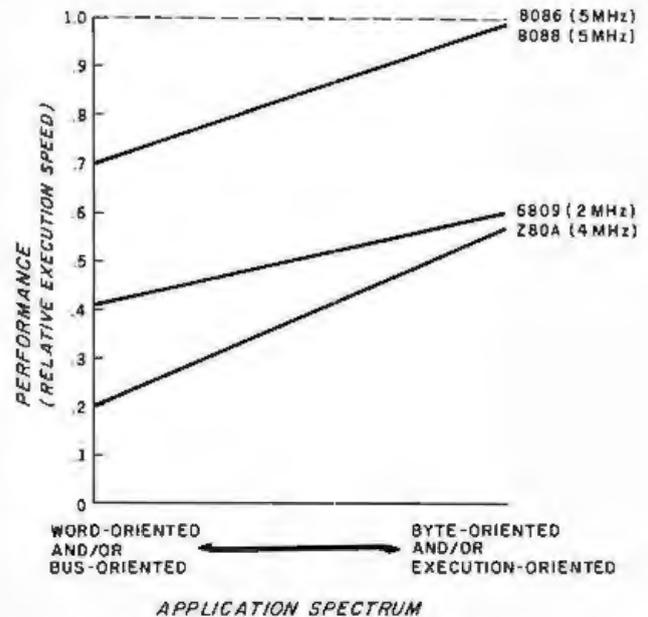


Figure 3: Relative performance of several 8- and 16-bit microprocessors. The types of programs a processor can run are divided into two groups: those that primarily move data around (word- or bus-oriented) and those that primarily manipulate byte-oriented data or perform many numeric operations. If the 16-bit 8086 microprocessor (dotted line) is defined as a performance figure of 1.0, the other three lines show the approximate relative performance of the three other microprocessors as influenced by the type of program being run.

Text continued from page 342:

**Scratchpad Allocation:** My video-board driver uses an 80-byte buffer and a 2-byte X,Y cursor-position variable. These, of course, can be removed or replaced according to your needs. Currently this storage is allocated in the processor boards, 1 K bytes of programmable memory in the (8185-2) device.

The only scratchpad memory required by MON88 is a 1-byte uppercase/lowercase flag variable. This is used by the K (keyboard toggle) command to allow emulation of uppercase-only peripherals in which letters are shifted, but numbers and special characters are not.

If you are not using the processor board described last month and don't have a dedicated scratchpad in the system, UCFLAG can be allocated at the top of memory:

```
UCFLAG EQU TOPMEM
```

where TOPMEM is the address of the top of memory.

**Stack:** My stack also resides on the scratchpad memory within the processor board. If you do not have scratchpad, allocate the stack 1 byte below the top of your memory (to leave room for UCFLAG). Note that the stack pointer is decremented before a PUSH operation is performed. Therefore, to allocate the stack 1 byte below the top of memory, set the stack pointer equal to the top of memory:

```
UCFLAG STACKP EQU TOPMEM
```

Listing 1: Assembly listing of MON88. The flowchart in figure 2 outlines the general operation of the program.

MCS-86 MACRO ASSEMBLER VID88

ISIS-II MCS-86 MACRO ASSEMBLER V2.0 ASSEMBLY OF MODULE VID88  
 OBJECT MODULE PLACED IN .FO:VID88.OBJ  
 ASSEMBLER INVOKED BY: ASMB6 VID88.A66

```

LOC OBJ          LINE    SOURCE
-----
1              1      ; *****
2              2      ; *
3              3      ; *           M O N 8 8
4              4      ; *
5              5      ; * A video oriented system monitor for the INTEL 8088
6              6      ; *   written 01 1980 - revision 0
7              7      ; *   by   Thomas Woodward Cantrell
8              8      ; *
9              9      ; *****
10             10     ;
11             11     ASSUME DS:ABS_0,CS:ABS_0,ES:ABS_0
12             12     ABS_0 SEGMENT BYTE AT 0
0900          13     M LABEL BYTE
F800          14     ORG   0F800H
15             15     ;
16             16     ; *****
17             17     ; *
18             18     ; *           EQUATES FOLLOW
19             19     ; *
20             20     ; *****
21             21     ;
F40D          22     VIDBUF EQU   0F400H           ;video buffer
F450          23     XY EQU   VIDBUF+80           ;holder for cursor position
F452          24     UCFLAG EQU  XY+2             ;upper/lower case flag
0C0C          25     FF EQU   0CH                 ;form feed (clear screen)
0D0A          26     LF EQU   0AH                 ;line feed
0D0D          27     CR EQU   0DH                 ;carriage return
0D08          28     BS EQU   0BH                 ;backspace
    
```

Listing 1 continued on page 348

where TOPMEM is the address of the top of memory.

**Initialization:** I/O initialization is done in the INIT section of the monitor (see listing 1, starting at line 76). Starting at hexadecimal F81D, I initialize the Tarbell cassette interface and TDL Video Interface. Replace the section of code from hexadecimal F81D to F828 to suit your I/O needs.

### I/O Drivers

MON88 currently uses the following environment-dependent I/O routines (their hexadecimal addresses are given in parentheses):

- **KEYIN (F90F)**—Reads a byte from the console keyboard, strips off the parity bit, and returns the character in the AL accumulator.
- **KEYSTAT (F922)**—Reads the console keyboard's status and returns AL=0 if a key has not been pressed and AL = hexadecimal FF if a key has been pressed.
- **CIN (F955)**—Reads a byte from a mass-storage device (Tarbell cassette, in my case) and returns the byte in the AL accumulator.
- **COU (F964)**—Writes the byte contained in the AL accumulator to the mass-storage device.
- **CSTART (FB60)**—Sets up the mass-storage device for a write operation. For the Tarbell interface, a start byte and a sync byte are required. Replace this code as necessary for your device.
- **READINIT (FB9D)**—Sets up the mass-storage device for a read operation. Replace the relevant code as necessary.
- **PUTSYNC (FBBF)**—Outputs a stream of sync bytes to

my cassette. This allows calibrating the interface. If your device has a similar feature, modify the PUTSYNC routine accordingly. If not needed, the whole P (PUTSYNC) command can be removed.

- **VIDOUT (FCDA)**—This routine outputs the character in the AL accumulator to the console display device. In my case, I converted an 8080 version of the video driver to 8088 code using Intel's CONV86 program. Using the code converter, it took only an hour or so to get the driver up and running. I will rewrite it as necessary to reduce the amount of memory used by MON88.

### Adding or Removing Commands

All commands are referenced through CTABLE (Command Jump Table) located at hexadecimal F8B8. Note that the commands are arranged in alphabetical order, A thru Z. To remove a command, simply replace its reference in CTABLE with ERR. For example, to remove the K command (uppercase/lowercase toggle), change:

```
F8CC DW KTOGGLE
```

to

```
F8CC DW ERR
```

then remove the KTOGGLE code (hexadecimal FCD1 to FCD9).

Similarly, to add a special memory test (for example) and call it using the letter T, first write the code (for example, starting label TESTMEM) for the command,

Text continued on page 360

Listing 1 continued:

```

E2E2      29  KSTAT  EGU   0E2E2H      ;keyboard status port
E3E3      30  KDATA  EGU   0E3E3H      ;keyboard data port
6E6E      31  CSTAT  EGU   6E6EH       ;Tarbell status port
6F6F      32  CDATA  EGU   6F6FH       ;Tarbell data port
F7FF      33  STACKP EGU   0F7FFH      ;Stack address
0003      34  CTLC   EGU   03H        ;ascii ct)-r
0004      35  CTLD   EGU   04H        ;ascii ct)-d
0013      36  CTLS   EGU   13H        ;ascii ct)-s
0011      37  CTLG   EGU   11H        ;ascii ct)-q
0000      38  FALSE  EGU   0          ;
00FF      39  TRUE   EGU   0FFH       ;
40 +1    $EJECT

```

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```

LOC OBJ          LINE    SOURCE
41              ;
42              ;
43              ; *****
44              ; *                               *
45              ; *           JUMP TABLE           *
46              ; *****
47              ;
48              ;
FB00 EB0D90      49      JMP     INIT      ;RESETS STACK, SEGMENT REGISTERS, CASSETTE INTERFACE
50              ; ;ALSO PRINTS SIGN-ON MESSAGE
51              ;
FB03 EB3090      52      JMP     START    ;'WARM START'-- REGISTERS NOT INITIALIZED
53              ;
FB06 E91901      54      JMP     KEYSTAT ;RETURNS [AL]=0 IF NO KEYPRESS PENDING. ELSE [AL]=OFFH
55              ;
FB09 E9E000      56      JMP     CONIN   ;WAITS FOR KEYPRESS. RETURNS [AL]=CHAR AND PRINTS IT.
57              ;
FB0C E9CB04      58      JMP     VIDOUT ;PRINTS CHAR IN AL ON CONSOLE
59              ;
60              ;
61              ; *****
62              ; *                               *
63              ; *           I N I T I A L I Z A T I O N           *
64              ; *                               *
65              ; *****
66              ;
67              ;
FB0F FC          68      INIT:  CLD     ;direction flag points 'up'
FB10 FA          69      CLI     ;disable interrupts
FB11 BCCB        70      MOV     AX,CS   ;initialize
FB13 BEDB        71      MOV     DS,AX   ; segment
FB15 BECO        72      MOV     ES,AX   ; registers
FB17 BED0        73      MOV     SS,AX   ; and set
FB19 BCFFF7      74      MOV     SP,STACKP ; stack pointer
FB1C FB          75      STI     ;enable interrupts
FB1D B010        76      MOV     AL,10H  ;Reset Cassette
FB1F BA6E6E      77      MOV     DX,CSTAT
FB22 EE          78      OUT     DX,AL   ; Interface
FB23 BAE0E0      79      MOV     DX,0E0E0H ;Reset Video
FB26 B088        80      MOV     AL,BBH  ; Interface
FB28 EE          81      OUT     DX,AL   ;Inverse video w/cursor
FB29 C60652F400  82      MOV     BYTE PTR M[UCFLAG],0 ;0=lower case, FFH=U/C only
83
FB2E BE5AFB90    84      MOV     SI,OFFSET SIGNON ;get sign on message
FB32 EB6301      85      CALL    PRINTMSG ;and print it
86 +1    $EJECT

```

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```

LOC OBJ          LINE    SOURCE
87              ;
88              ; *****
89              ; *                               *
90              ; *           W O R K I N G   L O O P           *
91              ; *                               *
92              ; *****
93              ;
FB35 EB3D01      94      START: CALL    CRLF      ;print CRLF
FB38 B03E        95      MOV     AL,'>' ;and prompt
FB3A EB9D04      96      CALL    VIDOUT
97              ;
FB3D            98      MAINLOOP:
FB3D B400        99      MOV     AH,0    ;clear AH
FB3F EBAA00     100     CALL    CONIN   ;get a command
FB42 3C41       101     CMP     AL,'A'  ;check range for
FB44 72EF       102     JB     START   ; A
FB46 3C5A       103     CMP     AL,'Z'  ; thru
FB48 7FEB       104     JG     START   ; Z
FB4A 2C41       105     SUB     AL,'A'  ;calculate offset

```

```

FB4C D0E0          106      SHL      AL,1          ;and multiply by 2
FB4E 05B8F890     107      ADD      AX,OFFSET CTABLE
FB52 8BDB         108      MOV      BX,AX
FB54 8B07         109      MOV      AX,WORD PTR M[BX]
FB56 FFDD         110      CALL    AX          ;go do it
FB58 E8DB         111      JMP      START      ;start over
                112 +1 %EJECT

```

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```

LOC  OBJ          LINE  SOURCE
                113  ;
                114  ; *****
                115  ; *
                116  ; *           M E S S A G E S           *
                117  ; *
                118  ; *****
                119  ;
FB5A 0C           120  SIGNON  DB      OCH
FB5B 38303838204D6F6E69746F72203C726574E20303E  121      DB      'BOBB Monitor (rev. 0)'
FB70 00           122  DBYTE   DB      0          ; dummy byte
                123  ;
FB71 41444452204D2020542020202044494646202020  124  COMHEAD DB      'ADDR M T DIFF'
FB85 00           125      DB      0
                126  ;
FB86 53554D202044494646  127  MHEAD   DB      'SUM DIFF'
FB8F 00           128      DB      0
                129  ;
FB90 53524320204D20202044455354204D20202044494646  130  VHEAD   DB      'SRC M DEST M DIFF'
FBA7 00           131      DB      0
                132  ;
FBAB 4C454E475448202848455829203D20  133  CHEAD   DB      'LENGTH (HEX) = '
FB87 00           134      DB      0
                135  ;
                136 +1 %EJECT

```

MCS-86 MACRO ASSEMBLER VID88

```

LOC  OBJ          LINE  SOURCE
                137  ;
                138  ; *****
                139  ; *
                140  ; *           C O M M A N D   J U M P   T A B L E           *
                141  ; *
                142  ; *****
                143  ;
FB88 80FC         144  CTABLE  DW      AENTER ;ENTER ASCII TEXT INTO MEMORY
FB8A A7F9         145      DW      ERR      ;B
FB8C D2FB         146      DW      COMPARE ;COMPARE CASSETTE INPUT WITH MEMORY
FB8E 00FB         147      DW      DUMP     ;DISPLAY MEMORY
FB80 78FC         148      DW      ESUBST  ;ENTER HEX DATA INTO MEMORY
FB82 7EFA         149      DW      FILL    ;FILL MEMORY WITH A CONSTANT
FB84 4AF8         150      DW      GOTO    ;GO TO & EXECUTE A USER PROGRAM
FB86 1AFC         151      DW      HEXMATH ;COMPUTE SUM AND DIFFERENCE OF HEX #'S
FB88 2CFB         152      DW      INPUT   ;INPUT FROM A PORT
FB8A A7F9         153      DW      ERR      ;J
FB8C D1FC         154      DW      KTOGGLE ;TOGGLE KEYBOARD UPPER/LOWER CASE FLAG
FB8E A7F9         155      DW      ERR      ;L
FB80 E7FA         156      DW      MOVE    ;MOVE MEMORY
FB82 38FC         157      DW      NTEST   ;NON DESTRUCTIVE MEMORY TEST
FB84 3FFB         158      DW      OUTPUT  ;OUTPUT TO A PORT
FB86 3FFB         159      DW      PUTSYNC ;OUTPUT CONTINUOUS SYNC STREAM TO CASSETTE
FB88 A7F9         160      DW      ERR      ;Q
FB8A 82FB         161      DW      READ    ;READ FROM CASSETTE
FB8C A7F9         162      DW      ERR      ;S
FB8E A7F9         163      DW      ERR      ;T
FB80 A7F9         164      DW      ERR      ;U
FB82 8DFA         165      DW      VERIFY  ;VERIFY EQUALITY OF TWO MEMORY BLOCKS
FB84 4FFB         166      DW      CWRITE  ;WRITE TO CASSETTE
FB86 A7F9         167      DW      ERR      ;X
FB88 A7F9         168      DW      ERR      ;Y
FB8A A7F9         169      DW      ERR      ;Z
                170 +1 %EJECT

```

Listing 1 continued on page 350

Listing 1 continued:

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```

LDC OBJ          LINE    SOURCE
                171      ;
                172      ;
                173      ; *****
                174      ; *
                175      ; *          UTILITY ROUTINES          *
                176      ; *          and                          *
                177      ; *          I / O DEVICE HANDLERS      *
                178      ; *          (except video driver)      *
                179      ; *
                180      ; *****
                181      ;
                182      ;
F8EC EB2000      183      CONIN:  CALL    KEYIN          ;get a keyboard character
F8EF 50          184          PUSH    AX
F8F0 A052F4      185          MOV     AL, BYTE PTR MIUCFLAGJ ;check for case conversion
F8F3 0AC0        186          OR     AL, AL          ;0?
F8F5 7405        187          JZ     CONNEXT       ;YES..no conversion
F8F7 58          188          POP     AX           ;restore character
F8F8 EB0900      189          CALL   UCCHEK        ;convert to UC
F8FB 50          190          PUSH    AX
F8FC 58          191      CONNEXT: POP    AX
F8FD EBDA03      192          CALL   VIDDUT        ;and echo it on console
F900 E80100      193          CALL   UCCHEK        ;always return UC
F903 C3          194      KQUIT:  RET
                195      ;
F904 3C61        196      UCCHEK:  CMP     AL, 'a'
F906 7206        197          JC     UQUIT
F908 3C7B        198          CMP     AL, 'z'+1
F90A 7302        199          JNC   UQUIT
F90C 245F        200          AND     AL, 5FH
F90E C3          201      UQUIT:  RET
                202      ;
F90F 52          203      KEYIN:  PUSH    DX          ;keyboard device handler
F910 BAE2E2      204          MOV     DX, KSTAT
F913 EC          205      KEYLOOP: IN     AL, DX          ;check for keypress
F914 2480        206          AND     AL, 80H
F916 74FB        207          JZ     KEYLOOP       ;no keypress, then wait for one
F918 5A          208          POP     DX
F919 52          209      KIN:    PUSH    DX
F91A BAE3E3      210          MOV     DX, KDATA
F91D EC          211          IN     AL, DX          ;else get the character
F91E 247F        212          AND     AL, 7FH        ;and strip parity
F920 5A          213          POP     DX
F921 C3          214          RET
                215      ;
F922            216      KEYSTAT: ; RETURN [AL]=0 IF NO KEYPRESS ELSE [AL]=OFFH
F922 B400        217          MOV     AH, FALSE
F924 52          218          PUSH    DX
F925 BAE2E2      219          MOV     DX, KSTAT
F928 EC          220          IN     AL, DX
F929 2480        221          AND     AL, 80H
F92B 74D7        222          JZ     KEXIT          ;return it if no keypress
F92D F6B4        223          NOT     AH
F92F BAC4        224      KEXIT:  MOV     AL, AH

```

MCS-86 MACRO ASSEMBLER VIDBB

```

LDC OBJ          LINE    SOURCE
                225          POP     DX
F932 C3          226          RET
                227      ;
F933            228      CTLCKEK: ; CHECK FOR CTL-S, CTL-G AND CTL-C
F933 50          229          PUSH    AX
F934 EBEBFF      230          CALL   KEYSTAT       ;keypress?
F937 3C00        231          CMP     AL, 0
F939 741B        232          JZ     CTLEXIT       ;no keypress so return
F93B EBDBFF      233          CALL   KIN           ;if keypress then get the data
F93E 3C13        234          CMP     AL, CTLS
F940 750D        235          JNZ   CTLCKEK       ;if not look for ctl-c
F942 EBCAFF      236      KWAIT:  CALL   KEYIN          ;if ctl-s then wait for another keypress
F945 3C11        237          CMP     AL, CTLG
F947 740A        238          JZ     CTLEXIT       ;YES..return
F949 3C03        239          CMP     AL, CTLC
F94B 745A        240          JE     ERR           ;abort?
F94D EBFB        241          JMP     KWAIT         ;otherwise wait some more
F94F            242      CTLCCKEK:
F94F 3C03        243          CMP     AL, CTLC
F951 7454        244          JZ     ERR           ;is it ctl-c
F953            245      CTLEXIT:

```

```

F953 5B      246      POP      AX
F954 C3      247      RET
                248
F955        249      ; GET BYTE FROM CASSETTE
F955 52      250      CIN:      PUSH      DX
F956 BA6E6E  251      MOV      DX, CSTAT
F959        252      CINLOOP:
F959 EC      253      IN       AL, DX
F95A 2410    254      AND     AL, 10H      ;cassette ready to read?
F95C 75FB    255      JNZ     CINLOOP     ;NO, wait
F95E BA6F6F  256      MOV     DX, CDATA   ;YES..
F961 EC      257      IN     AL, DX      ;get the data
F962 5A      258      POP     DX
F963 C3      259      RET
                260
F964        261      ; WRITE A BYTE TO CASSETTE
F964 52      262      COUT:    PUSH     DX
F965 50      263      PUSH     AX
F966 BA6E6E  264      MOV     DX, CSTAT
F969        265      COUTLOOP:
F969 EC      266      IN     AL, DX
F96A 2420    267      AND     AL, 20H     ;cassette ready for write?
F96C 75FB    268      JNZ     COUTLOOP   ;NO, wait
F96E 58      269      POP     AX          ;get char back
F96F BA6F6F  270      MOV     DX, CDATA
F972 EE      271      OUT     DX, AL      ;and send to tape
F973 5A      272      POP     DX
F974 C3      273      RET
                274
F975 50      275      ;
F976 EBBAFF  276      GRLF:   PUSH     AX
F977 B00D    277      CALL    CTLCHK      ;CHECK FOR ABORT
F978 EB3C03  278      MOV     AL, CR      ;SEND CR AND LF TO CONSOLE
                CALL    VIDOUT

```

MCS-86 MACRO ASSEMBLER VID88

```

LOC  OBJ      LINE  SOURCE
F97E 800A      279      MOV     AL, LF
F980 EB5703    280      CALL    VIDOUT
F983 58        281      POP     AX
F984 C3        282      RET
                283
F985        284      ; BLANK:      ;PRINT A BLANK, SAVE ALL REG.
F985 51        285      PUSH     CX
F986 B90100    286      MOV     CX, 1        ;print 1 blank
F989 EB0200    287      CALL    TABS
F98C 59        288      POP     CX
F98D C3        289      RET
                290
F98E        291      ; TABS:      ;PRINT # BLANKS IN CX.. ON EXIT CX=0
F98E 50        292      PUSH     AX
F98F B020     293      MOV     AL, ' '
F991 E94603    294      TLOOP:  CALL    VIDOUT
F994 E2FB     295      LOOP   TLOOP
F996 58        296      POP     AX
F997 C3        297      RET
                298
F998        299      ; PRINTMESS: ;PRINT THE MESSAGE <-- [SI] ON CONSOLE
F998 50        300      PUSH     AX          ;END OF MESSAGE IS A ZERO (0)
F999 AC        301      PMESS:  LODS    DBYTE        ;get a byte
F99A 3C00     302      CMP     AL, 0        ;check for end of message
F99C 7407     303      JE      PQUIT        ;quit if zero
F99E 56        304      PUSH     SI          ;otherwise save message pointer
F99F EB3B03    305      CALL    VIDOUT      ;and display byte
F9A2 5E        306      POP     SI
F9A3 EBF4     307      JMP     PMESS        ;print more message
F9A5 58        308      PQUIT:  POP     AX
F9A6 C3        309      RET
                310
F9A7 B02A     311      ; ERR:      MOV     AL, '*'      ;print error
F9A9 EB2E03    312      CALL    VIDOUT      ; message
F9AC BCFF7    313      MOV     SP, STACKP ;reinitialize stack
F9AF E9B3FE    314      JMP     START        ;and abort!
                315
F9B2        316      ; BINOUT:   ;OUTPUT [AL] AS EIGHT BINARY DIGITS (BITS)
F9B2 51        317      PUSH     CX
F9B3 B90B00    318      MOV     CX, 0
F9B6        319      BINOUT1:
F9B6 D0E0     320      SHL     AL, 1        ;get the bit
F9B8 7209     321      JB      BOUT1        ;output a 1
F9BA 50        322      PUSH     AX          ;otherwise..
F9BB B030     323      MOV     AL, '0'      ;output
F9BD EB1A03    324      CALL    VIDOUT      ;# 0
F9C0 EB0790    325      JMP     BINEND       ;continue
F9C3 50        326      BOUT1:  PUSH     AX
F9C4 B031     327      MOV     AL, '1'      ;output a 1
F9C6 EB1103    328      CALL    VIDOUT

```

Listing 1 continued on page 352

Listing 1 continued:

```

F9C9 5B          329  BINEND POP    AX
F9CA E2EA       330          LOOP   B INOUT1 ; do it eight times
F9CC 59         331          POP    CX
F9CD C3         332          RET

```

MCS-86 MACRO ASSEMBLER VID88

```

LOC  OBJ          LINE  SOURCE
;
F9CE          333
F9CE 50          334  HEXOUT: ; OUTPUT [AL] AS 2 HEX DIGITS. ALL REG SAVED
F9CF 51          335          PUSH  AX
F9D0 8AE0       336          PUSH  CX
F9D2 B104       337          MOV   AH,AL ; save AL
F9D4 D2EB       338          MOV   CL,4
F9D6 59         339          SHR   AL,CL ; shift AL right 4 places
F9D7 E80700     340          POP   CX
F9DA BAC4       341          CALL  HEXDIGOUT ; output upper nibble
F9DC E80200     342          MOV   AL,AH ; restore AL (now we do lower nibble)
F9DF 58         343          CALL  HEXDIGOUT
F9E0 C3         344          POP   AX
F9E1          345          RET
;
F9E1          346
F9E1 240F       347  HEXDIGOUT: ; CONVERT NIBBLE TO ASCII HEX
F9E3 0490       348          AND   AL,0FH ; mask upper 4 bits
F9E5 27         349          ADD   AL,90H ; tricky conversion...
F9E6 1440       350          DAA   ; but
F9E8 27         351          ADC   AL,40H ; it
F9E9 E8EE02     352          DAA   ; works!
F9EC C3         353          CALL  VIDOUT ; print the result
F9ED          354          RET
;
F9ED          355
F9ED 2C30       356  HEXCHK: ; CHECK AL FOR VALID HEX DIGIT, CONVERT TO BIN
F9EF 720E       357          SUB   AL,'0' ; IF INVALID RETURN WITH CARRY SET
F9F1 3C0A       358          JB   HRET ; Error... not alphanumeric
F9F3 F5         359          CMP   AL,0AH ; check for 0-9
F9F4 7309       360          CMC
F9F6 2C07       361          JNB  HRET ; return o.k. if 0-9
F9F8 3C0A       362          SUB   AL,7 ; adjust for A-F
F9FA 7203       363          CMP   AL,10
F9FC 3C10       364          JB   HRET ; return error if > 9
F9FE F5         365          CMC
F9FF C3         366          HRET: RET
;
FA00          367
FA00          368
FA00          369  GETPARMB: ; 16 BIT HEX VALUE TO BX. BX IS SHIFT REGISTER. ACCEPTS LAST 4
FA03 EBE6FE     370          ; ON ENTRY CX EQUALS NUMBER OF KEYPRESSES THAT CAN BE ACCEPTED.
FA06 3C30       371          ; ON EXIT AH CONTAINS TERMINATOR (I.E. CR, SPACE)
FA08 7210       372          ; UNLESS THE TERMINATOR IS INVALID (NOT EQUAL CR, SPACE OR ',')
FA0A 51         373          ; IN WHICH CASE AN ERROR IS GENERATED.
FA0B 8104       374
FA0D D3E3       375          MOV   BX,0 ; clear BX
FA0F 59         376  LOOPB: CALL  CONIN ; get a character
FA10 EBD0FF     377          CMP   AL,'0' ; alphanumeric?
FA13 7292       378          JB   BEXIT ; NO... quit
FA15 02B8       379          PUSH CX ; YES... then
FA17 E2EA       380          MOV   CL,4 ; shift BX to
FA19 D3E3       381          SHL  BX,CL ; make room for
FA1B 59         382          POP   CX ; latest addition
FA1D EBD0FF     383          CALL  HEXCHK ; check for valid hex and convert to binary
FA1F 7292       384          JB   ERR ; if invalid then error!
FA21 02B8       385          ADD  DL,AL ; otherwise add it in
FA23 E2EA       386          LOOPB ; keep looking

```

MCS-86 MACRO ASSEMBLER VID88

```

LOC  OBJ          LINE  SOURCE
;
FA19 C3         387
FA1A 3C20       388  BEXIT: RET
FA1C 7403       389          CMP   AL,' ' ; test for blank
FA1E 3C2C       390          JE   BGOOD
FA20 7407       391          CMP   AL,', ' ; comma
FA22 3C0D       392          JE   BGOOD
FA24 7403       393          CMP   AL,CR ; or carriage return
FA26 E97EFF     394          JE   BGOOD
FA29 8AE0       395          JMP  ERR ; if none of the above the ERROR
FA2B C3         396          BGOOD: MOV  AH,AL ; save terminator
FA2C          397          RET
;
FA2C          398
FA2C 53         399  GETPARMD: ; 16 BIT HEX VALUE TO DX. USE GETPARMB
FA2D E8D0FF     400          PUSH BX ; save BX
FA30 8B03       401          CALL GETPARMB ; get the parameter
FA32 5B         402          MOV  DX,BX ; put it where it belongs
FA33 C3         403          POP  BX ; restore BX
FA34          404          RET
;

```



Listing I continued:

```

FA94 83F3          479      MOV     SI,BX          ;save source in SI
FA96 51           480      PUSH    CX
FA97 B9FFFF       481      MOV     CX,OFFFHH     ;64K keypresses allowed
FA9A E863FF       482      CALL   GETFARMB      ;get the destination
FA9D 59           483      POP     CX
FA9E B8FB        484      MOV     DI,BX          ;into DI
FAA0 E8D2FE       485      CALL   CRLF
FAA3 56           486      PUSH    SI             ;save source
FAA4 BE90FB       487      MOV     SI,OFFSET VHEAD
FAA7 E8EEFE       488      CALL   PRINTMESS     ;print header
FAAA 5E           489      POP     SI             ;restore source
FAAB           490
FAAB F3           491      VLOOP: REPE CMPS     DBYTE, DBYTE ;do it!
FAAC A6
FAAD B3F900       492      CMP     CX,0           ;all done?
FAB0 7501         493      JNE    VERR           ;NO.. error
FAB2 C3           494      RET                   ; if done then return
;
FAB3 B8DE        495
FAB5 4B           496      VERR:  MOV     BX,SI      ;get the source addr
FAB6 E8B0FE       497      DEC     BX             ;adjust it
FAB9 E8B5FF       498      CALL   CRLF
FABC E8C6FE       499      CALL   OUTBX          ;output the addr
FABF 8A07        500      CALL   BLANK
FAC1 BAE0        501      MOV     AL,M[BX]      ;get what's there
FAC3 E808FF       502      MOV     AH,AL         ;save it in AH
FAC6 E8B0FE       503      CALL   HEXOUT        ;output the data
FAC9 E8B9FE       504      CALL   BLANK
FACC 88DF        505      CALL   BLANK
FACE 4B          506      MOV     BX,DI         ;get the destination addr
FACE 4B          507      DEC     BX             ;adjust it

```

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```

LOC  OBJ          LINE  SOURCE
FACF EB9FFF       508      CALL   OUTBX          ;display it
FAD2 8A07        509      MOV     AL,M[BX]      ;get the data
FAD4 EBAEFE       510      CALL   BLANK
FAD7 EBF4FE       511      CALL   HEXOUT        ;output the data
FADA E8ABFE       512      CALL   BLANK
FADD 32C4        513      XOR     AL,AH         ;determine bad bits
FADF EBD0FE       514      CALL   BINOUT        ;display in binary
FAE2 EB4EFE       515      CALL   CTLCHK        ;check for abort
FAE5 EBC4        516      JMP     VLOOP        ;continue
;
FAE7           517
FAE7 EB4AFF       518      MOVE:  CALL   SETUP     ;MOVE A BLOCK OF MEMORY
FAEA 3C0D        519      CMP     AL,ODH        ;get start and end
FAEC 7503        520      JNZ    M1             ;if not enough data
FAEE E9B6FE       521      JMP     ERR           ;then error!
FAF1 E855FF       522      M1:    CALL   CLENGTH     ;otherwise compute length
FAF4 53          523      PUSH    BX            ;save start address
FAF5 E83CFF       524      CALL   SETUP         ;and get destination
FAFB B8FB        525      MOV     DI,BX         ;[DI] ← destination
FAFA 5B          526      POP     BX
FAFB 83F3       527      MOV     SI,BX         ;[SI] ← source
FAFD F3          528      REP    MOVSB         ;... move it...
FAFE A4          529
FAFF C3          530      RET
;
FB00           531
FB00 EB31FF       532      DUMP:  CALL   SETUP     ;DISPLAY MEMORY
FB03 EB43FF       533      CALL   CLENGTH     ;get start and end
FB06 E81900       534      CALL   NULINE2     ;and compute length
FB09 8A07        535      CALL   NULINE2     ;set up console
FB0B E8C0FE       536      DLOOP1: MOV     AL,M[BX] ;get what's there
FB0E E874FE       537      CALL   HEXOUT     ;print it
FB11 43          538      CALL   BLANK      ;and a blank
FB12 F6C30F       539      INC     BX
FB15 7503        540      TEST   BL,OFH      ;test for 16 byte boundary
FB17 E80300       541      JNZ    DNEXT      ;if not then continue
FB1A E2ED        542      CALL   NULINE     ;otherwise set up console for new line
FB1C C3          543      DNEXT: LOOP    DLOOP1 ;continue
;
FB1D B3F901       544
FB20 7409        545      NULINE: CMP     CX,1
FB22 54B         546      JE     NUGUIT
FB22 E850FE       547      NULINE2: CALL   CRLF      ;go to new line
FB25 E849FE       548      CALL   OUTBX      ;print address
FB28 E85AFE       549      CALL   BLANK      ;and a blank
FB2B C3          550      NUGUIT: RET
;
FB2C           551
FB2C E805FF       552      INPUT: CALL   SETUP     ;INPUT FROM A PORT
FB2F E843FE       553      CALL   CRLF      ;get port address
FB32 8BD3        554      MOV     DX,BX
FB34 EC          555      IN     AL,DX
FB35 E896FE       556      CALL   HEXOUT     ;read the port
FB38 E84AFE       557      CALL   BLANK     ;print data in hex
;

```

```

LOC  OBJ          LINE  SOURCE
FB3B  EB74FE      561          CALL  BINOUT      ; binary
FB3E  C3          562          RET
                    563
;
FB3F          564  OUTPUT:          ; OUTPUT TO A PORT
FB3F  EBF2FE      565          CALL  SETUP        ; get address
FB42  BAC2        566          MOV   AL, DL        ; and data
FB44  FECB        567          DEC   AL            ; adjust data
FB46  B8D3        568          MOV   DX, BX
FB48  EE          569          OUT  DX, AL        ; output data
FB49  C3          570          RET
                    571
;
FB4A          572  GOTO:           ; EXECUTE A PROGRAM
FB4A  EBE7FE      573          CALL  SETUP        ; get the address
FB4D  FFE3        574          JMP  BX            ; GO!
                    575
;
FB4F          576  CWRITE:        ; WRITE TO CASSETTE
FB4F  E8E2FE      577          CALL  SETUP        ; get the range
FB52  EBF4FE      578          CALL  CLENGTH      ; compute the length
FB55  E81DFE      579          CALL  CRLF
FB5B  E85500      580          CALL  CPROMPT
FB5B  E80F00      581          CALL  CSTART
FB5E  E85600      582          CALL  LENGTHOUT    ; tell length
FB61  BA07        583  CLOOP:        MOV   AL, M[BX]    ; get a byte
FB63  E8FEFD      584          CALL  COUT         ; output
FB66  43          585          INC   BX           ; next byte
FB67  E8C9FD      586          CALL  CTLCHK      ; check for abort
FB6A  E2F5        587          LOOP CLOOP        ; continue
FB6C  C3          588          RET
                    589
;
FB6D  B03C        590  CSTART:        MOV   AL, 3CH      ; start byte
FB6F  EBF2FD      591          CALL  COUT
FB72  B0E6        592          MOV   AL, 0E6H    ; sync byte
FB74  E8EDFD      593          CALL  COUT
FB77  BAC5        594          MOV   AL, CH      ; high length
FB79  E8E8FD      595          CALL  COUT
FB7C  BAC1        596          MOV   AL, CL      ; low length
FB7E  E8E3FD      597          CALL  COUT
FB81  C3          598          RET
                    599
;
FB82          600  READ:          ; READ FROM CASSETTE
FB82  EBAFFE      601          CALL  SETUP        ; get address
FB85  E8EDFD      602          CALL  CRLF
FB88  E82500      603          CALL  CPROMPT
FB8B  E80F00      604          CALL  READINIT
FB8E  E82600      605          CALL  LENGTHOUT    ; prompt when reading
FB91  E8C1FD      606  RLOOP:        CALL  CIN          ; get a byte
FB94  B807        607          MOV   M[BX], AL
FB96  43          608          INC   BX           ; next byte
FB97  E899FD      609          CALL  CTLCHK      ; check for abort
FB9A  E2F5        610          LOOP RLOOP        ; continue
FB9C  C3          611          RET
                    612
;
FB9D          613  READINIT:      MOV   AL, 10H     ; reset interface
FB9D  B010        614

```

```

LOC  OBJ          LINE  SOURCE
FB9F  52          615          PUSH  DX
FBA0  BA6E6E      616          MOV   DX, CSTAT
FBA3  EE          617          OUT  DX, AL
FBA4  5A          618          POP  DX
FBA5  E8ADFD      619          CALL  CIN
FBA8  BAEB        620          MOV   CH, AL      ; get high length
FBAA  E8ABFD      621          CALL  CIN
FBAD  BAC8        622          MOV   CL, AL      ; and low length
FBAF  C3          623          RET
                    624
;
FB80          625  CPROMPT:      ; CASSETTE PROMPT
FB80  BEA8FB      626          MOV   SI, OFFSET CHAD
FB83  EBE2FD      627          CALL  PRINTMESS
FB86  C3          628          RET
                    629
;
FB87          630  LENGTHOUT:    ; OUTPUT RECORD LENGTH
FB87  53          631          PUSH  BX
FB88  B8D9        632          MOV   BX, CX      ; get the count
FB8A  E8B4FE      633          CALL  OUTBX       ; output it
FB8D  58          634          POP  BX
FB8E  C3          635          RET

```

Listing 1 continued on page 356

Listing 1 continued:

```

636
F8BF 637 PUTSYNC: ; SEND SYNC STREAM TO CASSETTE
F8BF E8B3FD 638 CALL CRLF
F8C2 639 SYNCLOOP:
F8C2 80E6 640 MOV AL, 0E6H ; sync character
F8C4 E89DFD 641 CALL COUT ; send it
F8C7 E858FD 642 CALL KEYSTAT ; check for keypress
F8CA 3C00 643 CMP AL, 0 ; zero = no keypress
F8CC 74F4 644 JE ; so continue
F8CE E848FD 645 CALL SYNCLOOP ; ignore the keypress
F8D1 C3 646 RET ; and quit
647
F8D2 648 COMPARE: ; COMPARE INPUT FROM CASSETTE WITH MEMORY
F8D2 E89FFE 649 CALL SETUP
F8D5 E89DFD 650 CALL CRLF
F8D8 BE71FB 651 MOV SI, OFFSET COMHEAD ; print header
F8DB E8BAFD 652 CALL PRINTMESS
F8DE E8A4FD 653 CALL BLANK
F8E1 E8C0FF 654 CALL CPROMPT
F8E4 E8B6FF 655 CALL READINIT
F8E7 E8CDFD 656 CALL LENGTHOUT
F8EA 657 COMLOOP:
F8EA E868FD 658 CALL CIN ; get char from cassette
F8ED 3A07 659 CMP AL, M[BX] ; compare with memory
F8EF 7507 660 JNE COMERR ; not equal!! error
F8F1 43 661 COMI: INC BX ; if equal
F8F2 E83EFD 662 CALL CTLCHK ; check for abort
F8F5 E2F3 663 LOOP COMLOOP ; then continue checking
F8F7 C3 664 RET
F8F8 50 665 COMERR: PUSH AX
F8F9 E879FD 666 CALL CRLF
F8FC E872FE 667 CALL OUTBX ; if error output memory address
F8FF E8B3FD 668 CALL BLANK

```

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```

LOC OBJ LINE SOURCE
FC02 BA07 669 MOV AL, M[BX] ; get memory data
FC04 BAF0 670 MOV DH, AL ; save it too
FC06 EBC5FD 671 CALL HEXOUT ; output what's in memory
FC09 E879FD 672 CALL BLANK
FC0C 58 673 POP AX ; restore cassette data
FC0D E8BEFD 674 CALL HEXOUT ; output it
FC10 E872FD 675 CALL BLANK
FC13 32C6 676 XOR AL, DH ; determine bad bits
FC15 E89AFD 677 CALL BINOUT ; and print in binary
FC18 E8D7 678 JMP COMI ; continue
679
FC1A 680 HEXMATH: ; COMPUTE SUM AND DIFFERENCE OF TWO HEX #'S
FC1A E817FE 681 CALL SETUP ; get the numbers
FC1D 53 682 PUSH BX ; save
FC1E 52 683 PUSH DX ; them
FC1F E853FD 684 CALL CRLF
FC22 BEB6FB 685 MOV SI, OFFSET MHEAD
FC25 E870FD 686 CALL PRINTMESS ; print the header
FC28 E84AFD 687 CALL CRLF
FC2B 03DA 688 ADD BX, DX ; sum
FC2D E841FE 689 CALL OUTBX
FC30 E852FD 690 CALL BLANK
FC33 5A 691 POP DX ; restore
FC34 5B 692 POP BX ; numbers
FC35 2BDA 693 SUB BX, DX ; difference
FC37 E837FE 694 CALL OUTDX
FC3A C3 695 RET
696
FC3B 697 NTEST: ; MEMORY TEST
FC3B E8F6FD 698 CALL SETUP ; get start and end
FC3E E808FE 699 CALL CLENGTH ; compute length
FC41 E831FD 700 CALL CRLF
FC44 53 701 MTEST1: PUSH BX
FC45 51 702 PUSH CX
FC46 9A07 703 MTL0OP: MOV AL, M[BX] ; get what's there
FC4B BAE0 704 MOV AH, AL ; save it
FC4A F6D0 705 NOT AL ; complement
FC4C 8807 706 MOV M[BX], AL ; and store it back
FC4E 8A07 707 MOV AL, M[DX] ; read it again
FC50 F6D0 708 NOT AL ; re-complement
FC52 3AC4 709 CMP AL, AH ; is it o.k.?
FC54 750C 710 JNE SHORT TERR ; if not then error
FC56 B827 711 MOV M[BX], AH ; restore previous value
FC5B 43 712 TNEXT: INC BX ; next location
FC59 E8D7FC 713 CALL CTLCHK ; check for abort
FC5C E2E8 714 LOOP MTL0OP ; continue
FC5E 59 715 POP CX
FC5F 5B 716 POP BX
FC60 E8E2 717 JMP MTEST1 ; test forever
718

```

```

FC62 E810FD      719  TERR  CALL  CRLF      , TELL USER ABOUT BAD MEMORY
FC65 E809FE      720  CALL  OUTBX     ; output bad address
FC68 E81AFD      721  CALL  BLANK     ; and a blank
FC6B 32C4        722  XOR   AL, AH    ; tell user which

```

MCS-86 MACRO ASSEMBLER VID88

```

LOC OBJ          LINE  SOURCE
FC6D E85EFD      723  CALL  HEXOUT    ; bits are bad in hex...
FC70 E812FD      724  CALL  BLANK
FC73 E83CFD      725  CALL  BINDOUT   ; and binary
FC76 EBEO        726  JMP   TNEXT     ; continue
727
;
FC78             728  ESUBST:        ; SUBSTITUTE MEMORY WITH HEX DATA
FC78 EBB9FD      729  CALL  SETUP     ; get address
FC78             730  NUSLOOP:
FC78 EBF7FC      731  CALL  CRLF      ; and
FC7E E8F0FD      732  CALL  OUTBX     ; print it
FC81 D90800      733  MOV   CX, 8     ; 8 entries per line
FC84 E8FEFC      734  SLOOP:  CALL  BLANK
FC87 8A07        735  MOV   AL, M[BX] ; get what's there
FC89 EB42FD      736  CALL  HEXOUT    ; and print it
FC8C 50          737  PUSH  AX        ; save it
FC8D B02D        738  MOV   AL, '-'   ; with a prompt
FC8F E84800      739  CALL  VIDOUT
FC92 58          740  POP   AX        ; restore it
FC93 E8C2FD      741  CALL  GETPARMA ; get new data
FC96 EB0890      742  JMP   GTEST     ; check for quit
FC99 8807        743  SNEXT:  MOV   M[BX], AL ; otherwise, put new data in memory
FC9B 43          744  INC   BX        ; and continue
FC9C E2E6        745  LOOP  SLOOP
FC9E EBDB        746  JMP   NUSLOOP
FCA0 80FC20      747  GTEST:  CMP   AH, ' '   ; if blank then
FCA3 74F4        748  JE    SNEXT     ; continue
FCA5 80FC0D      749  CMP   AH, 0DH   ; if carriage return
FCAB 7403        750  JE    G1        ; then we are done
FCAA E9FAFC      751  JMP   ERR       ; otherwise, error!
FCAD 8807        752  G1:    MOV   M[BX], AL ; save that last one!
FCAF C3         753  RET
754
;
FCB0             755  AENTER:        ; ENTER ASCII TEXT IN MEMORY
FCB0 B9FFFF      756  MOV   CX, 0FFFFH ; 64K keypresses
FCB3 EB4AFD      757  CALL  GETPARMA ; get the entry address
FCB6 EBBCFC      758  CALL  CRLF
FCB9 EB30FC      759  ELOOP:  CALL  CONIN
FCBC 3C04        760  CMP   AL, 0     ; done?
FCBE 7405        761  JE    EEXIT     ; YES
FCC0 8807        762  MOV   M[BX], AL ; NO . put data in memory
FCC2 43          763  INC   BX
FCC3 EBF4        764  JMP   ELOOP
FCC5 EBADFC      765  EEXIT:  CALL  CRLF
FCCB B040        766  MOV   AL, ' '
FCCA EB0D00      767  CALL  VIDOUT
FCCD E8A1FD      768  CALL  OUTBX     ; output the ending address
FCD0 C3         769  RET
770
;
FCD1             771  KTOGGLE:        ; TOGGLE THE UPPER/LOWER CASE FLAG
FCD1 A052F4      772  MOV   AL, BYTE PTR M[UCFLAG] ; get the flag
FCD4 F6D0        773  NOT   AL        ; toggle
FCD6 A252F4      774  MOV   BYTE PTR M[UCFLAG], AL ; put flag back
FCD9 C3         775  RET
776
;

```

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```

LOC OBJ          LINE  SOURCE
777 +1  $EJECT

```

MCS-86 MACRO ASSEMBLER VID88

```

LOC OBJ          LINE  SOURCE
778  ;
779  ;
780  ;
781  ;
782  ; *****
783  ; *           V I D E O   D R I V E R           *
784  ; *

```

Listing 1 continued on page 358

Listing 1 continued:

```

785 ; *
786 ; *          DRIVES TDL VDB VIDEO INTERFALIF *
787 ; *
788 ; *          converted from BOBO Assembler with CONV-B6 *
789 ; *
790 ; *****
791 ;
792 ;
793 ;          VIDEO DRIVER
794 ;
FCDA 50      795  VIDEOOUT: PUSH    AX
FCDB 56      796          PUSH    SI
FCDC 57      797          PUSH    DI
FCDD E80400  798          CALL    VIDEO
FCE0 5F      799          POP     DI
FCE1 5E      800          POP     SI
FCE2 58      801          POP     AX
FCE3 C3      802          RET
803 ;
804 ;***** CONVERTED CODE BEGINS HERE *****
805 ;
806 ; VDB DRIVER
00E1 807  VD      EQU     OE1H
00E0 808  VC      EQU     OE0H
00E0 809  XRD     EQU     OE0H
00E1 810  YRD     EQU     OE1H
00C0 811  YWR     EQU     OCOH
00E2 812  MRD     EQU     OE2H
0080 813  MWR     EQU     80H
0088 814  VMODE   EQU     88H
0098 815  BMODE   EQU     98H
816 ;
817 ;
FCE4 53      818  VIDEO.  PUSH    BX
FCE5 8B1E50F4 819          MOV     BX,WORD PTR M[XY],
FCE9 247F     820          AND     AL,7FH
FCEB 7403     821          JZ     SHORT L_2
FCED E80600  822          CALL   VOUT
FCF0 823  L_2:
FCF0 891E50F4 824          MOV     WORD PTR M[XY],BX
FCF4 5B      825          POP     BX
FCF5 C3      826          RET
827 ;
FCF6 3C20     828  VOUT.  CMP     AL,20H
FCF8 7303     829          JAE    SHORT L_3
FCFA E87490  830          JMP     CNTL
FCFD 831  L_3:

```

MCS-86 MACRO ASSEMBLER VIDB8

LOC	DBJ	LINE	SOURCE
FCFD	3C7F	832	CMP AL,7FH
FCFF	7501	833	JNZ SHORT L_4
FD01	C3	834	RET
FD02		835	L_4:
FD02	E6E1	836	OUT VD,AL
FD04	FECF	837	DEC BH
FD06	7401	838	JZ SHORT L_5
FD08	C3	839	RET
FD09		840	L_5:
FD09	8750	841	MOV BH,80
FD0B	FECB	842	DEC BH
FD0D	7401	843	JZ SHORT L_6
FD0F	C3	844	RET
FD10		845	L_6:
FD10	FEC3	846	VQ2: INC DL
FD12	53	847	;
FD12	53	848	SCROLL: PUSH BX
FD13	52	849	PUSH DX
FD14	51	850	PUSH CX
FD15	8098	851	MOV AL,BMODE
FD17	E6E0	852	OUT VC,AL
FD19	32C0	853	XOR AL,AL
FD1B	E6E0	854	OUT VC,AL
FD1D	8A50C1	855	MOV DX,0C150H
FD20	8AC6	856	MOV AL,DH
FD22	E6E0	857	OUT VC,AL
FD24	BAEA	858	MOV CH,DL
FD26	8B00F4	859	MOV BX,VIDBUF
FD29	E4E1	860	L1: IN AL,VD
FD2B	8B07	861	MOV M[BX],AL
FD2D	9F	862	LAHF
FD2E	43	863	INC BX
FD2F	9E	864	SAHF
FD30	FECB	865	DEC CH
FD32	75F5	866	JNZ L1
FD34	8AC6	867	MOV AL,DI

FD36	FECB	868	DEC	AL
FD3B	E6E0	869	OUT	VC, AL
FD3A	B800F4	870	MOV	BX, VIDBUF
FD3D	BAEA	871	MOV	CH, DL
FD3F	8A07	872	MOV	AL, MI BX1
FD41	E6E1	873	OUT	VD, AL
FD43	9F	874	LAHF	
FD44	43	875	INC	BX
FD45	9E	876	SAHF	
FD46	FECB	877	DEC	CH
FD4B	75F3	878	JNZ	L2
FD4A	FEC6	879	INC	BH
FD4C	8AC6	880	MOV	AL, BH
FD4E	3CD9	881	CMP	AL, 0B9H
FD30	72D0	882	JB	S1
FD52	BAEA	883	MOV	CH, DL
FD54	B020	884	MOV	AL, 20H
FD56	E6E1	885	OUT	VD, AL

MCS-86 MACRO ASSEMBLER

VID88

LOC	OBJ	LINE	SOURCE	
FD5B	FECB	886	DEC	CH
FD5A	75FA	887	JNZ	S2
FD5C	59	888	POP	CX
FD5D	5A	889	POP	DX
FD5E	5B	890	POP	BX
FD5F	B088	891	SETCAV	MOV AL, VMODE
FD61	E6E0	892	OUT	VC, AL
FD63	B050	893	SETCUR	MOV AL, B0
FD65	2AC7	894	SUB	AL, BH
FD67	E6E0	895	OUT	VC, AL
FD69	80D9	896	MOV	AL, 25+0C0H
FD6B	2AC3	897	SUB	AL, BL
FD6D	E6E0	898	OUT	VC, AL
FD6F	C3	899	RET	
		900		
FD70	3C0D	901		
FD72	7422	902	CNTL:	CMP AL, CR
FD74	3C0A	903		SHORT CCR
FD76	7415	904		AL, I F
FD7B	3C0C	905		SHORT CLF
FD7A	741E	906		AL, FF
FD7C	3C0B	907		SHORT CHF
FD7E	7401	908		AL, B3
FDB0	C3	909		SHORT CBS
FDB1	B04F	910	CDS:	MOV AL, 79
FDB3	2AC7	911		SUB AL, BH
FDB5	7901	912		JNS SHORT L_0
FDB7	C3	913		RET
FDB8		914	L_0:	
FDBB	E6E0	915		OUT VC, AL
FDBA	FEC7	916		INC BH
FDBC	C3	917		RET
FDBD	FECB	918	CLF:	DEC BL
FDBF	7503	919		JNZ SHORT L_7
FD91	E97CFF	920		JMP VD2
FD94		921	L_7:	
FD94	EBCD	922		JMP SETCUR
FD96	B750	923	CCR:	MOV BH, B0
FD9B	EBC9	924		JMP SETCUR
FD9A	B098	925	CFE:	MOV AL, BMODE
FD9C	E6E0	926		OUT VC, AL
FD9E	B8D007	927		MOV BX, 25*B0
FDA1	32C0	928	CFE1:	XOR AL, AL
FDA3	E6E1	929		OUT VD, AL
FDA5	9F	930		LAHF
FDA6	4B	931		DEC BX
FDA7	9E	932		SAHF
FDA8	BAC7	933		MOV AL, BH
FDA9	OAC3	934		OR AL, BL
FDAE	75F3	935		JNZ CFF1
FDAE	B01950	936		MOV BX, 256*B0+25
FDB1	EBAC	937		JMP SETCAV
		938		
----		939	ABS_0	ENDS

MCS-86 MACRO ASSEMBLER

VID88

LOC	OBJ	LINE	SOURCE	END	INIT
F80F		940			

ASSEMBLY COMPLETE. NO ERRORS FOUND

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Text continued from page 347.

followed by a RET (return) statement. Then replace:

```
F8DE DW ERR
```

with

```
F8DE DW TESTMEM
```

### Notes on Performance

How does the 8088 stack up in performance versus the popular 8-bit processors of the 1970s? To answer this question, we must develop at least a rough definition of what we mean by performance.

To evaluate performance I use three criteria:

- the execution speed for a set of applications,
- the amount of memory required to implement the applications, and
- the amount of software-development effort required for application implementation (as measured by lines of assembly-language code).

An appropriate set of applications will include a mix of mathematics, data-handling and process-control-type programs. In addition, both execution-bound (eg: heavy calculation) and bus-bound (eg: bubble sort) applications should be included.

This article is not meant to be a full-fledged benchmark report. Nevertheless, using my own background, manufacturer's documentation, and other sources, I have come to the following conclusions concerning the 5 MHz 8088, which on the average:

- is 1.5 to 5 times faster than the *fastest* versions of other popular 8-bit machines (ie: Z80B, 68B09, 6800, 8080A, etc),
- will typically require only 50% to 75% of the memory devoted to code by these other machines for a set of applications, and
- requires substantially less (as little as 50% or less) lines of code to implement a benchmark than these other machines.

Execution speed is the most visible measure of performance. Factors which contribute to the 8088's superiority are:

- *The high standard clock rate:* The standard 8088 runs at 5 MHz (in fact, possibly faster if you're willing to experiment). Intel claims that, next year, specially selected 8 MHz 8088s will be available. If 5 MHz 8088s are fast, 8 MHz 8088s will be *unreal*.
- *The pipelined architecture:* This architecture allows overlapped instruction fetch and execution, eliminating a traditional performance limitation present in other 8-bit machines.
- *The 16-bit internal data paths:* These enhance data movement and manipulation capability.
- *Its rich set of arithmetic instructions:* Math-oriented applications are served exceptionally well by the 8088. The 5 MHz 8088 can do most 16-bit integer math (add, subtract, multiply, divide) faster than a 9511 hardware math chip.

● *Powerful addressing modes:* The 8088 allows up to four address components to be used in calculating an absolute physical memory address. In addition, most instructions can operate *directly on a memory location*, eliminating the traditional accumulator bottleneck found in other machines.

The amount of memory required can have significant cost ramifications for an application. Here again, the 16-bit internal organization and powerful addressing modes of the 8088 reduce memory requirements. In extreme cases (heavily word- or math-oriented) the 8088 can implement applications in as little as 20% to 30% of the memory of other 8-bit machines.

The number of lines of code required to implement an application becomes more and more of an issue each day. For instance, the Department of Defense states that one line of debugged, documented code now costs close to \$60. Programming costs continue to rise, while productivity remains relatively fixed. This suggests a real "software crisis" in the 1980s.

The 8088 can require as little as 50% (average perhaps 75%) of the lines of code as compared to other 8-bit machines. This is because one assembly-language instruction can generate up to 6 bytes of code, and the instructions implemented are very powerful relative to other popular microprocessors.

A summary chart of my findings is shown in figure 3. The relative performance of the 8088 (5 MHz), 6809 (2 MHz) and Z80A (4 MHz) are shown, with an 8086 (true 16-bit machine) thrown in for reference. A differentiation between *word-* or *bus-*oriented and *byte-* or *execution-*oriented applications must be made here. Note that the bus-oriented versus execution-oriented differentiation does not apply to nonpipelined machines like the Z80A or 6809. The byte-orientation versus word-orientation differentiation *does* affect the performance of these machines.

Full-speed memories are assumed as shown below:

	Processor	Access Time (approximately)
5 MHz	8088, 8086	480 ns
2 MHz	6809	320 ns
4 MHz	Z80A	250 ns

As shown above, the 8088 can function at maximum speed but still use slower memory than the other microprocessors. In many cases (especially EPROMs), slower-memory-speed selected parts have much lower prices than faster selections.

Essentially, the 8088 has from 1.5 to 2.5 times the performance of the fastest 8-bit competition. Of course, the performance improvement over older 8-bit processors (ie: 6800s, 8080As, etc) is even higher.

### Finale

In the text box on pages 344 thru 346 you will find a full description of each MON88 command. A complete listing of the monitor program is given in listing 1.

The 8088 is not only the highest performance 8-bit processor available, but represents a "bridge" to the new architectures of the 1980s. I hope that you have found the 8088 project as challenging, educating and rewarding as I have. Welcome to the future! ■

# Add Macro Expansion to Your Microcomputer

## Part 2

---

David C Brown  
1704 Manor Rd  
Havertown PA 19083

---

Last month, I discussed the definition and use of the macro instruction and detailed a set of requirements for a macro processor. Part 1 also gave an overview in the form of text and flowcharts of how this macro processor would operate. Figures 1 thru 11 provide a more detailed flowchart of these processes and roughly correspond to the overview flowcharts in figure 1 of Part 1 of this article (October 1980 BYTE, page 162). Frequent reference should be made back to these overview flowcharts when reading the detailed flowcharts of figures 1 thru 11. A glossary of terms appears on page 371.

This completes the explanation of the macro definition and expansion. In the rest of the article I will discuss the interface of the macro processor to an assembler, as well as possible enhancements.

### Alternate Implementation Approaches

The last hurdle to clear is how to tie this macro facility into your assembler. Basically, there are two ways this can be done, *preprocessor* or *in-line*. The approach used depends upon your situation.

The simplest way to use your macro processor is as a preprocessor. This can be done in two ways. In the first way, the macro processor is a separate program, reading your source program and writing an output file of expanded code to cassette, paper tape, floppy disk, etc; it is this output file that is read into the assembler instead of the original source. While this is the easiest way to use the preprocessor, it is also the worst from the viewpoint of efficiency, requiring an intermediate file and a longer run time. However, if you cannot modify the assembler itself, this may be the only approach you can take.

A second, more efficient, preprocessor approach is to locate the read routine in the assembler and replace it

*Listing 1: Example of keyword parameters. A change that can be made in the macro assembler involves the use of keyword parameters. These allow the user to specify variable symbol values in any order or by default. The macro definition for MOVE is given in listing 1a; two examples of a macro call and its resulting code are given in listings 1b and 1c. In listing 1b, both &TO and &FROM are assigned the default values given in the prototype statement of the macro definition. In listing 1c, the value for &FROM is specified by default. Note the absence of the ampersand in naming variable symbols within the macro call.*

```
(1a)
1.      MACRO
2.  &JUMP MOVE  &TO = FIELDB,&FROM = FIELD A,&LENGTH =
3.      LXI    B,&TO
4.      LXI    D,&FROM
5.      MVI    H,&LENGTH
6.  &JUMP LDAX  D
7.      STAX  B
8.      INX  B
9.      INX  D
10.     DCR  H
11.     INZ  &JUMP
12.     MEND

(1b) LOOP  MOVE  LENGTH = 10

        LXI    B, FIELDB
        LXI    D, FIELD A
        MVI    H, 10
LOOP    LDAX  D
        STAX  B
        INX  B
        INX  D
        DCR  H
        INZ  LOOP

(1c) LOOP  MOVE  LENGTH = 9, TO = NEW

        LXI    B, NEW
        LXI    D, FIELD A
        MVI    H, 9
LOOP    LDAX  D
        STAX  B
        INX  B
        INX  D
        DCR  H
        INZ  LOOP
```

with a call to the macro processor. This is the direction taken in my flowcharts since it is a compromise between a separate program and making major revisions to the assembler.

Replacing the read routine is not as easy as it sounds, however. Microprocessor assemblers typically use character assembly rather than line assembly. They read the source statement one character at a time and process each character as it is read rather than reading an entire source statement and having the whole statement available to work on. My flowcharts are designed for line assembly in that a model statement is completely expanded before it is passed to the assembler.

If your assembler uses character-assembly processing, it will call the macro processor for each character. This will require the read routine to expand the model statement on the first call and pass it one character at a time to the assembler on successive calls until it is completely transferred, at which point the read routine will expand the next model statement. You can also modify the model-expansion routines to pass the statement a character at a time directly from the expansion routines, but this is a little more difficult.

The worst drawback of either preprocessor approach is that every operation code is looked up twice, once by the macro processor to check for macro calls and once by the normal assembler. This is quite time-consuming. Perhaps the most efficient way to incorporate macro processing is to put the macro processing in-line with the assembler's operation-code-lookup and read routines. This requires

*Text continued on page 366*

The worst drawback of the preprocessor approach is that every operation code is looked up twice.

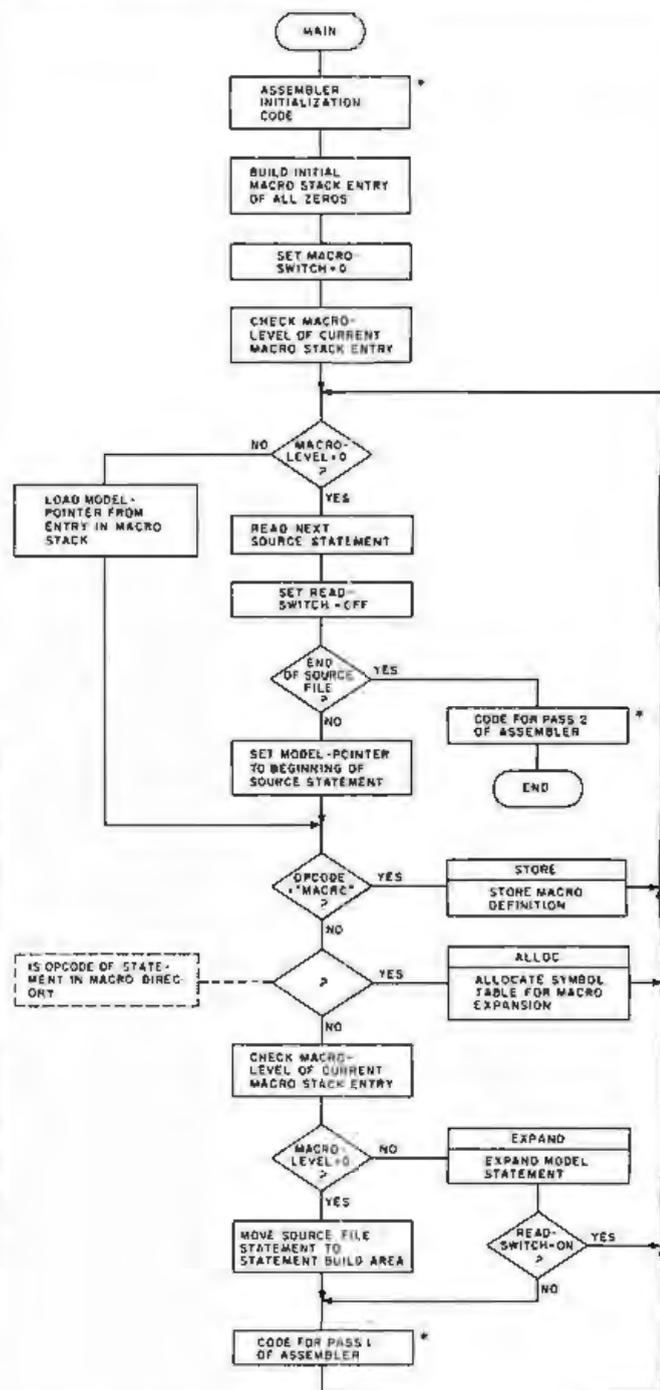


Figure 1: Overview flowchart for macro definition and expansion. This flowchart, MAIN, takes an assembly-language file containing both macro definitions and macro calls, stores the definitions, expands macro calls, and completes the work of a regular assembler. The boxes marked with asterisks represent the code that performs the assembler functions; the remaining boxes represent the code that is added through modification of the assembler's "read source" routine to implement the macro facility. Refer to the flowcharts in figures 2 thru 11 on pages 363 thru 370.

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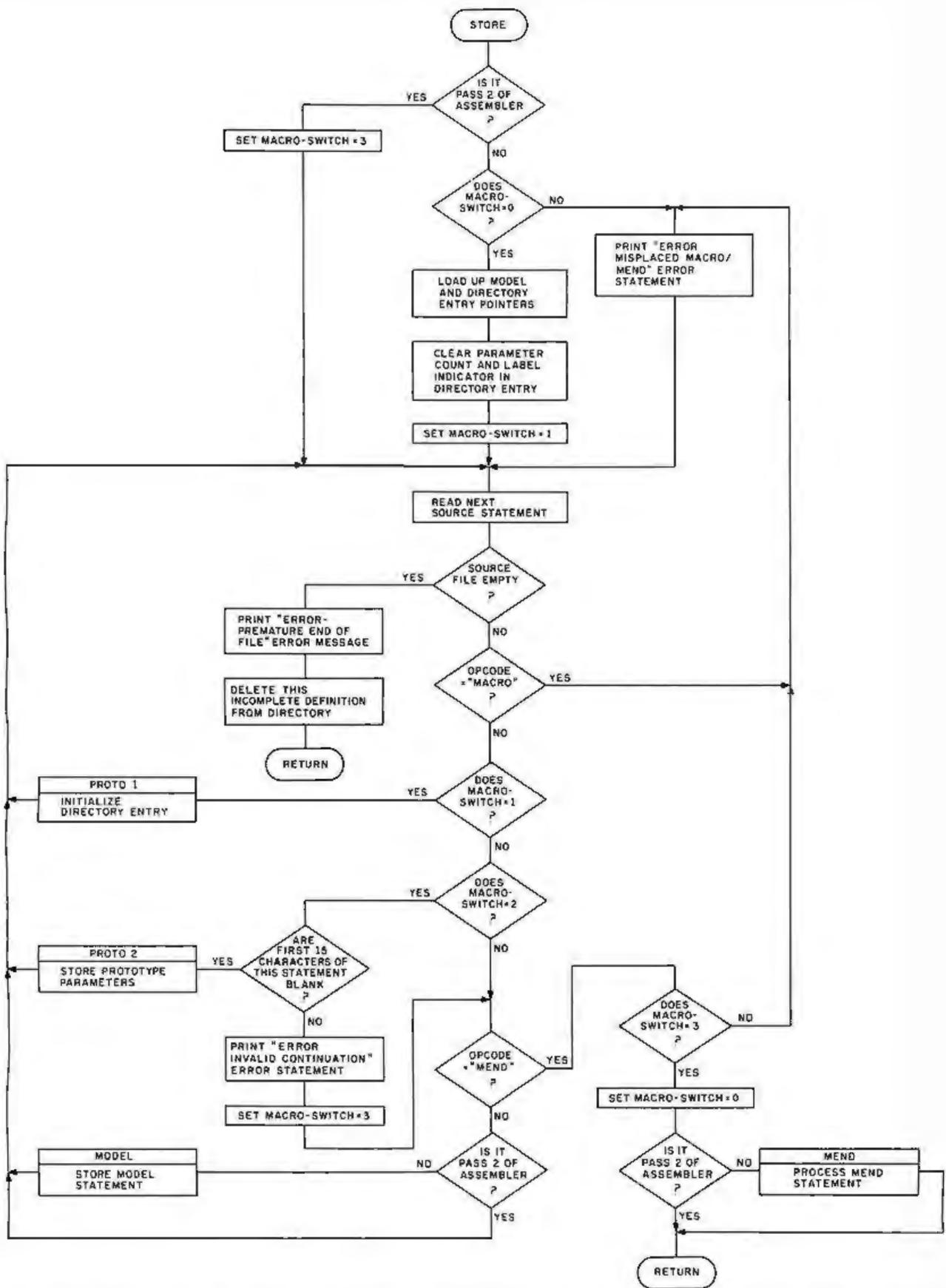
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**Figure 2:** Flowchart for STORE subroutine. This subroutine stores an entire macro definition within the macro-definition storage area. MACRO-SWITCH is a flag that tells the program what kind of line the routine is expecting next. MACRO-SWITCH=0 means that the computer is ready to process a new macro definition. MACRO-SWITCH=1 means that the computer has found a MACRO statement and is looking for the prototype statement. MACRO-SWITCH=2 means that the computer is ready to process the second line of the prototype statement, if there is one. MACRO-SWITCH=3 means the computer is ready to process the body of the macro definition.

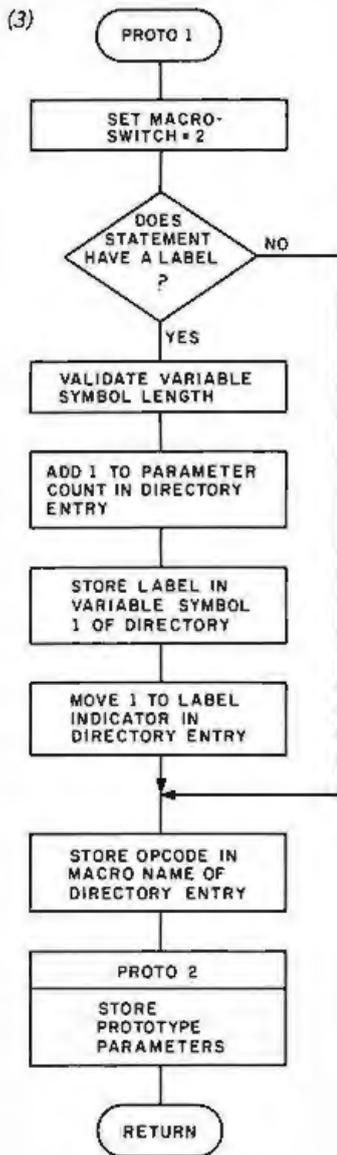
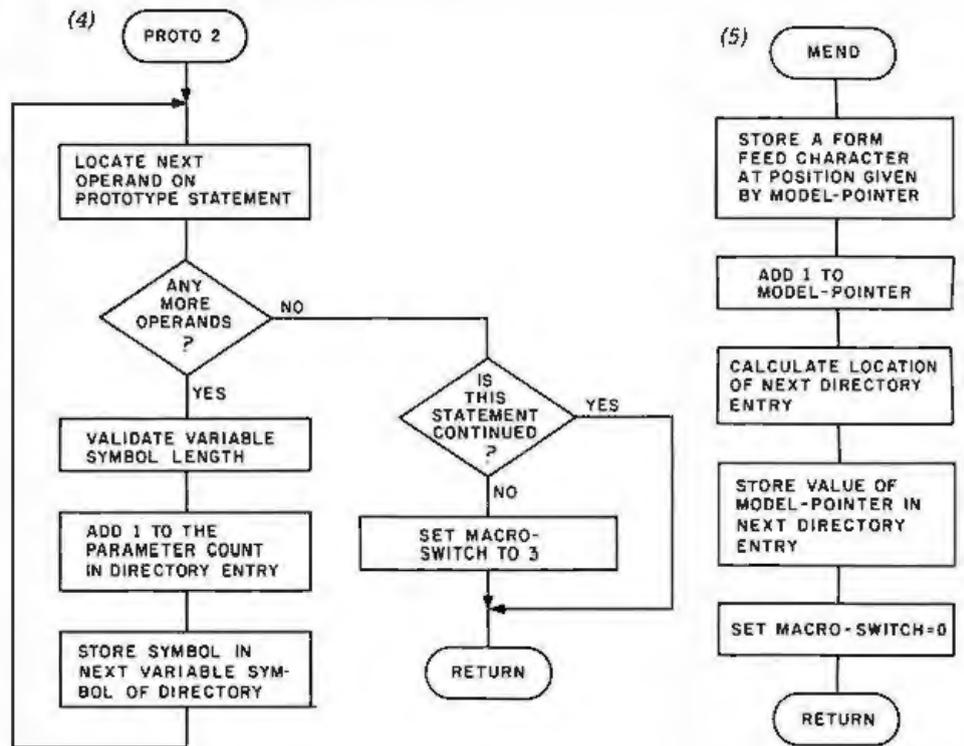


Figure 3: Flowchart for PROTO1 subroutine. This subroutine stores the prototype label, if any, the macro name, and calls PROTO2 to store the prototype variable symbols.

Figure 4: Flowchart for PROTO2 subroutine. This subroutine stores the variable symbols of a macro prototype statement in the directory.

Figure 5: Flowchart for MEND subroutine. This subroutine does several housekeeping chores associated with ending a macro definition.



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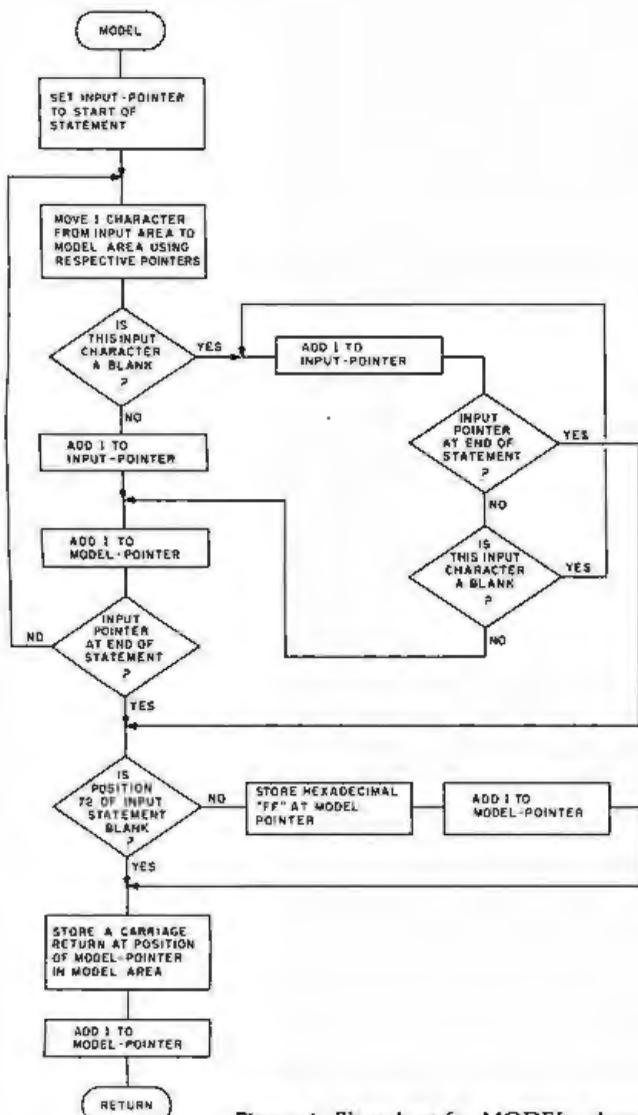


Figure 6: Flowchart for MODEL subroutine. This subroutine stores one model statement of a macro definition in the macro-storage area.

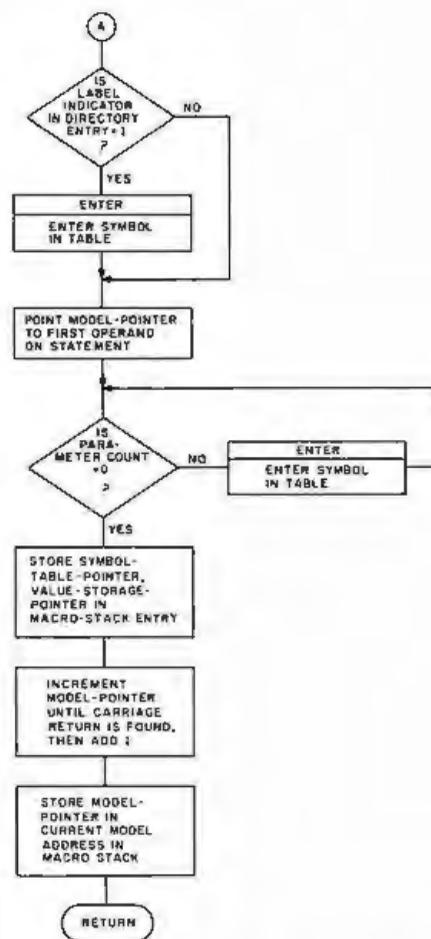
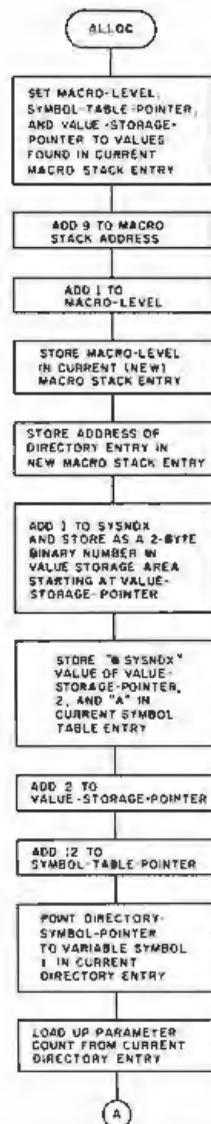


Figure 7: Flowchart for ALLOC subroutine. This subroutine is called when a macro call is found in the body of the assembly-language program; it sets up pointers in the macro stack and symbol table to identify the current values of the variable symbols as defined in the macro call.

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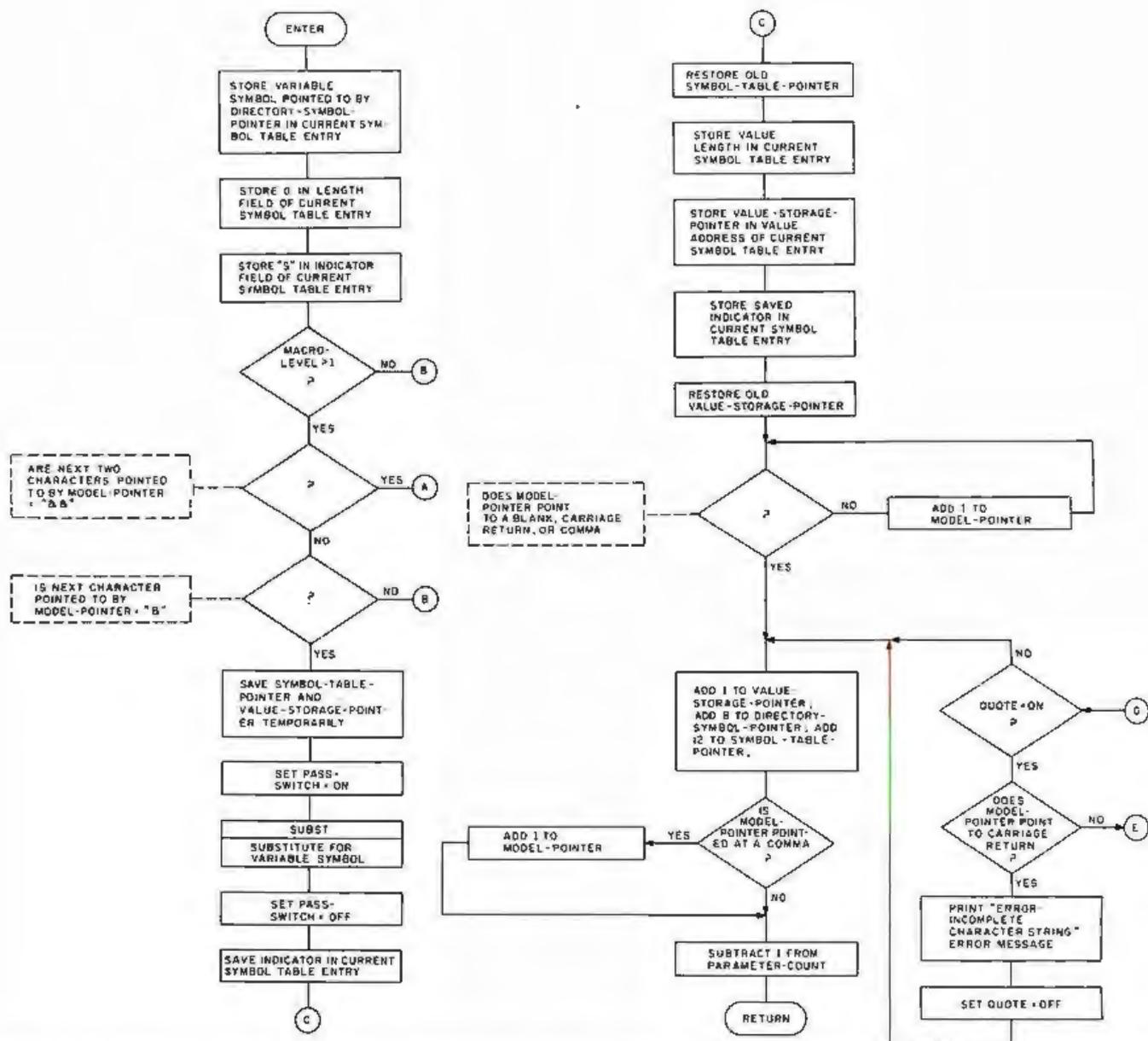


Figure 8: Flowchart for ENTER subroutine. This subroutine, called by ALLOC, stores the current value of a variable symbol in the symbol table.

Text continued from page 362:

source listings for your assembler and enough courage on your part to modify your assembler. The operation-code-lookup routine must be modified to first check for the identifier MACRO, at which point it stores the definition. If the operation code is not MACRO and is not found in the assembler's operation-code table, the assembler must then look it up in the macro directory and expand it if found.

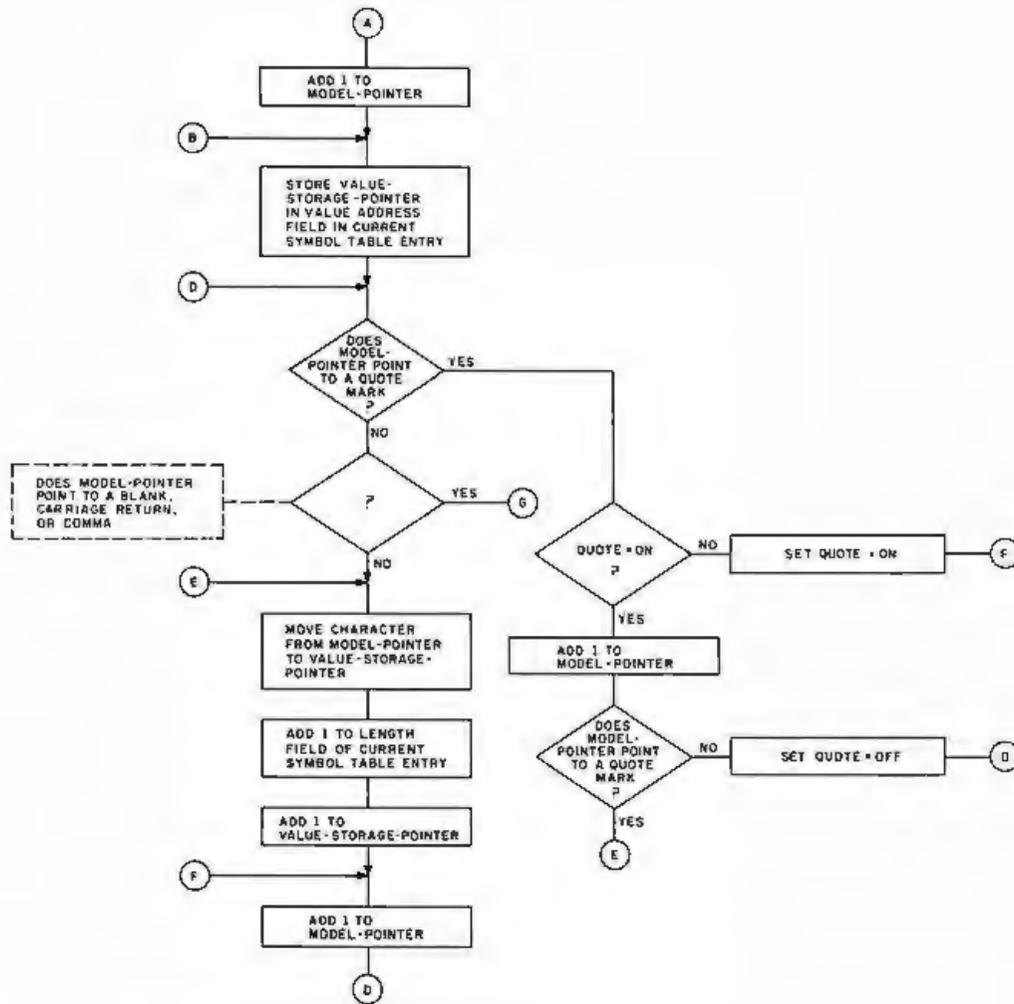
In using this in-line approach, you also have to modify the read routines to make use of the macro-level counter, as is done at the beginning of the flowchart in figure 5. This approach, more ambitious than the others, is the best, and it should be taken if you have the assembler source and can take the time. It will result in an efficient, well-integrated assembler, rather than a patchwork creation. However, if this route cannot be taken, the power of macro facilities is probably worth the inefficiency of the preprocessor technique.

## Extensions

If you are really ambitious, there are several other facilities that you can implement. Many of these facilities require modifications to the assembler as well as to the macro processor; but if you are still reading at this point, maybe you feel up to the task.

A large improvement can still be made in print facilities. As detailed so far, the macro call itself never gets to the assembler for printing so that you do not know from looking at the intermediate source listing which statements are generated by the macro assembler and which are in the original source. Ideally, the macro call should print and all generated statements should be identified as such. One solution is to print the macro-level indicator, since this shows the level of nesting when nested macro calls are used. You can also add an assembler directive that tells the assembler whether or not to print the generated statements.

Another facility that you can implement is conditional



assembly, which was mentioned in Part 1 of this article. This would go along with the ability to define local variable symbols within the body of the macro definition; these local variable symbols would be used for loop control and arithmetic within the macro definition.

Another possible modification is the addition of global symbols and a global symbol table. This would allow you to pass variable symbols from one macro expansion to another. When a global symbol is encountered, you look it up in the global symbol table to get its value. If it is not found there, it is added to the global symbol table. This global table does not have its entries deleted at the end of the macro generation, so the information put there is still present whenever the next macro call is processed.

The method for handling variable symbols and their values detailed in this article is known as *positional parameters*. This means that the first variable symbol on the prototype assumes the first value on the macro call, the second variable symbol assumes the second operand value, and so on. A more flexible method is *keyword parameters*. With keyword parameters, the macro prototype might look like this:

```
&LABEL MOVE &FROM=FIELD A,
          &TO=FIELD B,&LENGTH=
```

The macro call would then be coded:

```
LOOP2 MOVE LENGTH=14, FROM=FIELD C
```

Keyword operands are distinguished by an equals sign and have several interesting properties. As shown in listing 1a, the `&FROM=` and `&TO=` variable symbols in the prototype specify a default value—`FIELD A` and `FIELD B`, respectively. If the `FROM` and `TO` operands are omitted on the macro call, the defaults are used as in listing 1b; otherwise, the value from the macro call is used, as in listing 1c. The `&LENGTH=` parameter on the prototype has no default, so it must be specified on the macro call. Also, since you specify the keywords on the macro call, they do not have to be in the same order as specified on the prototype. Otherwise, the keywords are used in the macro-definition statements just like the positional parameters I have been discussing.

Keyword processing requires a more complicated loading of the symbol table when the macro call is encountered; it also requires modifications to the routine that stores the macro definition, since the defaults will have to be stored in the value-storage area and the directory entries will have to be modified to point to the default values. It is a lot of work, but it is much more flexible.

These are just some of the enhancements you can implement. If you have access to the IBM Assembler Language manual (referenced at the end of this article), you will find that it gives much more detailed explanations of these facilities, plus others that I have not mentioned.

To those of you who are still interested, study of the text and flowcharts of this article is all you need do before you can write your own macro assembler. Once you understand the processes involved ("walking through" the flowcharts with pencil and paper will help), there is no reason why you cannot give it a try. After all, there's no magic to system software—it's just another program. ■

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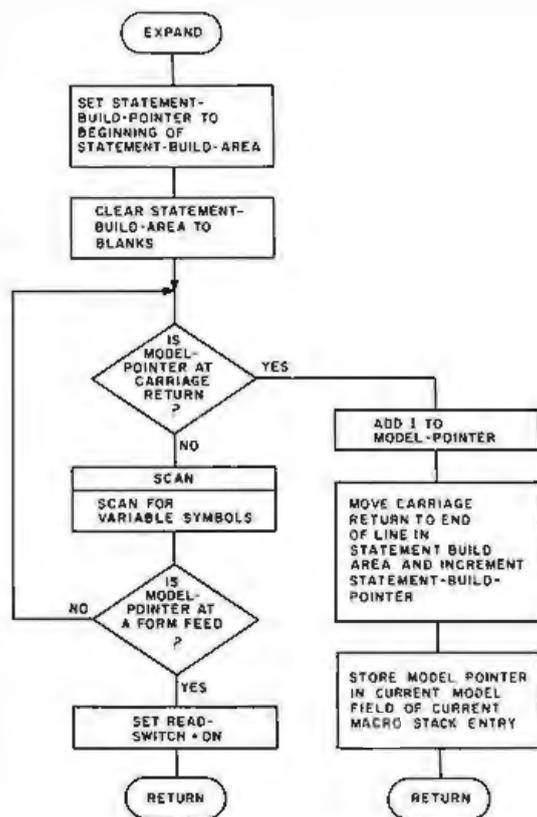


Figure 9: Flowchart for EXPAND subroutine. This subroutine expands a model statement using the current values of the variable symbols as found on top of the symbol table.

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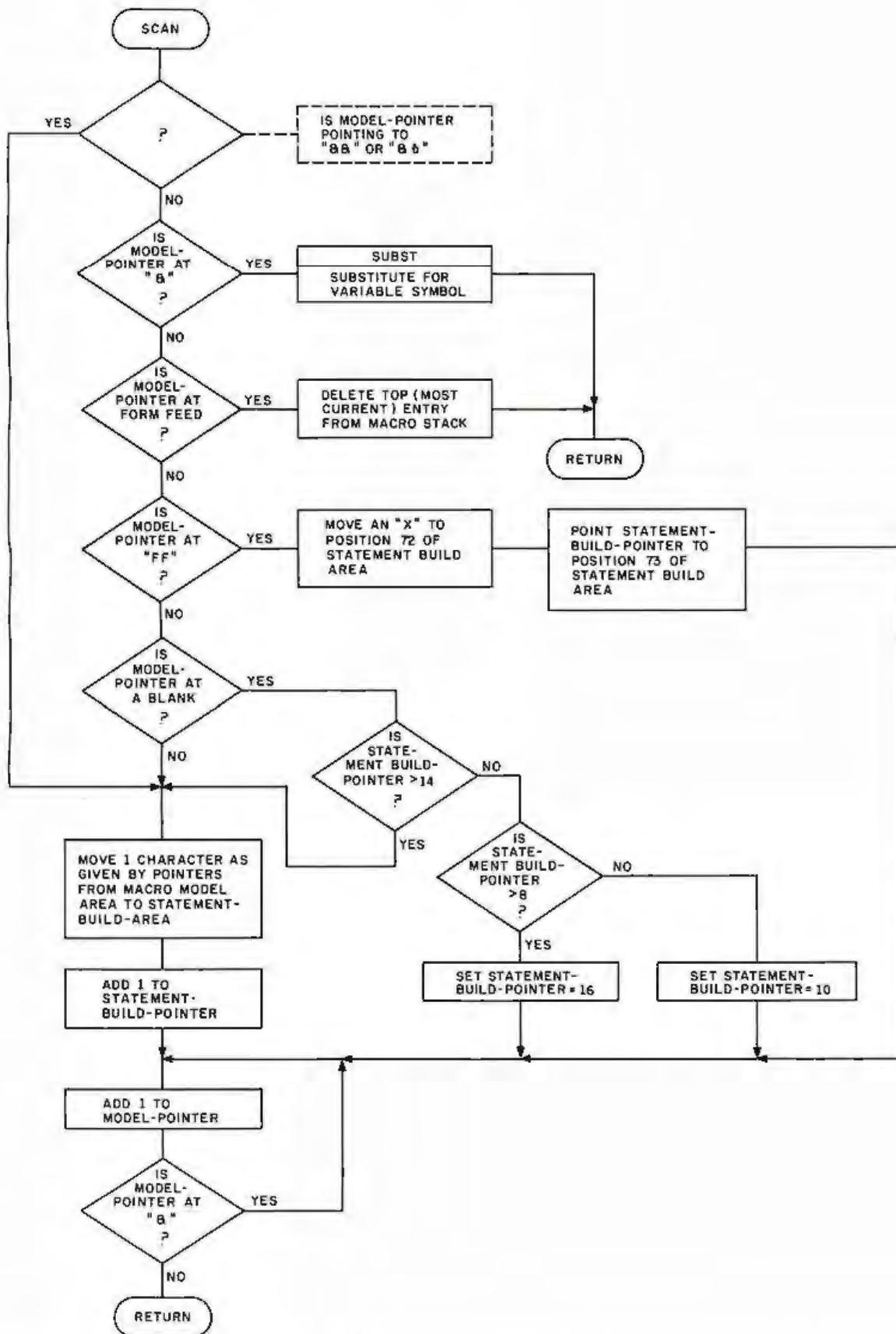


Figure 10: Flowchart for SCAN subroutine. This subroutine scans for variable symbols in the model statement and replaces them with their most recent values; it also restores blanks that were compressed out of the model statement.

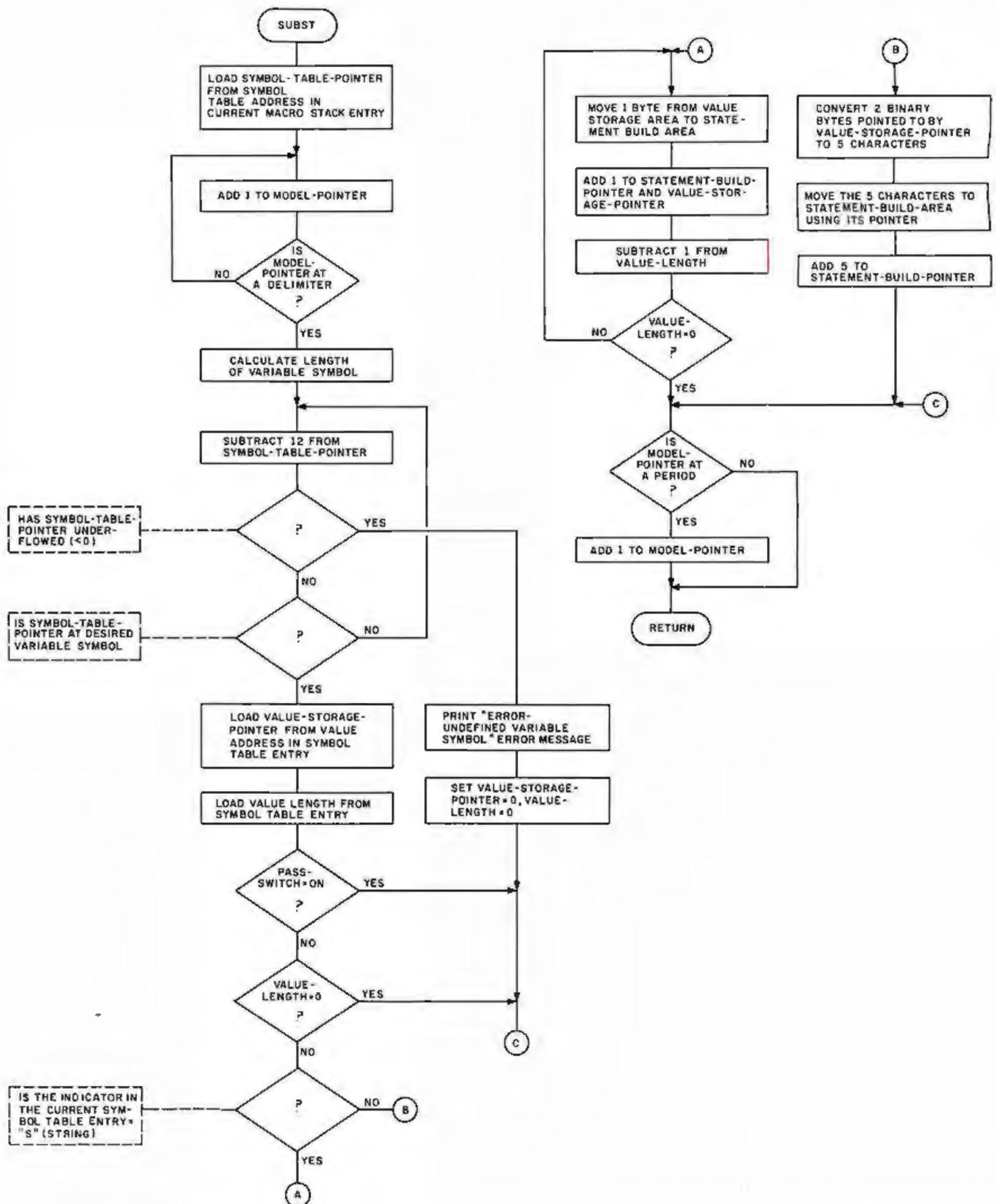


Figure 11: Flowchart for SUBST subroutine. This subroutine, called by SCAN, substitutes the appropriate value for its corresponding variable symbol in a model statement.

## GLOSSARY

**Conditional Assembly:** a feature of macro assemblers that instructs the assembler to generate or leave out certain lines of assembly-language code based on a given condition evaluated at the time of expansion.

**Descriptor:** useful when working with strings of characters. It is a fixed-length entry containing the length of the string and a pointer to where the string starts in the storage area. (Symbol-table entries can be considered descriptors.) Descriptors are used frequently in assemblers and in high-level language compilers.

**Directory:** it contains an entry for every macro defined, pointing to the start of the model statements and specifying the variable names (from the macro prototype) that must be entered into the symbol table before the macro is evaluated.

**Global Variable:** a variable whose value is in effect for the entire assembly and for every macro generation. Use of a given global variable name, even within different macros, refers to the same value (unlike local variable symbols, the values of which are lost at the end of the macro expansion). In this article, &SYSNDX is a global variable.

**Inner Macro:** a macro call specified within the model statements of another macro. When a macro referred to as the outer macro is generating statements and encounters an inner macro, it must stop, generate the statements from the inner macro call, add them to the statements belonging to the outer macro, then continue generating its own statements.

**Keyword Operand:** a variable symbol followed by an equals sign; it appears only on the macro prototype and the macro call. Unlike positional parameters, keyword operands can be coded in any order. They also allow the ability to specify default values in the macro prototype.

**Local Variable:** a variable, the value of which is in effect only for the macro in which it is defined. All variable symbols defined in macro prototype statements are local variables. The same local variable symbol name used in another macro is treated as a separate variable, even though the names are the same.

**Macro:** a user-defined assembly-language operation code that generates one or more assembler instructions.

**Macro Call:** a pseudoinstruction within an assembly-language program that refers to a macro definition of the same name. The eventual result is the replacement of the macro call statement with the expanded model statements of the macro definition.

**Macro Definition:** a sequence of statements that tell the macro processor what to generate when replacing the macro-call instruction. It is made up of a MACRO statement that signals the beginning of the macro, a prototype statement that defines the macro name and its operands, a series of model statements that replace the macro call, and a MEND statement that signals the end of the macro definition.

**Macro Stack:** a stack of certain information about currently incompleting macro calls; it is necessitated by the ability to call a macro within a macro. Each macro-stack entry points to the directory entry, the end of the symbol table, and the value-storage area for the macro.

**Model-Storage Area:** an area of computer memory set aside for storing the model statements of all macro definitions. The directory entry for each macro points to the start of that macro's model statements in the model-storage area.

**Pass 1:** the assembler's first reading of source statements. During pass 1, the assembler builds its symbol table, which includes every label in the program, and checks for duplicate symbols.

**Pass 2:** the assembler's second reading of the source statements. At this point, all symbols are known to the assembler as a result of pass 1, and the equivalent machine code can be generated from the source code.

**Positional Operands:** when the variable symbols in a macro prototype are defined as positional operands, they are assigned values from the list of operands in the macro-call statement in the order that they are defined in the prototype. The first variable symbol on the prototype gets the first operand value, and so on.

**Preprocessor:** a routine or program that processes and usually modifies the input before the main program gets it. Macro facilities are often written as preprocessors that replace macro calls with their expanded assembly-language statements before passing the source file to the assembler.

**Prototype:** the second statement in the macro definition. It defines the label entry, the operation code (macro name), and the allowable operands (in the form of variable symbols) for the macro call.

**Recursion:** a technique in which a called subroutine calls itself. A recursive function must be designed so that it eventually returns a value rather than calling itself again; otherwise, it calls itself in a loop that never finishes.

**Stack:** a last-in, first-out list that allows the user to remove only the value most recently placed onto the stack. Stacks are similar to the devices used to dispense plates in a cafeteria. Plates (values) are put on the top of the stack, pushing down all the others, and are removed from the top, causing the others to pop up. A stack in programming works the same way, giving rise to the terms PUSH and POP, which are commonly used when talking about computer stacks.

**Symbol Table:** a stack containing an entry for each variable in the macro prototype. The symbol-table entry specifies the variable name, the length of its current value, and the address where the value is stored in the value-storage area.

**Text Compression:** the process of removing all unnecessary blanks from a source statement in order to reduce the amount of space needed to store the text.

**Value-Storage Area:** an area of memory set aside for storing the values associated with a program's variables. The symbol-table entry for each variable points to the start of that variable's value and specifies the value length.

**Variable:** a variable (or variable symbol) is a character string that can have many different values assigned to it by either the programmer or the assembler. Variables can be either global or local; most references to variable symbols in this article actually refer to local variable symbols.

# What's New?

## PERIPHERALS



### Floppy-Disk Drive for the HP-85

The HP 82900 Series floppy-disk drives read double-sided, double-density, 5-inch floppy disks, and can be configured to provide from 279 K bytes to 1.08 megabytes of storage. The interface between the HP-85 and the disk drives is the HP-85 Mass Storage ROM (read-only memory). The ROM makes

available thirty additional BASIC commands including a Translate command, which upgrades written tape-based programs for use on the drives; the ability to store and retrieve the graphics display on the video screen; automatic default to the drive; and volume labeling, allowing users to refer to disks by name

and write programs independent of drive addresses. Prices for the floppy-disk drives start at \$1500 for a single-master drive and go to \$2500 for a dual-master drive. Contact the Inquiries Manager, Hewlett-Packard Co, 1507 Page Mill Rd, Palo Alto CA 94304.

Circle 662 on inquiry card.

### Seven Spinwriter Thimble Fonts from NEC

NEC Information Systems Inc, 5 Militia Dr, Lexington MA 01273, (617) 862-3120, has introduced Pica 10 Multilingual, Elite 12 Multilingual, British Elite 12, Greek/Times Roman, Scientific Times Roman, Super Courier/Publishers, and Light Italic/Manifold type fonts. These fonts meet the special printing requirements of many industries. The multilingual fonts offer the capability of printing over thirty languages. The fonts are offered on the NEC Spinwriter series of 55 character per second impact printers which feature the "thimble" print element.

Circle 663 on inquiry card.



### Line Driver Meets Bell Metallic-Line Specifications

Tuck Electronics has announced a line-driver series for use on metallic

pairs from 0 to 9.6 kbs for 4-wire full-duplex service. The driver complies with Bell 43401 amplitude and line balance specifications, and features a floating receiver amplifier. The unit features analog and digital loop-back test facilities, and a blinking light which indicates when the driver is in the test mode. The driver supports an RS-232 interface. The unit is available in stand-alone and multiple units. Single unit price for stand-alone units is \$175, and multiple-unit cards are \$162. For more information, contact Tuck Electronics Inc, 3645 Industrial Park Rd, Camp Hill PA 17011, (717) 761-4354.

Circle 664 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 judgement 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.

# What's New?

## PERIPHERALS

### Large-Screen Color Monitor



The AM-26, a 26-inch color monitor, with over 340 square inches of screen surface, combines Sony's Trinitron color system with switchable A/B inputs, switchable underscan, internal and external sync, and separate RGB (red, green, and blue) gun switches. Talley light,

separate horizontal and vertical scan delay are optional, and a separate tuner/audio amplifier and speaker section may be added. The Amtron AM-26 is priced at \$2395 from Amtron, Aptos CA 95003, (408) 688-4445.

Circle 665 on inquiry card.

### Digital Plotters from Houston Instrument

The DMP family of plotters comprises two standard and four intelligent models. All these models are available with plotting sizes of 21.5 by 28 cm (8.5 by 11 inches) and 28 by 44 cm (11 by 17 inches). The DMP-2 is a 21.5 by 28 cm plotter with an RS-232C and parallel interface. It has a pen speed of 2.4 inches per second and can plot at 100 or 200 increments per inch. The DMP-5 has a surface area of 28 by 44 cm and the RS-232C and parallel interface. The unit is plug-compatible with the DMP-2 and can utilize software developed for the DMP-2. The DMP-3 features a built-in microprocessor and pen speeds of 3 inches per second. Use of Houston In-

strument's Digital Micro/Plotter Language alleviates the software burden on the host computer. Self-test and pen positioning are accomplished via a computer or terminal keyboard. The DMP-3 comes with an RS-232C or Centronics-compatible interface. The DMP-6 is a 21.5 by 28 cm version of the DMP-3 and features a pen speed of 2.4 inches per second. The DMP-4 and the DMP-7 utilize electronic controls to facilitate positioning of the X and Y axes. Self-diagnostics are activated through front panel controls. Prices for the DMP Series plotters start at \$1085. For complete information, contact Houston Instrument, 1 Houston Sq, Austin TX 78753, (512) 837-2820.

Circle 666 on inquiry card.

### Paper-Tape Reader

A paper-tape reader/transmitter, the Model 612, is available from Addmaster Corporation, 416 Junipero Serra Dr, San Gabriel CA 91776, (213) 285-1121. The 612 features the ability to read five- to eight-level tape and to transmit 7 to 11 frames per character at 50 to 9600 bps (bits per second). Other features include starting and stopping on character at all speeds; choice of manual or automatic control; 90 to 260 V, 50 to 60 Hz power sources; and even, odd, or no parity; with a choice of desk-top or rack mounting. The price is \$656 to \$779.

Circle 667 on inquiry card.

### Chatterbox from Micromint



The Chatterbox is a packaging combination of the presently available COMM-80 I/O (input/output) interface for the TRS-80 and an acoustic modem. This box can turn even a 4 K-byte TRS-80 into a full time-sharing terminal. The Chatterbox includes a built-in programmable 50 to 19 K bps (bits per second) serial port, a Centronics-compatible parallel printer port, a 300 bps acoustic originate modem, and a spare TRS-BUS expansion connector. It comes with a power supply, connection cable, manual, and smart terminal software. When the modem is in use, the data conversation is automatically routed to the serial output port for printing. The Chatterbox allows a TRS-80 to communicate with time-sharing systems such as Micronet and the Source. In addition, Chatterbox can be used simply to provide an address selectable serial and parallel port. It is completely hardware- and software-compatible with existing TRS-80 products, and it connects either to the keyboard connector or screen printer port on the Expansion Interface. It does not require the Expansion Interface for operation. The Chatterbox is available for \$259 from The Micromint Inc, 917 Midway, Woodmere NY 11598, (516) 374-6793.

Circle 668 on inquiry card.

# What's New?

## SYSTEMS



### Systems from Wang

The Office Information Systems (OIS) Models 115-1 and 115-2 incorporate hard-disk drives located within the master control unit. The OIS systems can utilize the Wang Office-BASIC language, telecommunications and high-speed image printing capabilities, and Wang MAILWAY electronic mail software. These systems combine word-processing and data-processing capabilities in one device. The Model 105 supports two workstations and one printer, and contains a 2.5-megabyte hard disk. The addition of text editing, hyphenation, and justification to the 105 provides a complete photocomposition system. The 105 begins at \$9300.

The 115-1 and 115-2 support more users, peripherals, and larger hard-disk storage units. The 115-1 begins at \$13,400, and the 115-2 starts at \$15,400. For complete information, contact Wang Laboratories Inc, 1 Industrial Ave, Lowell MA 01851, (617) 459-5000.

Circle 669 on inquiry card.

### Casio Markets Its First Computer

The FX-9000P computer, priced under \$900, has been introduced by Casio Inc, 15 Gardner Rd, Fairfield NJ 07006, (201) 575-7400. It features instantaneous operation of the user system when the power is switched on. A graphic-display system makes it possible to display graphs, diagrams, and tables. The FX-9000P has all functions necessary to perform scientific and technical calculations and business analyses. The machine accepts memory packages to expand memory capacity.

Circle 670 on inquiry card.

### British S-100-Based Microcomputer

The Tuscan S-100 is based on the IEEE (Institute of Electrical and Electronics Engineers) standard S-100 bus. This single-board computer uses a Z80 microprocessor, can store 64 K bytes of programmable memory, is CP/M compatible, and includes a printer interface. Expansion capabilities include high-resolution graphics and speech synthesis cards. Transam offers application software packages that include BASIC and Pascal. Tuscan S-100 prices start at £195 for kits. For details, write Transam, 12 Chapel St, London NW1 5DH, England.

Circle 671 on inquiry card.

### Canon Introduces Its Desk-Top Computer



The TX Series microcomputers from Canon feature a 6809 microprocessor, extended BASIC and assembler language, a twenty-column alphanumeric video display, and a built-in twenty-six-column triple-copy impact printer. The models have 15 K bytes of user memory which can be expanded to 31 K bytes. Each model has an RS-232 interface port and a modem port. The TX-25 is a programmable machine with a full

typewriter keyboard and a built-in Canon floppy-disk drive. The TX-10 and TX-15 are nonprogrammable. The TX-15 incorporates a typewriter keyboard, while the TX-10 has a ten-key pad with twenty-six labeled keys. The price for the series is \$1295 from Canon Systems Division, 10 Nevada Dr, Lake Success, Long Island NY 11042, (516) 488-6700.

Circle 672 on inquiry card.

# What's New?

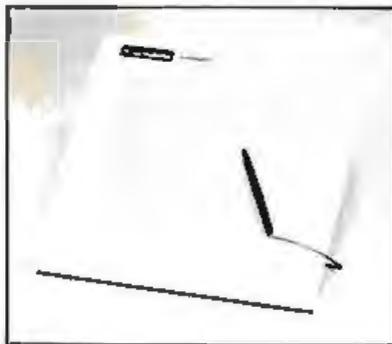
## GRAPHICS

### Colormaster Video and Graphics Board

The Colormaster allows users to program virtually any display format (eg: 64 by 32, 128 by 16, and 80 by 25). The board is designed for S-100 bus systems. Characters may be reversed, dimmed, flashing, underlined, and any of eight colors. Bit-mapped graphics or an optional PROM (programmable read-only memory) graphics set may also be displayed. Another option allows extension of the character set to include 128 user-defined characters. The Colormaster kit is \$399; assembled and tested, it is \$499; and the bare board is \$79. For more information, contact MicroDaSys, POB 36051, Los Angeles CA 90036, (213) 731-0876.

Circle 673 on inquiry card.

### Summagraphics Unveils Supergrid Digitizer



The microprocessor-based Supergrid utilizes a new technology—the Direct Magnetostrictive principle. This unit features high accuracy ( $\pm .005$  inch or 0.125 mm) and high-resolution (.001 inch or 0.025 mm) and eliminates the need for a biasing magnet. Supergrid is translucent with a flat surface; moreover, it supports a stylus and a cursor, and it permits simultaneous use of two digitizer tablets with the same driving electronics. The Supergrid comes in 11 by 11 and 20 by 20 inch forms, with larger versions to follow. RS-232C, IEEE, 8-bit parallel, and 16-bit parallel interfaces are supported. The technology behind the device is based on a principle that replaces a matrix of magnetostrictive wires with a matrix of plain copper wires and only one magnetostrictive wire per axis. For more information, contact Summagraphics Corporation, 35 Brentwood Ave, Box 781, Fairfield CT 06430, (203) 384-1344.

Circle 674 on inquiry card



### Hard-Copy Unit for Video Images

The Tektronix 4634 Imaging Hard Copy Unit produces high-quality continuous tone copies from raster-scan video sources in seconds. Designed to provide photographic quality images, the device is aimed at digital image processing, pattern recognition, remote sensing, video-disk, and high-resolution display environments. The 4634 records on dry silver paper using a fiber-optic video display. The process requires no toners or developers. The copies have a twelve-tone gray-scale range. The approximate cost per copy is \$0.20. It prints 6 by 8 inch images on 8½ by 11 inch paper. It usually requires a single cable connection and can be interfaced to most raster-scan video sources, whether analog or digital. An automatic gain-control circuit tracks the input



signal. Paper is available in 8½ inch by 500 foot rolls. Paper length can be adjusted from 7 to 11 inches. For more information, contact Marketing Communications Department, M S 63-635, Tektronix Inc, POB 500, Beaverton OR 97077, (503) 682-3411.

Circle 675 on inquiry card.

### Digitizer for the Apple II

The DS-65 Digisector is a random access video digitizer for the Apple II. It converts a television-camera's output into digital information that the Apple can process. The Digisector features high-resolution reproduction, sixty-four levels of gray scale, and accepts interlaced or industrial video input. The unit has on-board software featuring full screen scans directly to the Apple screen, random access digitizing by BASIC programs, line-scan digitizing for

reading charts or tracking objects, and utility functions for clearing and copying the screen. BASIC programs include a burglar alarm and a graph reader. Complete source listings are included in the package. The DS-65 is used for digitizing pictures; security systems; moving-target indicators; computer portraits; reading paper tape, strip charts, bar codes, and more. The price is \$349 from The Micro Works, POB 1110, Del Mar CA 92014, (714) 942-2400.

Circle 676 on inquiry card.

# What's New?

## SOFTWARE

### A Mail-List and Data-Base System

SelectraSort is a mail-list, data-base management system. It can pull records from mail-list files on the basis of over sixty selection criteria. The mail-list-file maintenance module enters new records to the mail list and changes or deletes existing entries. The selection module pulls records from the files. The print module prints selected and master mail lists as well as mail labels. Sorts can be done by ZIP code, country, state, last activity date, amount purchased or sold last year and this year. SelectraSort is \$195, which includes CBASIC source code. It is available on 8-inch soft-sectored and 5-inch soft- and hard-sectored floppy disks. Contact Software Hows, a division of MicroDaSys, POB 36275, Los Angeles CA 90036, (213) 731-0877.

Circle 677 on inquiry card.

### General Ledger for the Atari

MicroLedger, the Compumax general ledger program, has been converted to run on the Atari 800. The Atari MicroLedger performs trial balances and produces profit-and-loss statements and balance sheets. It features updating options, allowing the user to review and update records in the journal or chart of accounts; a running balance column in the journal listing; and error traps. The MicroLedger package retails for \$140, which includes the program, sample data, and a manual. BASIC source code is also included. Minimum hardware requirements are the Atari 800 with 24 K bytes of memory and a floppy-disk drive; a printer is offered as an option. Contact Compumax Inc, POB 1139, Palo Alto CA 94301, (415) 325-4503.

Circle 678 on inquiry card.

### Data Manager for the Apple

Information Master is a data manager for use with the Apple and includes the ability to do calculations, totals, sub-totals, and more. The program lets the user define, enter, edit, sort, and retrieve data. Printed report formats using the report-generation features can be defined. Other features include screen formatting, error trapping, and the ability to add, multiply, divide, and do exponentiations. A program is included that transfers files from the Management System for use with the Information Master. For further details on the Information Master program, contact High Technology Inc, POB 14665, 8001 N Classen Blvd, Oklahoma City OK 73113, (405) 840-9900.

Circle 679 on inquiry card.

### Vector Releases COBOL with Program Generator

Vector Graphic Inc has released a version of its ANSI-standard CIS COBOL, featuring program generation capability. Version 4.2 of CIS COBOL implements the eight modules necessary to meet the ANSI Level 1 standard at the low-intermediate level. The FORMS-2 utility generates data-entry screens and can create error-free data input programs without the programmer writing a line of code. It is available from Vector Graphic Inc, 31364 Via Colinas, Westlake Village CA 91361, (213) 991-2302.

Circle 680 on inquiry card.

### Job-Costing Package Under CP/M

This job-costing package consists of a reporting facility, a job-costing accounts payable, and a job-costing payroll. These programs are designed to run on a Z80 or 8080 processor using the CP/M operating system. Other CP/M-like systems are also supported. The software will run on hard or floppy disks. The business applications are integrated, yet each will run singly. The price is \$700 for a system from Arkansas Systems Inc, Suite 206, 8901 Kanis Rd, Little Rock AR 72205, (501) 227-8471.

Circle 681 on inquiry card.

### Business Application for the HP-85

Pro-Flow can figure sales analysis, forecast performance for products, evaluate material costs, and perform cash-flow analysis for a year's operation. By mixing initial raw data values with formulas, users can make projections about future operations. Pro-Flow is designed to run on the HP-85 micro-computer. It is available at a suggested retail of \$150 from Scelbi Publications, 20 Hurlbut St, Elmwood CT 06110, (203) 522-5515.

Circle 682 on inquiry card.

### Disk-O-Tape

Disk-O-Tape is a utility program for the Apple II and Apple II Plus computers. It enables users to transfer the data from a floppy disk to cassette tape and back again. The program features sector-by-sector copy of a DOS 3.2 disk to tape, error detection, and a verification pass for reliability. Each tape produced by the program contains a boot-strap for easy loading on disk. The program allows user-assigned naming of tapes. Disk-O-Tape requires at least 32 K bytes of programmable memory. The program comes on a floppy disk with Testape, a program to aid in adjusting the cassette recorder for optimum performance. Disk-O-Tape costs \$12 from Dann McCreary, POB 16435-B, San Diego CA 92116.

Circle 683 on inquiry card.

### Lifeboat Supports the Durango F-85

Lifeboat Associates has made available its 8080 software line formatted for the Durango F-85 computer. This software, which includes languages such as BASIC, COBOL, and Pascal; word-processing systems, such as Wordstar; communication software, such as BSTAM; and complete accounting packages, is available by the implementation of CP/M. The first version of CP/M supports the F-85 with up to four floppy-disk drives. This is priced at \$170. Later versions will support the 12-megabyte and 25-megabyte hard-disk systems. Contact Lifeboat Associates, 1651 Third Ave, New York NY 10028, (212) 860-0300.

Circle 684 on inquiry card.

### RECLAIM "Hides" Bad Sectors and Tracks from CP/M

Lifeboat Associates, 1651 Third Ave, New York NY 10028, (212) 860-0300, has announced a CP/M 2.0 utility program that tests floppy-disk and hard-disk systems for error-prone parts of the disk and allocates those parts to files that are invisible to the user. RECLAIM maps the bad spots out of the file directory so that they cannot be used again. It safely tests the disk with or without data files. At the completion of the program, it announces the number of blocks hidden from the file system. RECLAIM is available on all CP/M media formats supported by Lifeboat Associates. The cost is \$80.

Circle 685 on inquiry card.

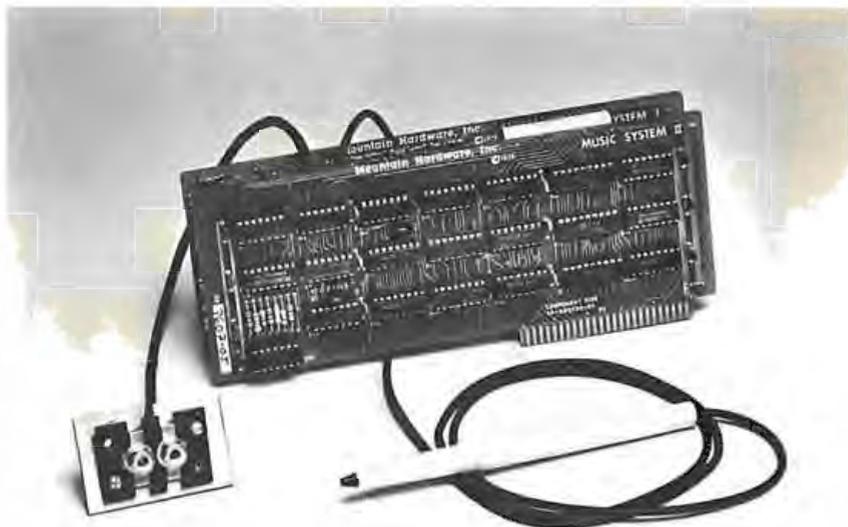
# What's New?

## SOFTWARE

### Digital Synthesizer for the Apple

Mountain Computer Inc has developed the MusicSystem for the Apple II. This sixteen-voice digital synthesizer permits the creation of the sounds of real musical instruments utilizing the principle of additive synthesis. The generation of sounds is accomplished through programmable waveforms, envelopes, and amplitudes for each musical voice. Software is included for editing and playing of compositions. The editor program permits graphical input of sheet music utilizing standard music notation. The player program permits polyphonic performance of musical compositions. Stereo output is to user's stereo amplifier and speakers or directly off card with stereo headphones. For information, write or call Mountain Computer Inc, 300 Harvey W Blvd, Santa Cruz CA 95060, (408) 429-8600.

Circle 656 on inquiry card.



### New Business Software for the TRS-80

American Business Systems (ABS) has announced that its line of financial- and business-applications software packages are now available to users of Radio Shack TRS-80 computers. These seven new ABS packages offer the same full-scale features and capabilities as the company's software for larger minicomputers and microcomputers.

The packages include a complete series of financial systems, ranging from Accounts Payable and Receivable through Payroll, Order Entry and Inven-

tory Control to a fully automated General Ledger System. The application systems currently available include Financial Modeling and Real-Estate Sales Management. Additional packages soon to be released will offer a Client Accounting System and a Correspondence Management Package, which includes a letter writer, word processor and mailing-label generator.

Information is available from American Business Systems Inc, 439 Littleton Rd, Westford MA 01886, (617) 486-3509.

Circle 687 on inquiry card.

### Reformat for the TRS-80

Reformat is a programming aid to be used prior to compiling with the Microsoft BASIC compiler. The BASIC compiler allows the use of long variable names which can contain BASIC reserved words, making the format of a BASIC source file and the use of spaces critical. BASIC program files that are written as multistatement compressed lines will be rejected by the compiler in almost all cases. Bluebird's has developed this machine-language program which will reformat any TRS-80 BASIC source file into a format acceptable to the compiler. Reformat is available for \$24.95 from Bluebird's Company 2267 23rd St, Wyandotte MI 48192, (313) 285-4455.

Circle 690 on inquiry card.

### TRS-80 CP/M 2.0 with 12 Megabytes

Lifeboat Associates, 1651 Third Ave, New York NY 10028, (212) 860-0300, has announced the release of CP/M version 2.0 for the TRS-80 Model II. The system features extended density format for each of up to four floppy-disk drives. Nearly 2.5 megabytes of storage is possible with floppy-disk drives alone. The Corvus 10 megabyte Winchester hard disk is suggested as a storage system, allowing CP/M to access 12 megabytes of memory. A menu-driven configuration program allows total control of the parallel printer port and both serial ports of the TRS-80.

The printer port software can be set to control a "dumb" printer that has no page control, or the software page control can be disabled for printing checks or mailing labels. The system includes

functions to set data rates of from 134.5 to 9600 bps (bits per second) for the serial ports. An ADM-3A emulation program is included which allows the TRS-80 to be used as a terminal through the serial ports. The system is offered with Corvus hard-disk capability for \$250 and floppy-disk capability for \$170.

Circle 688 on inquiry card.

### Software for the Apple II

Softpoint, Dept C, 103 Clinton Ave, Terryville NY 11776, has announced cassette programs for the Apple II including Function Plot, Speed Reading, Road Race, and more. The programs utilize the Apple's high-resolution graphics capabilities. The prices range from \$5.95 to \$9.95.

Circle 689 on inquiry card.

### Data-Base Program for Z80 Systems

Condor Computer Corporation, 3989 Research Park Dr, Ann Arbor MI 48104, (313) 769-3988, has announced Target/80 DBMS, a data-base system for Z80 microcomputers. Target/80 is designed for transaction processing applications. This version uses nineteen commands, including relational operations for selecting, sorting, appending, or posting data. Target/80 is compatible with most Z80 systems with at least 48 K bytes of programmable memory running under CP/M. The price is \$695.

Circle 691 on inquiry card.

# What's New?

## MISCELLANEOUS



### Logic Timing Recorder from A P Products



A P Products, 1359 W Jackson St, Painesville OH 44077, (800) 321-9668, in Ohio (216) 354-2101—collect, has introduced the Logic Timing Recorder, a device for charting logic timing. The unit is an ABS plastic board with 320 slides arranged in eight horizontal rows. The slides represent the two logic levels of a circuit. After the slides are manually moved into position to represent the logic state in a circuit, the board is checked for proper design, then it can be placed on a copying machine to make a permanent record for your files. The recorder may be used over and over again to chart the logic timing of all circuits. The Logic Timing Recorder, P/N 923758, has a suggested price of \$44.95.

Circle 694 on inquiry card.



### Computer in a Case

The Quasar Micro-Information System consists of a hand-held computer, video display, printer, modem, cassette deck, expandable programmable memory unit, I/O (input/output) driver—and it all fits in a briefcase. The hand-held computer fits in the palm of a hand, weighs less than a pound and con-

trols the peripheral devices. A library of memory capsules in ROM (read-only memory) for use in the computer include fourteen languages, calorie counter, bar/wine guide, phonetic pronunciation, and games. The system is available from Quasar Company, Franklin Park IL 60131.

Circle 692 on inquiry card.

### Nine-Voice Synthesizer

Vista Media Products has announced the Music Machine Nine. Using LSI (large-scale integration) technology, the device can produce nine voices on the Apple II computer. The board uses three AY3-8910 integrated circuits and requires one expansion slot. It can use software now available to produce and play back nine-voice music compatible

with other music boards. It will respond to commands for pitch, amplitude, duration, attack, delay, and more. Two high-impedance, low-level outputs are provided with six voices assigned to each channel. It is available through Advanced Computer Products, 1310 E Edinger, Santa Ana CA 92705, (714) 558-8813.

Circle 693 on inquiry card.

### A/D Converter for S-100 Systems

The AIM-12 is a 16- or 32-channel 12-bit A/D (analog-to-digital) converter designed for laboratory and industrial applications. The card plugs directly into the standard IEEE S-100 bus. Features include an on-board resistor programmable instrumentation amplifier and operation of up to 25 ms with 12 bits of accuracy. The AIM-12 is I/O (input/output) mapped and can be used with either BASIC or assembly-language instructions. The module is designed for direct conversion of voltages from thermocouples, level sensors, pressure transducers, pH electrodes and other low-level signal sources. The device provides thirty-two single-ended or sixteen fully differential inputs; input impedance exceeds one billion ohms. It is fully compatible with North Star, Cromemco, and most S-100 system. Multiple boards can be employed, and BASIC and assembly-language programs are supplied. The price of the AIM-12 is from \$575, depending on options, from Dual Systems Control Corporation, 1825 Eastshore Hwy, Berkeley CA 94710, (415) 549-3854.

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**Speed up your PET programming with The BASIC Programmer's Toolkit™, now only \$39.95.**

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The BASIC Programmer's Toolkit has two kilobytes of ROM firmware on a single chip. This extra ROM store lets you avoid loading tapes or giving up valuable RAM storage. It plugs into a socket inside your PET system, or is mounted on a circuit board attached on the side of your PET, depending on which model you own.

There are basically two versions of PET. To determine which Toolkit you need, just turn on your PET. If you see \*\*\*COMMODORE BASIC\*\*\* your PET uses the TK-80P Toolkit. If you see ###COMMODORE BASIC###, your PET uses the TK-160 Toolkit. Other versions of the BASIC Programmer's Toolkit are available for PET systems that have been upgraded with additional memory.

# Increase your PET's IQ for \$39.95.



**How Toolkit makes your programming easier:**

**FIND** locates and displays the BASIC program lines that contain a specified string, variable or keyword.

If you were to type **FIND AS,100-500**, your PET's screen would display all lines between line numbers 100 and 500 that contain **AS**.

**RENUMBER** rennumbers the entire program currently in your PET.

You can instantly change all line numbers and all references to those numbers. For instance, to start the line numbers with 500 instead of 100, just use **RENUMBER 500**.

**HELP** is used when your program stops due to an error. Type **HELP**, and the line on which the error occurs will be shown. The erroneous portion of the line will be indicated in reverse video on the screen.

These simple commands, and the other seven listed on the screen, take the drudgery out of program development work. And for a very low cost. The BASIC Programmer's Toolkit costs as little as \$39.95, or at most, \$59.95.

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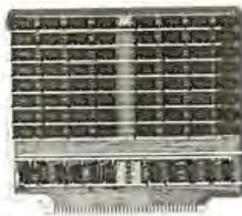


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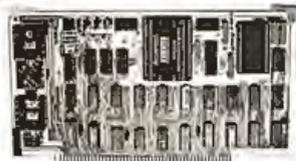
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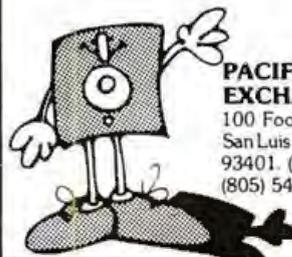
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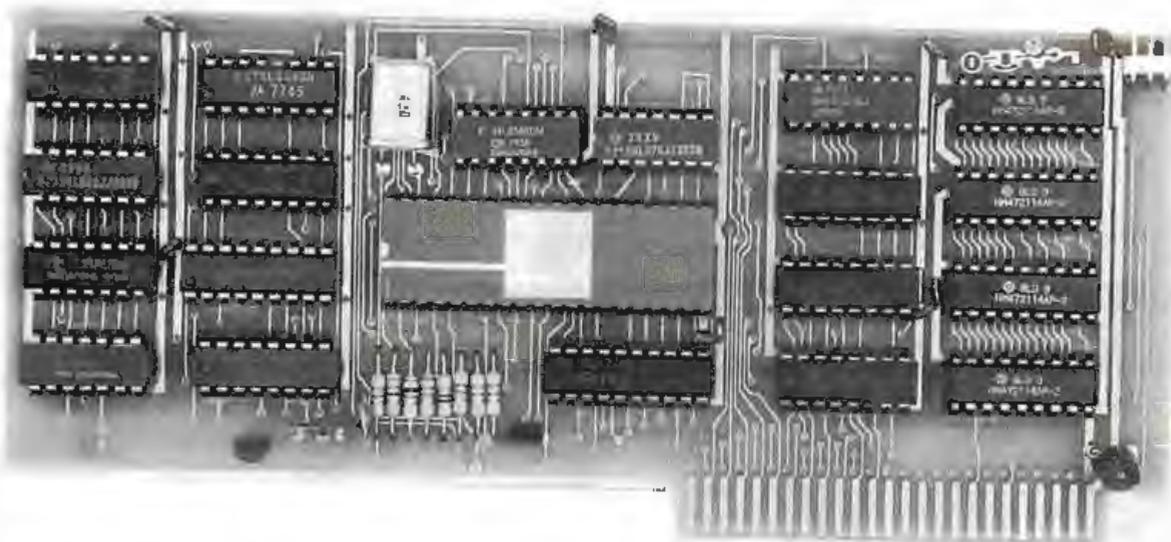
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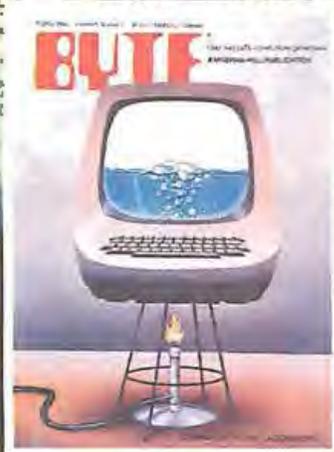
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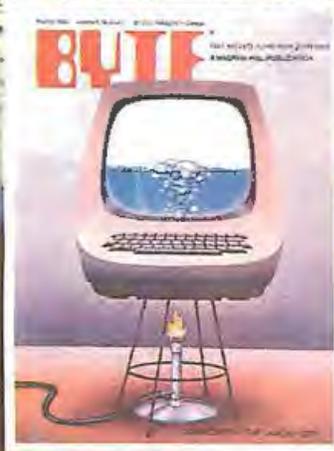
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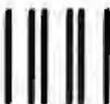
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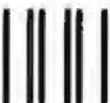
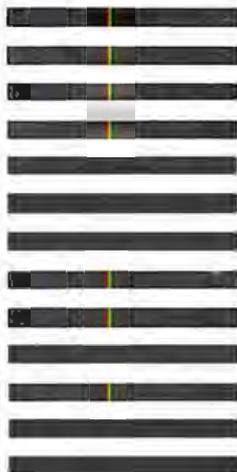
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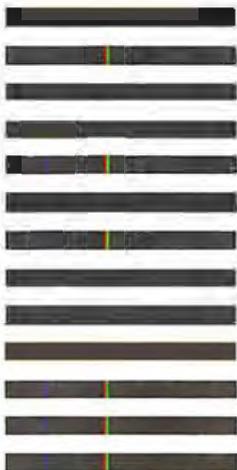
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DEVELOPMENT PAC	89

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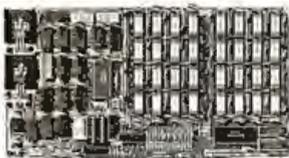
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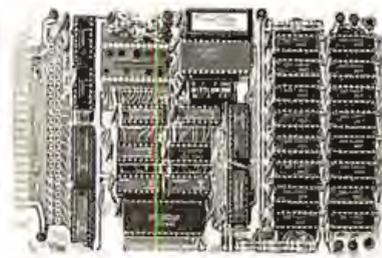
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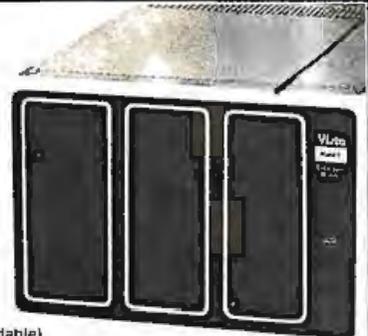
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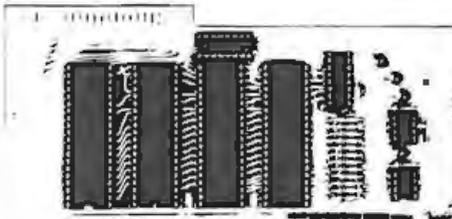
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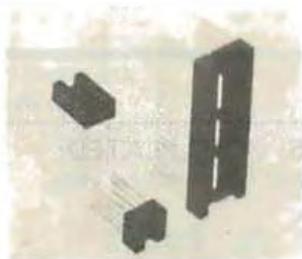
Length	100/Bag	500/Bag	1K/Bag	Length	100/Bag	500/Bag	1K/Bag	Kit No. 1	\$9.95	Kit No. 3	\$32.95
2.5"	\$1.25	\$3.58	\$ 6.19	6.5"	\$1.92	\$6.44	\$11.81	250 3"	100 4½"	500 2½"	500 4½"
3.0"	1.30	3.86	6.78	7.0"	1.99	6.76	12.44	250 3½"	100 5"	500 3"	500 5"
3.5"	1.37	4.15	7.37	7.5"	2.08	7.07	13.09	100 4"	100 6"	500 3½"	500 5½"
4.0"	1.42	4.44	7.94	8.0"	2.14	7.38	13.73			500 4"	500 6"
4.5"	1.48	4.74	8.54	8.5"	2.18	7.69	14.36	<b>Kit No. 2 \$24.95</b>		<b>Kit No. 4 \$59.95</b>	
5.0"	1.54	5.04	9.13	9.0"	2.24	8.11	15.01	250 2½"	250 5"	1000 2½"	1000 4½"
5.5"	1.58	5.38	9.72	9.5"	2.30	8.32	15.65	500 3"	100 5½"	1000 3"	1000 5"
6.0"	1.65	5.66	10.31	10.0"	2.39	8.71	16.28	500 3½"	250 6"	1000 3½"	1000 5"
								500 4"	100 6½"	1000 4"	1000 6"
								250 4½"	100 7"		

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

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IDE 26	\$4.05	IDS 26	2.65	IDP 24	2.25	IDH20WR	2.75	IDH20SR	1.25	
IDE 34	\$4.85	IDS 34	3.50	IDP 40	3.65	IDH26WR	3.60	IDH26SR	1.85	
IDE 40	\$5.65	IDS 40	4.05	<b>DB25 Connectors</b>		IDH34WR	4.15	IDS34SR	2.15	
IDE 50	\$5.90	IDS 50	5.06	Male	\$4.95	IDH40WR	4.90	IDH40SR	2.50	
				Female	\$5.25	IDH50WR	6.15	IDH50SR	3.15	
								10	2.90	17.00
								14	3.40	23.80
								16	3.70	27.20
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								26	5.40	44.20
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10180	20/40	W/W TRS 80	.200	3.30	3.00	2.15		15710 22/44 W/W KIM/VEC				200	3.48	3.20	2.85	
10190	20/40	S/T TRS 80	.140	3.20	2.90	2.55		15875 25/50 S/E				140	4.05	4.20	3.75	
10485	36/72	S/E Vector	.140	5.50	4.90	4.40		15880 25/50 S/T				140	4.55	4.10	3.65	
10490	36/72	W/E Vector	.200	5.80	5.25	4.85		15885 25/50 W/W				200	4.85	4.35	3.90	
10500	36/72	S/T Vector	.140	5.70	4.20	4.80		16115 36/72 S/E				140	6.50	5.85	5.20	
10535	40/80	S/E PET	.140	5.85	5.35	4.75		18120 36/72 S/T				140	6.55	5.90	5.25	
10540	40/80	W/W PET	.200	6.00	5.40	4.80		18125 36/72 W/W				200	6.75	6.10	5.40	
10550	40/80	S/T PET	.140	5.80	5.25	4.65		16145 36/72 S/T				200	6.50	5.85	5.20	
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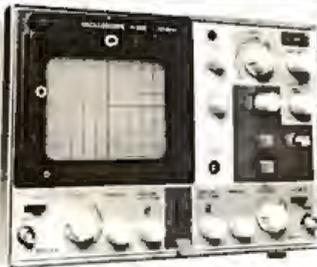
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74LS07	28	74LS17	14
74LS08	28	74LS18	14
74LS09	28	74LS19	14
74LS10	14	74LS20	14
74LS11	14	74LS21	14
74LS12	14	74LS22	14
74LS13	14	74LS23	14
74LS14	14	74LS24	14
74LS15	14	74LS25	14
74LS16	14	74LS26	14
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74LS67	14	74LS77	14
74LS68	14	74LS78	14
74LS69	14	74LS79	14
74LS70	14	74LS80	14
74LS71	14	74LS81	14
74LS72	14	74LS82	14
74LS73	14	74LS83	14
74LS74	14	74LS84	14
74LS75	14	74LS85	14
74LS76	14	74LS86	14
74LS77	14	74LS87	14
74LS78	14	74LS88	14
74LS79	14	74LS89	14
74LS80	14	74LS90	14
74LS81	14	74LS91	14
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• On board batteries with one year life.  
• Uses MSM5832-crystal controlled.

**APPLE EXPANSION KIT**  
16K Memory Add-On **\$44<sup>44</sup>**

MEMORY ADD-ON KIT INCLUDES INSTRUCTIONS

**MSM5832 MICROPROCESSOR**  
REAL-TIME CLOCK / CALENDAR **\$745**

GENERAL DESCRIPTION

The MSM5832 is a real-time microprocessor which provides a complete real-time clock/calendar system. It is designed to be used in conjunction with the Apple II Plus computer system. The MSM5832 is a 28-pin DIP package and is compatible with the Apple II Plus computer system. It provides a real-time clock/calendar system which is accurate to within one second per year. It also provides a date and day-of-week function. The MSM5832 is a non-volatile device and does not require a battery to maintain its data. It is a very compact and reliable device which is ideal for use in the Apple II Plus computer system.

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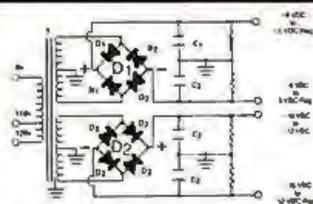
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ITEM NO.	USED IN KIT NO.	PRI. WINDING TAPS	SECONDARY WINDING OUTPUTS			SIZE W x D x H	UNIT PRICE
			2x 8 Vac	2x 14 Vac	2x 24 Vac		
T <sub>1</sub>	1	0V, 110V, 120V	2x7.5A	2x2.5A	—	3 3/4" x 3 3/8" x 3 1/8"	21.95
T <sub>2</sub>	2	0V, 110V, 120V	2x12.5A	2x3.5A	—	3 3/4" x 4 3/8" x 3 1/8"	27.95
T <sub>3</sub>	3	0V, 110V, 120V	2x9A	2x2.5A	2x2.5A	3 3/4" x 4 3/8" x 3 1/8"	29.95
T <sub>4</sub>	4	0V, 110V, 120V	2x4A	(28V, CT)	48V, CT, @3A	3 3/4" x 3 3/8" x 3 1/8"	22.95

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Z-80 Optimized (Under OS-1 or CP/M)

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**CP/M** Version 2.2 150.00  
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## Qume Datatrak 8

Double sided floppy with NO HEADACHES. Although many think this an impossibility, seeing is believing, and this drive is really something! Shugart compatible, fully optioned, reliable, and rapidly becoming the standard in double-sided diskdom.

\$599. Two/\$549.



## Siemens FDD 100-8D

Single sided 8" floppy drive, the latest & greatest revision. Features double density plus much more. An extremely reliable drive \$439 2/\$409

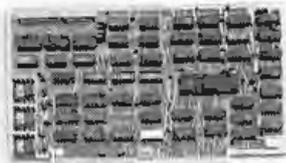
Hard sector option kit... \$9.95  
Data separator option kit... \$9.95

The following 5 1/4" mini-floppies share most features with their 8" cousins, so without further ado...

Siemens FDD 100-5D..... \$279.  
Qume Datatrak 5 (double sided)... 399.  
BASF Mini mini..... 279.  
SA 400..... 299.

All the above mini-floppies are fully SA400 compatible.

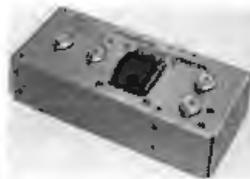
Manuals for all drives are \$10, refundable against future purchase of drives. Also, all 8" drives can be ordered with 220 v/50 hz for world-wide use.



## Disk controllers

Delta Products double density	\$349
Micromation doubler	439
Tarbell single density, A & T	225
Tarbell single density, kit	184
Tarbell double density, DMA	425
Sorrento Valley 8" single density for Apple	375

## Accessories



Cable kits for 8" drives with 10' 50 cond. flat cable, power cable, and all connectors. Assembled if desired. One drive 27.50, two 33.95, three 38.95 for mini floppies (34 cond): one 24.95, two, 29.95

CP-206 Power-one power supply. Powers two drives more than adequately, top quality. 2.8A/24V, 2.5A/5V, 5A/-5V..... \$99.

mini-floppy power supply ..... \$79

## Hard Disk

CII HB 10 MBY fully REMOVEABLE cartridge drive. Complete with controller, personality card, media, power supply, cabling, connectors and documentation. Highlighted by stylish & modern cabinetry. \$6995.

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## Electrolabs

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## ENCLOSURES

Rackmount Mainframe MT-200. This gorgeous beast is so appealing that it can easily function also as stand-alone mainframe. Very modern styling with fully actively terminated S-100 bus.

With two 8" single-sided disk drives... \$1899.

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Desktop Mainframe MT-100. Contemporary styling, a handsome cabinet coated with durable epoxy finish colors (blue, beige, off-white & silver). Easy to fit into an office environment. The proper way to start your system.

Above plus two 8" single sided disk drives..... \$1599.

Above with two 8" double sided disk drives in place of single-sided variety..... \$2199.



## PRAGMATIX 1

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with Qume Datatrak 8" double-sided drive \$2495



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TELEVIDEO 912C ..... \$745

TELEVIDEO 920C ..... 812

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used 12" Sylvania monitors. Composite video, 12 MHz, 120 VAC. with new P-39 or P-4 tube, \$79, used tube \$59, OEM style (without case), subtract \$12. U-fix model, 10/\$300.

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Set of 8, 16K, for Apple, TRS-80, Exidy, Heath & more. 200 Ns, prime parts, at the unheard of \$49/8.

Large discounts available for quantity & dealers (500 & up). Offer limited while supply lasts, as these will vanish quickly!!!

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8" ...\$39.99 SS/SD

8" ...\$49.00 SS/DD

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8" ...\$59.00 DS/DD

5 1/4" \$34.95 SS

5 1/4" \$59.00 DS

Verbatim, Memorex, Scotch, or equivalent name brand

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Wabash 8" diskettes \$29.00 SS

\$39.00 DS

Price is cheap, but they run like champs!!!!

Diskette head cleaning kit for 5 1/4" or 8"

\$28.75 includes everything for 1 drive

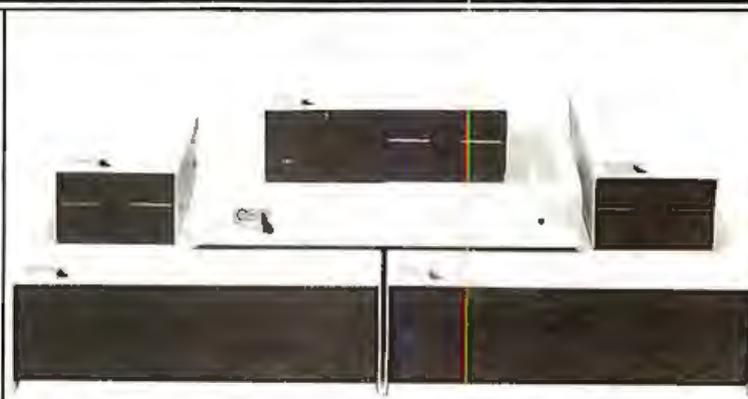
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Expansion and enhanced capabilities are key words in achieving full utilization of your computer system. Our complete line of LOBO disk drive subsystems are the ideal, cost-effective way to provide the expansion capabilities you need to meet your system growth requirements. All of our subsystems are complete, thoroughly-tested, 100% burned-in, and feature a 1 year 100% parts/labor warranty.

## APPLE

3101	Minifloppy
3101I	Minifloppy w/interface card
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8202CA	Two SA800 in cabinet w/power, SVA Controller, cable and manual
5101CA	One SA850 in cabinet w/power, SVA Controller, cable and manual
5202CA	Two SA850 in cabinet w/power, SVA Controller, cable and manual

## S-100 BASED COMPUTERS

MODEL NO.	DESCRIPTION
4101C	SA400 in cabinet w/power
8212C	Two SA801 in cabinet w/power
5212C	Two SA851 in cabinet w/power

## GENERAL

MODEL NO.	DESCRIPTION
8212	Two SA801 in cabinet
8212C	Two SA801 in cabinet w/power
5212	Two SA851 in cabinet
5212C	Two SA851 in cabinet w/power

## TRS80

MODEL NO.	DESCRIPTION	MODEL NO.	DESCRIPTION
4101C	SA400 in cabinet w/power	CB08	Cable for TRS80 Eight-inch Floppy
8101C II	One SA800 in cabinet w/power for Mod II	LX80	Double density expansion interface
8202C II	Two SA800 in cabinet w/power for Mod II	RS232	Dual Serial Port Option
CB02	Cable for Mod II	16K	16K Byte RAM for LX80 (32KB max.)
CB05	Cable for TRS80 Minifloppy	VTGS	4.0 Disk Operating System

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64K Byte dynamic RAM BOARD— Utilizes the Intel 3242 refresh controller and a single delay line for total internal refresh. Uses time proven 4116 RAMS. Memory mapped I/O boards are allowed to coexist by the use of A16 buss pin 16.

Assembled & Tested **Price \$350.**

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The basic 8080 based system. Includes CPA front panel, 22 slot motherboard (with all 22 edge connectors), MPU-A 8080 processor board, PS28 power supply (28AMP +8V 3AMP -16V), and chassis.

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Options: Thinker Toys Motherboard \$75 extra

### I8080 ENCLOSURE Sheet Metal Only:

THE ORIGINAL IMSAI: Mainframe with blue cover, cardguides and hardware spaced for 28A power supply, up to 22 slot motherboard.

- Either jump start or front panel
- Uses various motherboards

**Price \$95.**

### IMSAI PS28D Parts Kit:

Mounts in the I8080 mainframe + 5V 28A, -/+16V 3A, kit includes board, transformer, and all components.

**KIT \$95.50**

Terms: (1) PREPAID—Send check for merchandise amount only— We pay the shipping —or— (2) UPS C.O.D. and bank card orders by phone or mail. Shipping charges will be added. California residents add 6½% sales tax.

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# DIGITAL RESEARCH COMPUTERS

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## 32K S-100 EPROM CARD

**NEW!**



**\$74.95**  
KIT

USES 2716's  
Blank PC Board - \$34  
ASSEMBLED & TESTED  
ADD \$30

SPECIAL: 2716 EPROM's (450 NS) Are \$14.95 EA. With Above Kit.

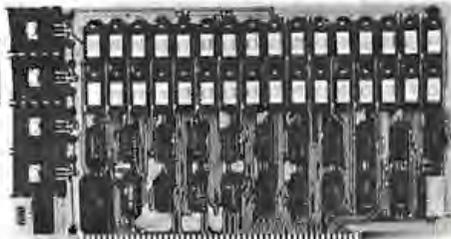
**KIT FEATURES:**

- |   |  |
|---|--|
| 1. Uses +5V only 2716 (2Kx8) EPROM's          | 7. Any or all EPROM locations can be disabled.                         |
| 2. Allows up to 32K of software on line!      | 8. Double sided PC board solder-masked, silk-screened                  |
| 3. IEEE S-100 Compatible                      | 9. Gold plated contact fingers.  |
| 4. Addressable as two independent 16K blocks  | 10. Unselected EPROM's automatically powered down for low power select |
| 5. Cromemco extended or Northstar bank select | 11. Fully buffered and bypassed  |
| 6. On board wait state circuitry if needed.   | 12. Easy and quick to assemble   |

## 16K STATIC RAM KIT-S 100 BUSS

PRICE CUT!  
**\$199.95**  
KIT

FOR 4MHZ  
ADD \$10



**KIT FEATURES:**

1. Addressable as four separate 4K Blocks.
2. ON BOARD BANK SELECT circuitry, (Cromemco Standard). Allows up to 512K on line!
3. Uses 2114 (450NS) 4K Static Rams.
4. ON BOARD SELECTABLE WAIT STATES.
5. Double sided PC Board, with solder mask and silk screened layout. Gold plated contact fingers.
6. All address and data lines fully buffered.
7. Kit includes ALL parts and sockets.
8. PHANTOM is jumpered to PIN 67.
9. LOW POWER: under 1.5 amps TYPICAL from the +5 Volt Buss
10. Blank PC Board can be populated as any multiple of 4K.

BLANK PC BOARD W/DATA-\$33  
LOW PROFILE SOCKET SET-\$12  
SUPPORT IC'S & CAPS-\$19.95  
ASSEMBLED & TESTED-ADD \$35

**OUR #1 SELLING  
RAM BOARD!**

## 16K DYNAMIC RAM PARTIALS

LOOK! INTEL 2108 8K X 1 RAMS LOOK!  
8 FOR \$9.95 32 FOR \$35  
FACTORY PRIME!

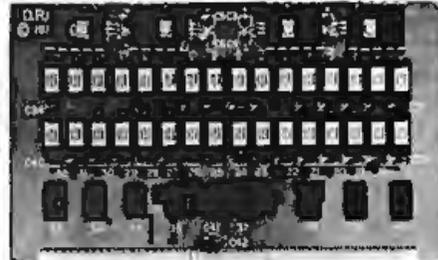
Huge special purchase of INTEL Dynamic RAM's. These are 2108-4, 300NS, 8K, Ceramic DIP. The 2108 is the INTEL 2116 (16K) tested for either upper or lower 8K only. These are factory prime. Full Spec. See INTEL 1978 Cat. for details or Memory Design Handbook for application data. Both IMSAI and EXTENSYS did mfg. S-100 RAM boards using these devices. — P.S. These devices will not work in the SD EPANDORAM™. Please specify upper or lower 8K. (S1626 or S1627). A super easy RAM to interface to a Z80, 16 PIN DIP.

FOR 4MHZ PRICE CUT!  
LOW POWER - 300NS 8 FOR \$37.50  
**2114 RAM SALE!**  
4K STATIC RAM'S. MAJOR BRAND, NEW PARTS.  
These are the most sought after 2114's, LOW POWER and 300NS FAST,  
8 FOR \$37.50

## 16K STATIC RAM SS-50 BUSS

PRICE CUT!  
**\$210** KIT

FULLY STATIC!  
FOR 2MHZ  
ADD \$10



FOR SWTPC  
6800 BUSS!

ASSEMBLED AND  
TESTED - \$35

**KIT FEATURES**

1. Addressable on 16K Boundaries
2. Uses 2114 Static Ram
3. Fully Bypassed
4. Double sided PC Board Solder mask and silk screened layout
5. All Parts and Sockets included
6. Low Power Under 1.5 Amps Typical

BLANK PC BOARD—\$30 COMPLETE SOCKET SET—\$12  
SUPPORT IC'S AND CAPS—\$19.95

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At last, an S-100 Board that unleashes the full power of two unbelievable General Instruments AY3-8910 NMOS computer sound IC's. Allows you under total computer control to generate an infinite number of special sound effects for games or any other program. Sounds can be called in BASIC, ASSEMBLY LANGUAGE, etc.

**KIT FEATURES:**

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  - FOUR PARALLEL I/O PORTS ON BOARD
  - USES ON BOARD AUDIO AMPS OR YOUR STEREO.
  - ON BOARD PROTO TYPING AREA.
  - ALL SOCKETS, PARTS AND HARDWARE ARE INCLUDED.
  - PC BOARD IS SOLDERMASKED, SILK SCREENED, WITH GOLD CONTACTS.
  - EASY, QUICK, AND FUN TO BUILD, WITH FULL INSTRUCTIONS.
  - USES PROGRAMMED I/O FOR MAXIMUM SYSTEM FLEXIBILITY
- Both Basic and Assembly Language Programming examples are included.

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SCL™ is now available! Our Sound Command Language makes writing Sound Effects programs a SNAP! SCL™ also includes routines for Register-Examine-Modify, Memory-Examine-Modify and Play-Memory. SCL™ is available on CP/M compatible diskette of 2708 or 2716 Diskette—\$24.95 2708 - \$19.95 2716 - \$29.95 Diskette includes the source EPROMS are ORG at E000H.

**COMPLETE KIT!**

**\$84.95**

(WITH DATA MANUAL)

BLANK PC  
BOARD W/DATA  
\$31

## 4K DYNAMIC RAM BLOWOUT!

SAME AS INTEL 2107B!

4K RAMS AT AN UNBELIEVABLE 50¢ EACH!!!

Prime, new, National Semi., 1979 date coded, full spec. parts. N.S. #MM5280-5N. Same as INTEL 2107B-4, T.I. TMS4060, NEC uPD411, etc. We bought a HUGE QTY. from a West Coast Distributor at truly DISTRESS PRICES! One of the most popular and reliable RAM's ever made. These parts have been used by almost all Major Computer Main Frame Mfg. the world over! Arranged as 4K x 1, 270NS Access Time, 22 Pin Dip. These units DO NOT use multiplexed addressing, thus making REFRESH and other timing very simple. See INTEL MEMORY DESIGN HANDBOOK for full application notes. The NAT. SEMI. MEMORY DATA BOOK is available at most Radio Shack Stores. Prime units in original factory tubes!

(With Pin Out Data)

#5280-5N 4096 BITS x 1 270 NS ACCESS

8 FOR \$4.95 32 FOR \$16

FACTORY CASE (450 PCS) — \$180

Sockets Special: 22 Pin Low Profile (With Purchase of 5280's) 8 FOR \$1.

## COMPUTER PARTS SPECIALS

- |                |                                    |
|----------------|------------------------------------|
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| 74LS240 - 1.79 | Signetics 2901 4 Bit Slice - 6.95  |
| 74LS241 - 1.79 | AMD 2903 4 Bit Super Slice - 12.50 |
| 74LS244 - 1.79 | AMD 29705 Dual Port RAM - 8.95     |
| 74LS373 - 1.99 |                                    |

## NEW! G.I. COMPUTER SOUND CHIP

AY3-8910. As featured in July, 1979 BYTE! A fantastically powerful Sound & Music Generator. Perfect for use with any 8 Bit Microprocessor. Contains: 3 Tone Channels, Noise Generator, 3 Channels of Amplitude Control, 16 bit Envelope Period Control, 2-8 Bit Parallel I/O, 3 D to A Converters, plus much more! All in one 40 Pin DIP. Super easy interface to the S-100 or other busses. \$11.95 PRICE CUT!

SPECIAL OFFER: \$44.95 each Add \$3 for 80 page Data Manual.

TERMS: Add \$1.50 postage. We pay balance. Orders under \$15 add 75¢ handling. No C.O.D. We accept Visa and MasterCard. Tex. Res. add 5% Tax. Foreign orders (except Canada) add 20% P & H 90 Day Money Back Guarantee on all items. Orders over \$50, add 85¢ for insurance.

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### HEX ENCODED KEYBOARD

Four onboard LEDs indicate the HEX code generated for each key depression. The board requires a single +5 volt supply. Board only \$15.00 Part No. HEX-3, with parts \$49.95 Part No. HEX-3A. 44 pin edge connector \$4.00 Part No. 44P.



### ASCII TO CORRESPONDENCE CODE CONVERTER

This bidirectional board is a direct replacement for the board inside the Trendata 1000 terminal. The on board connector provides RS-232 serial in and out. Sold only as an assembled and tested unit for \$249.95. Part No. TA 1000C

### ASCII KEYBOARD

53 Keys popular ASR-33 format • Rugged G-10 P.C. Board • Tri-mode MOS encoding • Two-Key Rollover • MOS/DTL/TTL Compatible • Upper Case lockout • Data and Strobe inversion option • Three User Definable Keys • Low contact bounce • Selectable Parity • Custom Keycaps • George Risk Model 753. Requires +5, -12 volts. \$59.95 Kit.

### ASCII KEYBOARD

TTL & DTL compatible • Full 67 key array • Full 128 character ASCII output • Positive logic with outputs resting low • Data Strobe • Five user-definable spare keys • Standard 22 pin dual card edge connector • Requires +5VDC 325 mA. Assembled & Tested. Cherry Pro Part No. P70-05AB \$119.95.



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Analog to Digital, Digital to Analog Converter. A/D conversion time 20us. D-A conversion 5us. Uses include speech and music synthesizing and slow scan TV. Single power supply (5V), 8 Bits wide, latched I/O, strobe lines. Part No. 79287K Complete Kit \$49.95 • Part No. 79287A Assembled \$69.95

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### T.V. INTERFACE



• Converts video to AM modulated RF, Channels 2 or 3. So powerful almost no tuning is required. On board regulated power supply makes this extremely stable. Rated very highly in Doctor Dobbs' Journal. Recommended by Apple • Power required is 12 volts AC C.T., or +5 volts DC • Board only \$7.60 part No. 107, with parts \$13.50 Part No. 107A

### TAPE INTERFACE



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

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• Converts TTL to RS-232, and converts RS-232 to TTL • Two separate circuits • Requires -12 and +12 volts • All connections go to a 10 pin edge connector, kit \$9.95 Part No. 232A10P, edge connector \$3.00 part No. 10P.

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• Board supplies a regulated +5 volts at 3 amps., +12, -12, and -5 volts at 1 amp. • Power required is 8 volts AC at 3 amps., and 24 volts AC C.T. at 1.5 amps. • Board only \$12.50 Part No. 6085, with parts excluding transformers \$42.50 Part No. 6085A



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Has provisions for ten 44 pin (.156) connectors, spaced 3/4 of an inch apart. Pin 20 is connected to X, and 22 is connected to Z for power and ground. All the other pins are connected in parallel. This board also has provisions for bypass capacitors. Board cost \$15.00 Part No. 102. Connectors \$3.00 each Part No. 44WP.

### RS-232/20mA INTERFACE



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

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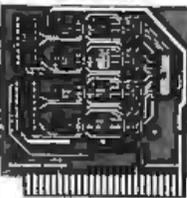
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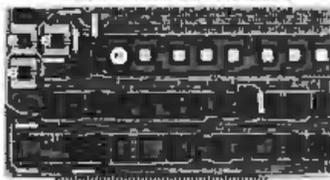
This board has 8 triacs capable of switching 110 volt 6 amp loads (660 watts per channel) or a total of 5280 watts. Board only \$15.00 Part No. 210, with parts \$119.95 Part No. 210A

## APPLE II SERIAL I/O INTERFACE



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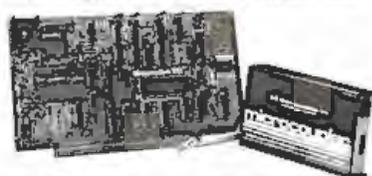
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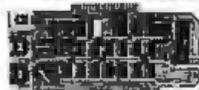
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## TIDMA

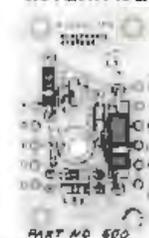


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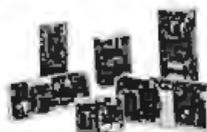
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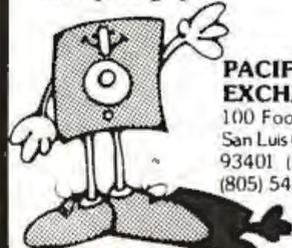
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6502 based single board with full ASCII keyboard and 20 column thermal printer. 20 char. alphanumeric display, ROM monitor, fully expandable. \$375.00, 4K version \$450.00, 4K Assembler \$85.00, 8K Basic Interpreter \$100.00.

Special small power supply for AIM65 assem. in frame \$54.00. Complete AIM65 in thin briefcase with power supply \$499.00. Molded plastic enclosure to fit both AIM65 and power supply \$47.50. Special Package Price: 4K AIM, 8K Basic, power supply, cabinet \$599.00.

AIM65/KIM/VM/Super EII 44 pin expansion board, 3 female and 1 male bus. Board plus 3 connectors \$22.95.

### 60 Hz Crystal Time Base Kit \$4.40

Converts digital clocks from AC line frequency to crystal time base. Outstanding accuracy.

### Video Modulator Kit \$8.95

Convert TV set into a high quality monitor w/o affecting usage. Comp. kit w/full instr.Kit

### Multi-volt Computer Power Supply

8v 5 amp, ±16v 5 amp, 5v 1.5 amp, ±12v 5 amp, 12v 5 amp, —12v output ±5v, ±12v are regulated. Basic Kit \$29.95. Kit with chassis and all hardware \$43.95. Add \$4.00 shipping. Kit of hardware \$14.00, Woodgrain case \$10.00, \$1.50 shipping.

TERMS: \$5.00 min. order U.S. Funds. Calif residents add 6% tax. \$10.00 min. order BankAmericard and Master Charge and COO. \$1.00 insurance optional. Shipping charge will be added on charge cards.

# Get the inside copy of CP/M\*

Just purchase a Jade Double-D or CCS double density disk controller this month and CP/M\* 2.2 is yours for free.

## S-100 Boards

### DOUBLE-D - Jade

Double density disk controller with the inside track

IOD-1300K Kit & CP/M 2.2	\$395.00
IOD-1300A 8" A & T & CP/M 2.2	\$469.00
IOD-1305A 5 1/4" A & T & CP/M 2.2	\$469.00
IOD-1200B Bare board	\$55.00

### DOUBLE DENSITY - Cal Comp Sys

5 1/4" or 8" disk controller with free CP/M 2.2

IOD-1400A A & T	\$374.95
-----------------	----------

### THE BIG Z\* - Jade

2 or 4 MHz switchable Z-80\* CPU with serial I/O

CPU-30201K Kit	\$145.00
CPU-30201A A & T	\$199.00
CPU-30200B Bare board	\$35.00

### SBC-100 - SD Systems

2.5 MHz Z-80\* CPU with serial & parallel I/O ports

CPC-30109K Kit	\$269.95
CPC-30109A Jade A & T	\$339.95

### SBC-200 - SD Systems

1 MHz Z-80\* CPU with serial & parallel I/O ports

CPC-30200K Kit	\$299.95
CPC-30200A Jade A & T	\$375.00

### CB2 - S.S.M.

2 or 4 MHz switchable Z-80\* CPU with RAM, ROM, & I/O

CPU-30300K Kit	\$239.95
CPC-30300A A & T	\$299.95

### 2810 Z-80\* CPU - Cal Comp Sys

2.4 MHz Z-80A\* CPU w/serial I/O port

CPU-30400A A & T	\$275.00
------------------	----------

### ExpandoRAM I - SD Systems

2.4 MHz RAM board expandable from 16K to 64K

MEM-16130K 16K kit	\$245.00
MEM-16130A 16K Jade A & T	\$295.00
MEM-32131K 32K kit	\$275.00
MEM-32131A 32K Jade A & T	\$325.00
MEM-48132K 48K kit	\$305.00
MEM-48132A 48K Jade A & T	\$355.00
MEM-64133K 64K kit	\$335.00
MEM-64133A 64K Jade A & T	\$385.00

**64K RAM BOARD \$359.95**

### ExpandoRAM II - SD Systems

4 MHz RAM board expandable from 16K to 256K

MEM-16630A 16K kit	\$249.95
MEM-16630A 16K Jade A & T	\$299.95
MEM-32631K 32K kit	\$289.95
MEM-32631A 32K Jade A & T	\$339.95
MEM-48632K 48K kit	\$324.95
MEM-48631A 48K Jade A & T	\$374.95
MEM-64633K 64K kit	\$359.95
MEM-64633A 64K Jade A & T	\$409.95

**32K STATIC RAM BOARD \$299.95**

**16K STATIC RAM BOARD \$169.95**

### 32K STATIC RAM - Jade

2 or 4 MHz expandable static RAM board uses 2114 L's

MEM-16151K 16K 4 MHz kit	\$169.95
MEM-16151A 16K 4 MHz A & T	\$224.95
MEM-32151K 32K 4 MHz kit	\$299.95
MEM-32151A 32K 4 MHz A & T	\$349.95

### S.P.I.C. - Jade

Our new I/O card with 2 SIO's, 4 CTC's, and 1 PIO

IOI-1045K 2 CTC's, 1 SIO, 1 PIO	\$199.00
IOI-1045A A & T	\$259.00
IOI-1046K 4 CTC's, 2 SIO's, 1 PIO	\$259.00
IOI-1046A A & T	\$319.00
IOI-1045B Bare board w/ manual	\$59.95
IOI-1045D Manual only	\$20.00

### 16K STATIC RAM - Cal Comp Sys

2 or 4 MHz 16K static RAM - a real memory bargain

MEM-16160K 16K 2 MHz kit	\$249.95
MEM-16160A 16K 2 MHz A & T	\$279.00
MEM-16162K 16K 4 MHz kit	\$279.95
MEM-16162A 16K 4 MHz A & T	\$309.00
MEM-16160B Bare board	\$29.95

### PB-1 - S.S.M.

2708, 2716 EPROM board with built-in programmer

MEM-99510K Kit	\$159.95
MEM-99510A A & T	\$239.95

### PROM-100 - SD Systems

2708, 2716, 2712, 2758, & 2516 EPROM programmer

MEM-99520K Kit	\$175.00
MEM-99520A Jade A & T	\$225.00

### I/O-4 - S.S.M.

2 serial I/O ports plus 2 parallel I/O ports

IOI-1010K Kit	\$179.95
IOI-1010A A & T	\$259.95
IOI-1010B Bare board	\$35.00

### BIT STREAMER II - Vector Graphic

3 serial I/O ports plus 2 parallel I/O ports

IOI-1025A A & T	\$259.00
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### 100K DAY CLOCK - Mtn Hardware

Crystal controlled S-100 clock with NiCad backup

IOK-1400A A & T	\$329.95
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### SB1 - S.S.M.

15 Hz to 25K Hz music synthesizer for S-100

IOS-1005K Kit	\$239.95
IOS-1005A A & T	\$299.95

### TB-4 - Mullen

Extremely versatile extender board with logic probe

TSX-180K Kit	\$55.00
TSX-180A A & T	\$75.00

### TERMINATOR & EXTENDER - C.C.S.

Can be used as both an S-100 extender and terminator

TSX-150K Kit	\$39.95
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### S-100 EXTENDER - Cal Comp Sys

Put's problem boards within easy reach

TSX-160A A & T	\$24.95
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### VERSAFLOPPY I - SD Systems

Versatile floppy disk controller for 8" or 5 1/4"

IOD-1150K Kit	\$219.95
IOD-1150A Jade A & T	\$269.95

### VERSAFLOPPY II - SD Systems

New double density controller for both 8" & 5 1/4"

IOD-1160K Kit	\$309.95
IOD-1160A Jade A & T	\$369.95

### S-100 PROTO BOARD - Jade

Universal design, plated thru holes, gold fingers

TSX-140B Bare board	\$24.95
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### 2708/2716 EPROM BOARD - Jade

Holds up to 16 EPROMs, addressable on 1K banks

MEM-16230K Kit	\$69.95
MEM-16230A A & T, no PROMs	\$99.95
MEM-16230B Bare board	\$30.00

\*Z-80, Z-80A, and the letter Z are recognized trademarks of Zilog, Inc.

### VDB-8024 - SD Systems

80 x 24 I/O mapped video board with keyboard I/O

IOV-1020K Kit	\$339.95
IOV-1020A Jade A & T	\$399.95

### VB3 - S.S.M.

80 x 24 or 80 x 48 memory mapped with graphics

IOV-1095K Kit, 4 MHz	\$399.95
IOV-1095A A & T, 4 MHz	\$464.95
IOV-1096K 80 x 48 upgrade, 4 MHz	\$89.00

### VIDEO BOARD - Jade

64 x 16 assembled & tested S-100 video board

IOV-1050B Bare board	\$29.95
IOV-1050A A & T sale price	\$99.95

## Single Board Computers

### AIM-65 - Rockwell

6502 computer with printer, display, & keyboard

CPK-50165 1K AIM	\$374.95
CPK-50465 4K AIM	\$449.95
SFK-74600008E 8K BASIC ROM	\$99.95
SFK-64600004E 4K assembler ROM	\$84.95
PSX-030A Power supply	\$59.95
ENX-000002 Enclosure	\$49.95
4K AIM, 8K BASIC, power supply, & enclosure	
Special package price	\$599.00

### Z-80\* STARTER KIT - SD Systems

Z-80\* computer with RAM, ROM, I/O, & keyboard

CPS-30010K Kit	\$319.95
CPS-30010A Jade A & T	\$399.95

## Video Monitors

### VIDEO 100 - Leedex

12" B & W video monitor with 12 MHz bandwidth

VDM-801210	\$139.95
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### VIDEO 100-80 - Leedex

81 x 24 version of Video 100 with metal cabinet

VDM-801230	\$179.95
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### 9" B & W MONITOR - A.P.F.

High quality, high resolution video monitor

VDM-750900 9" monitor	\$149.95
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### 13" COLOR MONITOR - Zenith

The hi res color you've been promising yourself

VDC-201301	\$449.00
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### 12" GREEN SCREEN - NEC

20 MHz, P11 phosphor video monitor with audio

VDM-651200 12" monitor	\$249.95
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## Software

### SDOS - SD Systems

DOS, CBASIC-2, Z-80\* assembler/editor/linker

SFX-55001000D Manual set	\$24.95
SFX-55001002M 5 1/4" disks & man	\$199.95
SFX-55001006F 8" disk & manual	\$199.95

### CP/M 2.2 - Digital Research

Latest & most powerful release of CP/M

SFC-52506000D Manual set	\$24.95
SFC-52506000M 5 1/4" disk & manual	\$149.95
SFC-52506000F 8" disk & manual	\$149.95

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# track and a free 2.2 to boot !!!

## Accessories for Apple

### 16K MEMORY UPGRADE

- Add 16K of RAM to your TRS-80, Apple, or Exidy
- MEX-16100K TRS-80 kit ..... \$39.95
  - MEX-16101K Apple kit ..... \$39.95
  - MEX-16102K Exidy kit ..... \$39.95

### PRINTER INTERFACE - Cal Comp

- Centronics type I/O card w/ firmware
- IOI-2041A A & T ..... \$99.95

### 8" DRIVES for APPLE

- Controller, DOS, two 8" drives, cabinet, & cable
- Special package price ..... \$1475.00

### AIO - S.S.M.

- Parallel & serial interface for your Apple
- IOI-2050K Kit ..... \$159.00
  - IOI-2050A A & T ..... \$199.00

### APPLE CLOCK - Cal Comp Sys

- Real time clock w/ battery back-up
- IOK-2100A A & T ..... \$125.00

### SUPERTALKER - Mtn Hardware

- Speech recognition/synthesizer w/ speaker & mike
- IOS-2015A A & T ..... \$275.00

### Z-80\* CARD for APPLE

- Z-80\* CPU card with CP/M for your Apple
- CPX-30800A A & T ..... \$298.00

### MICROMODEM - D.C. Hayes

- Auto answer/dial modem card for Apple or S-100
- IOI-2010A Apple modem ..... \$349.95
  - IOI-1100A S-100 modem ..... \$375.00

## Printers

### BASE 2 - Impact Printer

- 132 cps, bi-directional, tractor feed, & graphics
- PRM-13100 ..... \$675.00

### DP-9501 - Anadex

- 9 x 11 dot matrix, 220 column, 200 cps, & graphics
- PRM-10501 Standard DP-9501 ..... \$1495.00
  - PRM-10511 with graphics & 2K .. \$1595.00

### ANACOM 150 - Special

- 150 cps, 9 x 9 matrix, tractor feed
- PRM-11150 Parallel interface ..... \$895.00
  - PRM-11151 Serial interface ..... \$895.00

### SPINWRITER - NEC

- 65 cps, bi-directional, letter quality with tractor
- PRD-55510 with 2K buffer ..... \$2695.00

### NOVATION CAT

- 300 baud, auto answer/originate acoustic modem
- IOI-5200A Special sale price ..... \$139.00

### D-CAT 300 baud, direct connect modem

- IOI-5201A Special sale price ..... \$189.00

### EPROM ERASERS

- L.S. Engineering UV eraser for up to 48 EPROMs
- XME-3200 A & T ..... \$39.95

### Spectronics hi intensity industrial eraser

- XME-3100 Without timer ..... \$69.95
- XME-3101 With timer ..... \$94.50

### TV-1 - Best Buy

- The inexpensive alternative to video monitors
- IOR-5040K Kit ..... \$8.95

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Circle 372 on Inquiry card.

## Disk Drives

### JADE DISK PACKAGE

- Double-D controller kit, two 8" double density drives  
CP/M 2.2, cabinet, power supply, & cables
- Special package price ..... \$1395.00

### DUAL 8" DRIVES - Jade

- A pair of double density Shugarts in a cabinet
- MSF-12800R 2 single sided ..... \$995.00
  - MSF-125202 2 double sided ..... \$1425.00

### 8" DISK DRIVES

- Highly reliable double density floppy disk drives  
Shugart 801R single sided, double density
- MSF-10801R SA-801R ..... \$425.00
  - Special Sale Price ..... 2 for \$800.00
  - Qume Datatrak 8 double sided, double density
  - MSF-750080 851R compatible ..... \$625.00

### DISKETTES - Jade

- Bargain prices on magnificent magnetic media
- 5 1/4" single sided, single density, box of 10
  - MMD-5110103 Soft sector ..... \$27.95
  - MMD-5111003 10 sector ..... \$27.95
  - MMD-5111603 16 sector ..... \$27.95
  - 5 1/4" double sided, double density, box of 10
  - MMD-5220103 Soft sector ..... \$39.95
  - 8" single sided, single density, box of 10
  - MMD-8110103 Soft sector ..... \$33.95
  - 8" single sided, double density, box of 10
  - MMD-8120103 Soft sector ..... \$55.95
  - 8" double sided, double density, box of 10
  - MMD-8220103 Soft sector ..... \$57.95

### DUAL DISK CABINET Jade

- Metal enclosure for 2 801R's, power supply & fan
- END-000021 Bare cabinet ..... \$99.00

## Motherboards

### ISO-BUS - Jade

- Silent, simple, and on sale - a better motherboard
- 8 Slot (5W" x 8W")
  - MBS-061B Bare board ..... \$19.95
  - MBS-061K Kit ..... \$39.95
  - MBS-061A A & T ..... \$49.95
  - 12 Slot (9W" x 8W")
  - MBS-121B Bare board ..... \$29.95
  - MBS-121K Kit ..... \$69.95
  - MBS-121A A & T ..... \$89.95
  - 18 Slot (14W" x 8W")
  - MBS-181B Bare board ..... \$49.95
  - MBS-181K Kit ..... \$99.95
  - MBS-181A A & T ..... \$139.95

## Mainframes

### MAINFRAME - Cal Comp Sys

- 12 slot S-100 mainframe with 20 amp power supply
- ENC-112105 Kit ..... \$309.95
  - ENC-112106 A & T ..... \$349.95

### DISK MAINFRAME - NNC

- Dual 8" drive cutouts with 8 slot motherboard
- ENS-112320 with 30 amp p.s. .... \$699.95

**TRS-80 APPLE**  
16K MEMORY UPGRADE KIT  
**\$39.95**

### MICROPROCESSORS

- Z-80 ..... 10.95
- Z-80A ..... 12.95
- 8502 ..... 11.50
- 6800 ..... 11.95
- 6802 ..... 17.95
- 6809 ..... 39.95
- 8035 ..... 24.00
- 8035-B ..... 24.00
- 8080A ..... 6.59
- 8085 ..... 15.95

### SUPPORT DEVICES

- 8212 ..... 4.95
- 8214 ..... 4.65
- 8216 ..... 2.95
- 8224 ..... 3.25
- 8224-4 ..... 10.95
- 8226 ..... 3.85
- 8228 ..... 4.95
- 8238 ..... 4.95
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- 8250 ..... 14.95
- 8251 ..... 6.50
- 8253 ..... 13.95
- 8255 ..... 6.50
- 8257 ..... 19.95
- 8259 ..... 17.95
- 8275 ..... 49.95
- 8279 ..... 15.95

### Z-80 SUPPORT

- 3881 PIO ..... 9.50
- 3881-4 PIO-MHz ..... 14.50
- 3882 CTC ..... 9.50
- 3882-4 CTC-MHz ..... 14.95
- 3883 SIO ..... 29.50
- 3884 SIO ..... 49.50

### BAUD RATE GENERATORS

- MC1441 ..... 10.00
- 1.843 MHz xtal ..... 4.95

### UARTS

- 8800
- SUPPORT
- AY5-1013A ..... 5.25
- AY3-1014A ..... 8.25
- TR1602B ..... 5.25
- IM6402 ..... 9.00

### RAMS

- 21102 2 MHz ..... 1.25
- 21102A 1 MHz ..... 1.50
- 2114L 2 MHz ..... 3.75
- 2114LA 4 MHz ..... 3.95

### PROMS

- 2708 450ns ..... 8.95
- 4116 ..... 4.95
- 2716 12.5u ..... 14.95
- 4164 61K x1 ..... 175.00
- 2716 5u ..... 14.95
- 5257 2 MHz ..... 6.75
- 2732 5u ..... 59.95
- 5257A 4 MHz ..... 7.25
- 2768 5u ..... 19.95
- MK-4118 ..... 18.95

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Write for our FREE 1980 catalog

**JADE**  
COMPUTER PRODUCTS

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SN7400N	.25
SN7401N	.25
SN7402N	.25
SN7403N	.25
SN7404N	.25
SN7405N	.25
SN7406N	.25
SN7407N	.25
SN7408N	.25
SN7409N	.25
SN7410N	.25
SN7411N	.25
SN7412N	.25
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SN7450N	.25
SN7451N	.25
SN7452N	.25
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SN7455A	.25
SN7456N	.25
SN7457N	.25

74LS	
74LS00	.20
74LS01	.20
74LS02	.20
74LS03	.20
74LS04	.20
74LS05	.20
74LS06	.20
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74S49	.50
74S50	.50

CA-LINEAR	
CA3001H	3.35
CA3002H	3.35
CA3003H	3.35
CA3004H	3.35
CA3005H	3.35
CA3006H	3.35
CA3007H	3.35
CA3008H	3.35
CA3009H	3.35
CA3010H	3.35
CA3011H	3.35
CA3012H	3.35
CA3013H	3.35
CA3014H	3.35
CA3015H	3.35
CA3016H	3.35
CA3017H	3.35
CA3018H	3.35
CA3019H	3.35
CA3020H	3.35
CA3021H	3.35
CA3022H	3.35
CA3023H	3.35
CA3024H	3.35
CA3025H	3.35
CA3026H	3.35
CA3027H	3.35
CA3028H	3.35
CA3029H	3.35
CA3030H	3.35
CA3031H	3.35
CA3032H	3.35
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CA3036H	3.35
CA3037H	3.35
CA3038H	3.35
CA3039H	3.35
CA3040H	3.35
CA3041H	3.35
CA3042H	3.35
CA3043H	3.35
CA3044H	3.35
CA3045H	3.35
CA3046H	3.35
CA3047H	3.35
CA3048H	3.35
CA3049H	3.35
CA3050H	3.35
CA3051H	3.35
CA3052H	3.35
CA3053H	3.35
CA3054H	3.35
CA3055H	3.35
CA3056H	3.35
CA3057H	3.35
CA3058H	3.35
CA3059H	3.35
CA3060H	3.35

## JEB08 PROGRAMMER

### 2708 EPROM PROGRAMMER



The JEB08 EPROM programmer is a compact and powerful unit which is controlled by computer control and memory an additional system. It is a complete system for programming the 2708 EPROM. It is a complete system for programming the 2708 EPROM. It is a complete system for programming the 2708 EPROM.

**JEB08 KIT Assembled and tested \$399.95**  
**JEB08A Assembled and tested \$499.95**

### DISCRETE LEADS

XC555A 200' red	5/81	MV90 085' red	6/31	KC111R 180' red	5/31
XC555G 200' green	4/51	XK209R 125' red	5/31	KC111G 180' green	4/51
XC555Y 200' yellow	4/51	XK209G 125' green	4/51	KC111Y 180' yellow	4/51
XC555C 200' clear	4/51	XK209B 125' blue	4/51	KC111C 180' clear	4/51
KC22R 200' red	5/51	XK209S 185' red	6/31		
KC22G 200' green	4/51	XK209S 185' green	4/51		
KC22Y 200' yellow	4/51	XK209S 185' yellow	4/51		
MV10B 170' red	4/51	XK209S 185' clear	4/51		

### DISPLAY LEADS

G.A. - Common Anode			C.C. - Common Cathode		
Type	Polarity	Ht Price	Type	Polarity	Ht Price
MAN 1	C.A.-red	.270 2.95	DL741	C.A.-red	.500 1.25
MAN 2	C.A.-red	.300 3.35	DL742	C.A.-red	.600 1.49
MAN 3	C.C.-red	.125 .20	DL743	C.C.-red	.600 1.49
MAN 4	C.A.-green	.300 3.35	DL744	C.C.-red	.600 1.49
MAN 5	C.C.-green	.300 3.35	DL745	C.C.-red	.600 1.49
MAN 6	C.A.-red	.300 3.35	DL746	C.C.-red	.600 1.49
MAN 7	C.C.-red	.300 3.35	DL747	C.C.-red	.600 1.49
MAN 8	C.A.-yellow	.300 3.35	DL748	C.C.-red	.600 1.49
MAN 9	C.C.-yellow	.300 3.35	DL749	C.C.-red	.600 1.49
MAN 10	C.A.-orange	.300 3.35	DL750	C.C.-red	.600 1.49
MAN 11	C.C.-orange	.300 3.35	DL751	C.C.-red	.600 1.49
MAN 12	C.A.-orange	.300 3.35	DL752	C.C.-red	.600 1.49
MAN 13	C.C.-orange	.300 3.35	DL753	C.C.-red	.600 1.49
MAN 14	C.A.-orange	.300 3.35	DL754	C.C.-red	.600 1.49
MAN 15	C.C.-orange	.300 3.35	DL755	C.C.-red	.600 1.49
MAN 16	C.A.-orange	.300 3.35	DL756	C.C.-red	.600 1.49
MAN 17	C.C.-orange	.300 3.35	DL757	C.C.-red	.600 1.49
MAN 18	C.A.-orange	.300 3.35	DL758	C.C.-red	.600 1.49
MAN 19	C.C.-orange	.300 3.35	DL759	C.C.-red	.600 1.49
MAN 20	C.A.-orange	.300 3.35	DL760	C.C.-red	.600 1.49
MAN 21	C.C.-orange	.300 3.35	DL761	C.C.-red	.600 1.49
MAN 22	C.A.-orange	.300 3.35	DL762	C.C.-red	.600 1.49
MAN 23	C.C.-orange	.300 3.35	DL763	C.C.-red	.600 1.49
MAN 24	C.A.-orange	.300 3.35	DL764	C.C.-red	.600 1.49
MAN 25	C.C.-orange	.300 3.35	DL765	C.C.-red	.600 1.49
MAN 26	C.A.-orange	.300 3.35	DL766	C.C.-red	.600 1.49
MAN 27	C.C.-orange	.300 3.35	DL767	C.C.-red	.600 1.49
MAN 28	C.A.-orange	.300 3.35	DL768	C.C.-red	.600 1.49
MAN 29	C.C.-orange	.300 3.35	DL769	C.C.-red	.600 1.49
MAN 30	C.A.-orange	.300 3.35	DL770	C.C.-red	.600 1.49
MAN 31	C.C.-orange	.300 3.35	DL771	C.C.-red	.600 1.49
MAN 32	C.A.-orange	.300 3.35	DL772	C.C.-red	.600 1.49
MAN 33	C.C.-orange	.300 3.35	DL773	C.C.-red	.600 1.49

### RADIO CONTROL CIRCUITS

Ideal for remote control systems which use pulse amplitude modulation. (Toy cars, boats, tanks, etc.) Features five function control, adjustable steering angle, suitable for 27 and 47MHz bands and low power consumption.

**KB-4428 TRANSMITTER** (27MHz) Cl. Supply Volt. Vcc: \$4.25  
 Power Dissip. PDI 300mW. Temp. range Oper. 0-100°C  
 Storage -30-125°C. Rec. oper. volt.: 7-11V. Crystal or CR Oscillation circuit acceptable.

**KB-4429 RECEIVER** (27MHz) Cl. Supply Volt. Vcc: \$5.95  
 Abs. max. rating (TYPICAL): Supply volt.: Vcc: 11V. Vcc2: 7.5V. Power Dissip.: 60mW. Temp. range Oper. 0-100°C. Rec. oper. volt.: VDR: 7-11V - VDR: 3-6V.

LOW PROFILE (TINI) SOCKETS		SOLDER TAIL STANDARD (TIN)						
124	25-49	50-100	1-24	25-49	50-100			
8 pin LP	17	16	15	14 pin ST	27	26	25	24
14 pin LP	20	19	18	16 pin ST	33	32	31	30
16 pin LP	22	21	20	18 pin ST	35	34	33	32
18 pin LP	24	23	22	24 pin ST	43	42	41	40
20 pin LP	26	25	24	26 pin ST	45	44	43	42
22 pin LP	28	27	26	28 pin ST	47	46	45	44
24 pin LP	30	29	28	30 pin ST	49	48	47	46
26 pin LP	32	31	30	32 pin ST	51	50	49	48
28 pin LP	34	33	32	34 pin ST	53	52	51	50
30 pin LP	36	35	34	36 pin ST	55	54	53	52
32 pin LP	38	37	36	38 pin ST	57	56	55	54
34 pin LP	40	39	38	40 pin ST	59	58	57	56
36 pin LP	42	41	40					
38 pin LP	44	43	42					
40 pin LP	46	45	44					

### 1/4 WATT RESISTOR ASSORTMENTS - 5%

ASST. 1	5ea.	10 Ohm	12 Ohm	15 Ohm	18 Ohm	22 Ohm	50pcs.	\$1.95
ASST. 2	5ea.	150 Ohm	220 Ohm	330 Ohm	470 Ohm	560 Ohm	50pcs.	\$1.95
ASST. 3	5ea.	470 Ohm	560 Ohm	680 Ohm	820 Ohm	1K	50pcs.	\$1.95
ASST. 4	5ea.	1.2K	1.5K	1.8K	2.2K	2.7K	50pcs.	\$1.95
ASST. 5	5ea.	22K	27K	33K	39K	47K	50pcs.	\$1.95
ASST. 6	5ea.	50K	56K	68K	82K	100K	50pcs.	\$1.95
ASST. 7	5ea.	1M	1.2M	1.5M	1.8M	2.2M	50pcs.	\$1.95
ASST. 8R		Includes Resistor Ass'ts. 1-7 (350 pcs.) \$10.95 ea.						

### Jameco ELECTRONICS

MAIL ORDER ELECTRONICS - WORLDWIDE  
 1355 SHOREWAY ROAD, BELMONT, CA 94002  
 PRICES SUBJECT TO CHANGE

Part No.	Function	Price
70511R	CMOS Precision Timer	15.95
70512R	Stowatch Chip, LCT	22.95
70513R	3 1/2 Digit A/D (LCD Drive)	16.95
70514R	IC, Circuit Board, Display	34.95
70515R	3 1/2 Digit A/D (LED Drive)	15.95
70516R	IC, Circuit Board, Display	24.95
70517R	3 1/2 Digit A/D LCD Dis. H.L.C.	18.95
70518R	3 1/2 Digit A/D LED Dis. H.L.C.	15.95
70519R	Low Battery Volt Indicator	2.25
70520R	CMOS LED Stowatch/Timer	12.95
70521R	Stowatch Chip, XTL	10.95
70522R	Tone Generator, XTL	5.15
70523R	Tone Generator Chip, XTL	9.95
70524R	Oscillator Controller	6.50
70525R	Freq. Counter Chip, XTL	11.10
70526R	7 Segment Counter	17.95
70527R	Clock Generator	3.95
70528R	4 Func. CMOS Stowatch Ckt	13.95
70529R	4 Func. Stowatch Chip, XTL	19.95
70530R	8-Digit Univ. Counter C.A.	32.00
70531R	8-Digit Univ. Counter C.C.	26.95
70532R	8-Digit Univ. Counter C.C.	23.95
70533R	8-Digit LED Up/Down Counter	10.95
70534R	8-Digit Univ. LED Drive	10.95
70535R	LCD 4-Digit Univ. Counter DRI	11.25
70536R	8-Digit Univ. Timer Counter	21.95
70537R	5 Function Counter Chip, XTL	24.95
70538R	CMOS Bin Prog. Timer/Counter	4.95
70539R	CMOS Divide-by-256 RC Timer	2.95
70540R	CMOS BCD Prog. Timer/Counter	5.25
70541R	CMOS 555 Timer (3 pin)	1.45
70542R	CMOS 555 Timer (8 pin)	2.20
70543R	CMOS Op Amp Comparator	5MV 2.25
70544R	CMOS Op Amp Cmv.	5MV 3.95
70545R	CMOS Dual Op Amp Cmv.	5MV 3.95
70546R	CMOS Tri Op Amp Cmv.	10MV 5.25
70547R	CMOS Quad Op Amp Cmv.	10MV 13.50
70548R	CMOS Dual Op Amp Comp. 10M	7.50
70549R	Voltage Converter	2.95
70550R	50ppm Band-GAP Volt. Ref. Diode	2.95
70551R	Volt Ref/Indicator	2.50
70		

### National Semiconductor Clock Modules

12VDC AUTOMOTIVE/ INSTRUMENT CLOCK



**APPLICATIONS:**

- In-dash auto/clocks
- After-market auto/ RV clocks
- Aircraft marine clocks
- 12VDC oper. instru.
- Portable/battery powered instruments.

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

**MA 1003 Module** ..... \$16.95

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

### National Semiconductor RAM SALE



**MM5290J-2** (MK4116/UPD416) . . . \$6.95 each  
 16K DYNAMIC RAM (150NS)  
 (8 EACH \$49.95) (100 EACH \$550.00/lot)

**MM5298J-3A** ..... \$3.25 each  
 8K DYNAMIC RAM (LOW HALF OF MM5290.J) 200NS  
 (8 EACH \$23.95) (100 EACH \$250.00/lot)

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

**MM2114L-3** ..... \$6.25 each  
 4K STATIC RAM (LOW POWER 300NS)  
 (8 EACH \$44.95) (100 EACH \$475.00/lot)

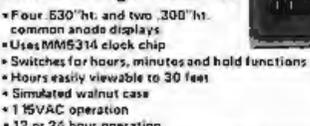
### EPROM Erasing Lamp



- Erases 2708, 2716, 1702A, 52030, 52040, etc.
- Erases up to 4 chips within 20 minutes.
- Maintains constant exposure distance of one inch.
- Special conductive foam liner eliminates static build-up.
- Built-in safety lock to prevent UV exposure.
- Compact - only 7-5/8" x 2-7/8" x 2"
- Complete with holding tray for 4 chips.

**UVS-11E** ..... \$79.50

### Jumbo 6-Digit Clock Kit



- Four 530'ht. and two 300'ht. common anode displays
- Uses MM5314 clock chip
- Switches for hours, minutes and hold functions
- Hours easily viewable to 30 feet
- Simulated walnut case
- 1 15VAC operation
- 12 or 24 hour operation
- Includes all components, case and wall transformer
- Size: 6W" x 3-1/8" x 13"

**JE747** ..... \$29.95

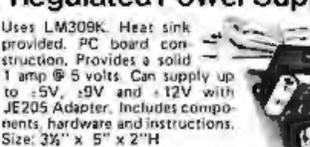
### 6-Digit Clock Kit



- Bright 300'ht. comm. cathode display
- Uses MM5314 clock chip
- Switches for hours, minutes and hold modes
- Hrs. easily viewable to 20 ft.
- Simulated walnut case
- 115 VAC operation
- 12 or 24 hr. operation
- Incl. all components, case & wall transformer
- Size: 6W" x 3-1/8" x 13"

**JE701** ..... \$19.95

### Regulated Power Supply

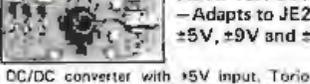


Uses LM309K. Heat sink provided. PC board construction. Provides a solid 1 amp @ 5 volts. Can supply up to +5V, +9V and +12V with JE205 Adapter. Includes components, hardware and instructions. Size: 3 3/4" x 5" x 2 1/4"

**JE200** ..... \$14.95

### ADAPTER BOARD

Adapts to JE200 - ±5V, ±9V and ±12V



DC/DC converter with +5V input. Toroidal hi speed switching X.M.F.R. Short circuit protection. PC board construction. Piggy-back to JE 200 board. Size: 3 3/4" x 2" x 9 1/16" H

**JE205** ..... \$12.95

### MICROPROCESSOR COMPONENTS

8080A/8080A SUPPORT DEVICES		DATA ACQUISITION (CONTINUED)	
INTELC8080A	CPU	ADCONV2	4 Bit A/D Converter (8 Ch. Multi)
INTELC8080B	8 Bit Input/Output	ADCONV4	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080C	8 Bit Input/Output	ADCONV8	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080D	8 Bit Input/Output	ADCONV16	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080E	8 Bit Input/Output	ADCONV32	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080F	8 Bit Input/Output	ADCONV64	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080G	8 Bit Input/Output	ADCONV128	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080H	8 Bit Input/Output	ADCONV256	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080I	8 Bit Input/Output	ADCONV512	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080J	8 Bit Input/Output	ADCONV1024	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080K	8 Bit Input/Output	ADCONV2048	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080L	8 Bit Input/Output	ADCONV4096	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080M	8 Bit Input/Output	ADCONV8192	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080N	8 Bit Input/Output	ADCONV16384	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080O	8 Bit Input/Output	ADCONV32768	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080P	8 Bit Input/Output	ADCONV65536	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080Q	8 Bit Input/Output	ADCONV131072	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080R	8 Bit Input/Output	ADCONV262144	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080S	8 Bit Input/Output	ADCONV524288	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080T	8 Bit Input/Output	ADCONV1048576	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080U	8 Bit Input/Output	ADCONV2097152	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080V	8 Bit Input/Output	ADCONV4194304	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080W	8 Bit Input/Output	ADCONV8388608	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080X	8 Bit Input/Output	ADCONV16777216	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080Y	8 Bit Input/Output	ADCONV33554432	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080Z	8 Bit Input/Output	ADCONV67108864	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080AA	8 Bit Input/Output	ADCONV134217728	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080AB	8 Bit Input/Output	ADCONV268435456	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080AC	8 Bit Input/Output	ADCONV536870912	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080AD	8 Bit Input/Output	ADCONV1073741824	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080AE	8 Bit Input/Output	ADCONV2147483648	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080AF	8 Bit Input/Output	ADCONV4294967296	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080AG	8 Bit Input/Output	ADCONV8589934592	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080AH	8 Bit Input/Output	ADCONV17179869184	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080AI	8 Bit Input/Output	ADCONV34359738368	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080AJ	8 Bit Input/Output	ADCONV68719476736	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080AK	8 Bit Input/Output	ADCONV137438953472	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080AL	8 Bit Input/Output	ADCONV274877906944	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080AM	8 Bit Input/Output	ADCONV549755813888	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080AN	8 Bit Input/Output	ADCONV1099511627776	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080AO	8 Bit Input/Output	ADCONV2199023255552	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080AP	8 Bit Input/Output	ADCONV4398046511104	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080AQ	8 Bit Input/Output	ADCONV8796093022208	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080AR	8 Bit Input/Output	ADCONV17592186444416	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080AS	8 Bit Input/Output	ADCONV35184372888832	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080AT	8 Bit Input/Output	ADCONV70368745777664	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080AU	8 Bit Input/Output	ADCONV14073749155328	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080AV	8 Bit Input/Output	ADCONV28147498310656	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080AW	8 Bit Input/Output	ADCONV56294996621312	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080AX	8 Bit Input/Output	ADCONV112589993242624	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080AY	8 Bit Input/Output	ADCONV225179986485248	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080AZ	8 Bit Input/Output	ADCONV45035997297056	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080BA	8 Bit Input/Output	ADCONV90071994594112	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080BB	8 Bit Input/Output	ADCONV180143989088224	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080BC	8 Bit Input/Output	ADCONV360287978176448	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080BD	8 Bit Input/Output	ADCONV720575956352896	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080BE	8 Bit Input/Output	ADCONV1441151912705792	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080BF	8 Bit Input/Output	ADCONV2882303825411584	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080BG	8 Bit Input/Output	ADCONV5764607650823168	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080BH	8 Bit Input/Output	ADCONV11529215301646336	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080BI	8 Bit Input/Output	ADCONV23058430603292672	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080BJ	8 Bit Input/Output	ADCONV46116861206585344	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080BK	8 Bit Input/Output	ADCONV92233722413170688	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080BL	8 Bit Input/Output	ADCONV184467448826341376	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080BM	8 Bit Input/Output	ADCONV368934897652682752	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080BN	8 Bit Input/Output	ADCONV737869795305365504	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080BO	8 Bit Input/Output	ADCONV1475739590610730016	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080BP	8 Bit Input/Output	ADCONV2951479181221460032	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080BQ	8 Bit Input/Output	ADCONV5902958362442920064	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080BR	8 Bit Input/Output	ADCONV11805916724885840128	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080BS	8 Bit Input/Output	ADCONV23611833449771680256	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080BT	8 Bit Input/Output	ADCONV47223666899543360512	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080BU	8 Bit Input/Output	ADCONV94447333799086721024	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080BV	8 Bit Input/Output	ADCONV188894667598173442048	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080BW	8 Bit Input/Output	ADCONV377789335196346884096	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080BX	8 Bit Input/Output	ADCONV755578670392693768192	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080BY	8 Bit Input/Output	ADCONV1511157340785387536384	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080BZ	8 Bit Input/Output	ADCONV3022314681570775072768	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080CA	8 Bit Input/Output	ADCONV6044629363141550145536	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080CB	8 Bit Input/Output	ADCONV12089258726283100291104	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080CC	8 Bit Input/Output	ADCONV24178517452566200582208	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080CD	8 Bit Input/Output	ADCONV483570349051324011644416	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080CE	8 Bit Input/Output	ADCONV967140698102648022888832	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080CF	8 Bit Input/Output	ADCONV19342813962052960577776	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080CG	8 Bit Input/Output	ADCONV3868562792410592115555552	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080CH	8 Bit Input/Output	ADCONV773712558482118423111104	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080CI	8 Bit Input/Output	ADCONV1547425116764376462222208	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080CJ	8 Bit Input/Output	ADCONV3094850233528752924444416	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080CK	8 Bit Input/Output	ADCONV6189700467057504848888832	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080CL	8 Bit Input/Output	ADCONV123794009341150096977776	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080CM	8 Bit Input/Output	ADCONV2475880186823001939555552	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080CN	8 Bit Input/Output	ADCONV495176037364600387911104	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080CO	8 Bit Input/Output	ADCONV9903520747292007758222208	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080CP	8 Bit Input/Output	ADCONV19807041494558015176444416	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080CQ	8 Bit Input/Output	ADCONV39614082989117030352888832	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080CR	8 Bit Input/Output	ADCONV792281659782340607057776	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080CS	8 Bit Input/Output	ADCONV158456321164480121411555552	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080CT	8 Bit Input/Output	ADCONV3169126423289602428222208	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080CU	8 Bit Input/Output	ADCONV6338252846579204856444416	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080CV	8 Bit Input/Output	ADCONV12676505693158409712888832	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080CW	8 Bit Input/Output	ADCONV253530113863168194257776	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080CX	8 Bit Input/Output	ADCONV507060227726336388511555552	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080CY	8 Bit Input/Output	ADCONV1014120455452672777022208	4 Bit A/D Converter (16 Ch. Multi)
INTELC8080CZ	8 Bit Input/Output	ADCONV2028240910905345554044416	4 Bit A/D Converter (16 Ch. Multi)
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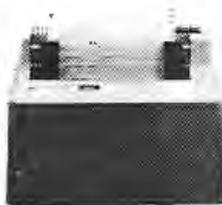
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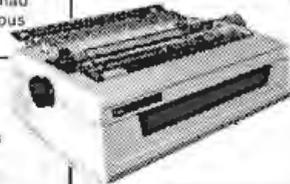
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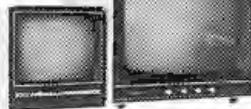
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Preview of the Apple III

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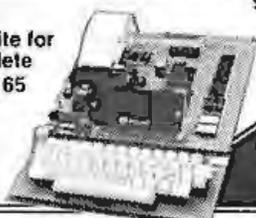
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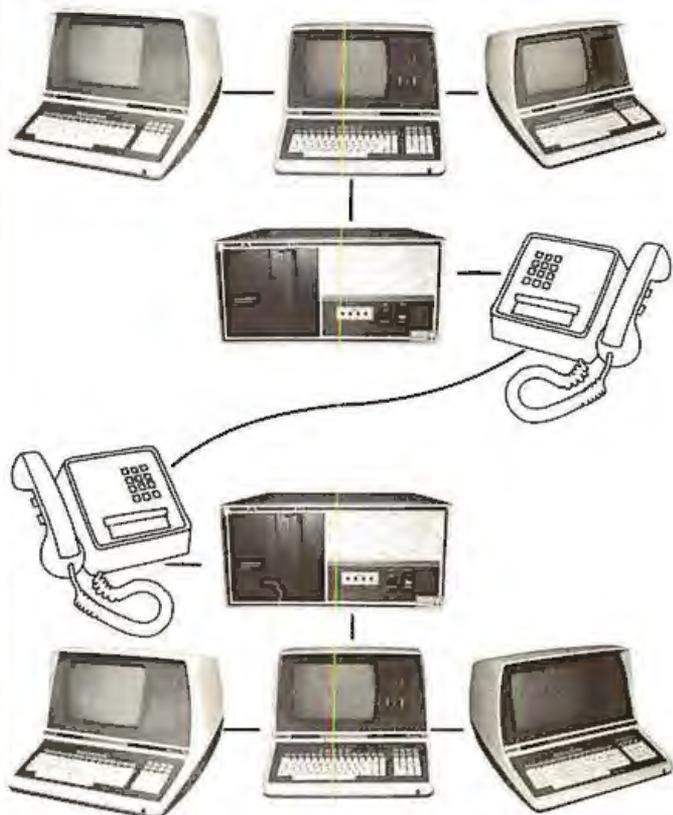
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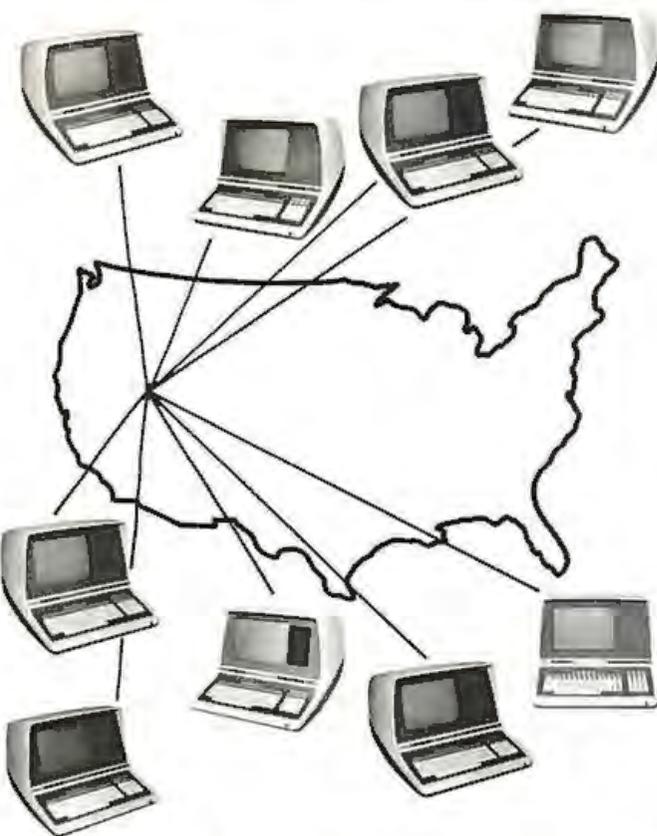
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**PRIORITY ONE ELECTRONICS**  
 16723B ROSCOE BLVD. • SEPULVEDA, CA. 91343  
 (800) 423-5633 or (213) 894-8171

## MICROPOLIS OVERSTOCK LIST

MODEL	DESCRIPTION	LIST PRICE	SALE PRICE
MCP-1053-2	630 KB DUAL	\$1895.00	\$995.00
MCP-1043-2	315 KB SINGLE	\$1145.00	\$695.00
MCP-1041-2	315 KB SINGLE, NO PS	\$1045.00	\$635.00
MCP-1042-1	143 KB SINGLE	\$795.00	\$625.00
MCP-1041-1	143 KB SINGLE, NO PS	\$695.00	\$595.00

COMPLETE W/S-100 CONTROLLER, CABLES, MANUALS & MICROPOLIS MDOS & BASIC

### ADD-ON DRIVES

MCP-1033-2	630 KB DUAL	\$1395.00	\$895.00
MCP-1023-2	315 KB SINGLE	\$645.00	\$495.00
MCP-1021-2	315 KB SINGLE, NO PS	\$545.00	\$475.00
MCP-1022-1	143 KB SINGLE	\$545.00	\$375.00
MCP-1021-1	143 KB SINGLE, NO PS	\$445.00	\$360.00

REQUIRES ACCESSORY ADD-ON CABLES

### TRS-80® DISK DRIVES

APP 395M	35 TRACK SINGLE	\$545.00	\$360.00
VRB-MD 525-16	35 TRACK DUAL	\$1195.00	\$695.00
VRB-MD 577-16	77 TRACK SINGLE	\$645.00	\$495.00
VRB-MD 525-01	77 TRACK DUAL	\$1395.00	\$895.00
VRB-FD05	NEW DOS/80 TRS-80® 35 thru 77 TRACK OPERATING SYSTEM	\$545.00	\$360.00
PR1-34CEEE-2	Verbatim 16 Sector Diskettes Box of 10	\$1195.00	\$695.00
PR1-34CEEE-4	Verbatim 16 Sector 77 Track Cert Box of 10	\$645.00	\$495.00
	Verbatim Soft Sector Diskettes Box of 10	\$1395.00	\$895.00
	5 1/4" Disk Drive Cleaning Kit	\$149.00	\$100.00
	Two Drive Data Cable	\$29.95	\$29.95
	Four Drive Data Cable	\$48.00	\$48.00
		\$29.95	\$29.95
		\$29.95	\$29.95
		\$39.95	\$39.95

ALL DRIVES NEW, IN FACTORY SEALED CARTONS WITH FULL MANUFACTURES WARRANTY.

\* Sale Prices are for prepaid orders only • Quantities are limited, subject to prior sale • CREDIT CARD ORDERS WILL BE CHARGED APPROPRIATE FREIGHT • PRICES GOOD THRU NOVEMBER, 1980



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Terms: Visa, MC, BAC, Check, Money Order, U.S. Funds Only. CA residents add 6% sales tax. Minimum order \$15.00 Prepaid U.S. orders less than \$75.00 include 5% shipping and handling. MINIMUM \$2.50. Excess refunded. Just in case...please include your phone number. Prices subject to change without notice. We will do our best to maintain prices thru November 1980.

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PRIORITY ONE IS HERE NOW!  
BUT YOU'LL SLEEP BETTER IF  
YOU DON'T KNOW WHAT PRICES  
I'VE QUOTED .....



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I SAID BUILD 300  
DRIVES NOT 3000!

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# 1

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# California Digital

Post Office Box 3097 B • Torrance, California 90503

## NEW

from  
INTEGRAL DATA  
**460**  
Paper Tiger

\*\*\*\* All the features of the 440 and more \*\*\*\*  
The 460 uses a dot matrix character formation technique in which the placement of the dots overlap both horizontally and vertically to achieve a correspondence-quality printing. The printer's nine-wire print head uses staggered needle rows to create the vertically overlapping dots. The head is driven bidirectionally under microprocessor control by a stepper motor driven mechanism with logic-seeking look ahead capability. Standard "Two-K Byte" buffer allows the printer to accept the entire content of a 1,920-character CRT screen. Weight 27 lbs. suggested list price \$1,295. Calif. Digital price **\$1,076**

## S-100 POWER SUPPLY

Mfg. for California Digital by **\$59**  
**SIERRACIN**



Designed for on board regulation  
8V, 16V, 24V, 28V, 32V, 36V, 48V  
Input: 115/230V A.C.  
Power: 100W-200W  
(Same as above but \$1.200; 215V-24V; 216W; 200W-200W)  
195

## TELETYPE MODEL 43

4320 KEYBOARD  
TTL ..... AAA \$ 950  
RS232.... AAK 1050 plus shipping  
Friction... AAE 1100  
103 Modem AAB 1575



## WESTERN UNION ENCLOSURE

These enclosures were manufactured for Western Union by Integral Data Technology. The exact purpose of the product is still a mystery but the enclosure is ideally suited for an S-100 interface board with standard power supply. Removable front and plastic front cover fits enclosure as an attractive home for any hobby project. New surplus in factory boxes supplied with forty 22/14 wire connectors. 100% guaranteed volume production, also not guaranteed power output and more. Available dimensions: 19" x 13 1/2" x 4 1/2". Shipping weight 8 lbs.



\$24.95

FREE with purchase of each box of ....  
Memorex mini-diskettes, 15 value.

**\$27** BOX of TEN  
10 Boxes \$24.95  
100 Boxes \$22.25  
forty track

## IEE Projection Module



**\$995**  
set of three  
\$25

Voltage applied to one of the twelve discrete miniature incandescent 3.5W 100V lamps causes the module to display the selected character. 14-60Hz 50/60Hz. Users may substitute the character film and display pictures and symbols of their own choosing. Manufactured by Industrial Electronic Engineers Inc. SFC-4, 12 Good Creek Blvd. 24 lamp module also available.

### DB25

each 10+  
male \$250 225  
female 325 305  
hood-zp 125 98  
Centronic 695

### Edge Connectors

**GOLD 100 PIN**  
MSAI/ALTAIR

msai solder .125x.250 \$2.95 3/4 1.50  
msai w/125 centers \$4.95 3/4 13.00  
Altair solder tail .140mm \$5.95 3/4 15.00

22/44 Kim style .156" \$1.95 3/4 5.00  
25/50 solder tab .156" \$1.09 3/4 3.00  
36/72 wide post w/w.156" \$1.85 3/4 5.00

### BCD Thumbwheel Switch 195

The Position Mfg. by Duglitch 1 7/8" high 1 1/2" wide

### Lear Seigler Inc. In Plant

## POCKET INTERCOM \$14.95

Another one of our mystery products. Manufactured by the Lear Seigler Company. The pocket intercom is supplied in a sleek drawn laser applied aluminum enclosure. Excellent for those special projects which require a touch of elegance. List price \$145. Supplied with chrome pocket clip. 3V transistor volume required. Model 1103. New surplus. measures 2.5x2.7x1.125" SFC-134

### XEROX 800 WORD PROCESSING KEYBOARD

ASCII ENCODED

This 77 key word processing keyboard was manufactured by Microswitch for use in the Xerox 800 word processing system. The keyboard outputs a seven bit ASCII code along with an eighth bit that allows most keys to shift and double function as special characters. Extra large "Tab & Return" keys are designed into the layout of the keyboard to emulate the IBM Selectric. 17 illuminated keys serve for special word processing codes. The keyboard is equipped with two thumbwheel switches for defining line width.

Original Xerox acquisition over \$100.00 California Digital price only \$49.99 Excellent condition. Documentation included.

### Scotch Data Products

740-0 IBM soft format	\$39.00	\$3.50
740-2 Double side soft	65.00	6.00
741-0 Double density	53.00	4.90
743-9 Double/Double	70.00	6.60
740-32 8" Hard sector	39.00	3.50
744-10K 10K16) 5 1/4" mini	39.00	3.50

Library case for any above: Add \$3.00  
834 A Data Cassette 5.50  
DC 100 Mini Cartridge 16.00  
DC 300 Data Cartridge 20.00  
820( ) Disk Cartridge 89.20

### Shugart Associates

## SAB800-R Floppy Disk Drive \$449.50

The SAB800-R floppy disk drive is a high performance, reliable, and easy to use device. It is designed for use with the SAB800-R floppy disk controller and the SAB800-R floppy disk format. The drive is compatible with the SAB800-R floppy disk format and the SAB800-R floppy disk controller. The drive is available in two configurations: 5 1/4" and 8".

### Scotch Diskette Head Cleaning Kit \$24.95

Scotch Diskette Head Cleaning Kit is a complete kit for cleaning and maintaining the heads of your Scotch diskette drive. The kit includes a cleaning solution, a cleaning cloth, and a cleaning brush. The kit is easy to use and will help you keep your diskette drive in top condition.

## MEMORY

### TRS-80 APPLE II \$39

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

Installation is simple. Anyone who has ever changed a spark plug should be able to up-grade his microcomputer.

How can California Digital offer these memory up-grade sets at 25% below our competition? Simple, we buy in volume, wholesale to dealers and sell the balance directly to owners of personal micro-computers. These 16K dynamic memory circuits are factory prime and unconditionally guaranteed for one full year. NOW, before you change your mind, pick up the telephone and order your up-grade memory from California Digital. Add \$3 for TRS80 jumpers.

### DATA INPUT TERMINAL \$49

This Kenatron terminal was recently acquired from the CDC division of the Perkin Corporation. The unit was originally designed for inputting data directly into magnetic tape.

The system is composed of a premium cast aluminum and fiberglass enclosure, along with a memory/7 channel shift key effect keyboard. Three display lamps indicate the position of the system status. Four touch key tactile sensitive switches are used to control the operation of the terminal.

Most of all this "USED" terminal, with a little imagination, can be converted to make the perfect home for a 3-100 computer and video display, or with slight modification will accept the Intel-8085 micro-computer.

Free with regular price supply is available for an additional \$10. See your local dealer for more information. Original acquisition over \$100. 22 lbs.

### MINIATURE SWITCHES \$1.98

your choice

SPDT Miniature Toggle

7101 CAN	ON-NONE-ON
7102 INT	ON-OFF-INT-ON
7103 CK	ON-OFF-ON

Rotary 3P-4-Pos. 3P-6-Pos.  
Push B (N.C.) \$3.95 ea. 4/51

## 2716 EPROM SALE \$13

THOUSANDS

We have slashed price in an effort to reduce our over stocked inventory. These are Single Five Volt Eproms, manufactured by one of the World's largest producers of semiconductors. Please phone for volume pricing.

STATIC	1-31	32-99	100-5C	899	1K+
21L02 450nS.	1.19	.89	.95	.90	.85
21L02 250nS.	1.49	1.39	1.25	*	*
2114 1Kx4 450	5.95	5.50	5.25	4.75	4.50
2114 1Kx4 300	8.95	8.50	8.00	*	*
4044 4Kx1 450	5.95	5.50	5.25	*	*
4044 4Kx1 250	8.95	8.50	8.00	*	*
4045 1Kx4 450	8.95	8.50	8.00	*	*
4045 1Kx4 250	8.95	8.50	8.00	*	*
3257 low pow.	5.95	5.50	5.00	4.80	4.60

### CONTROL DATA CRT Terminal? \$49

Found? we make a mistake and are offering these terminals below our cost just to get them out of our warehouse. As far as we can determine the units are complete. But we are offering them as "AS IS" basis without any return privilege.

The terminals were originally purchased from All State Insurance. At present we have been unable to secure any printed information on the units. If you have any doubts, please do not purchase one of these terminals shipped via truck. freight collect.

### KEYBOARD \$24.95

This classic three keyboard is similar to the models used in the Hewlett Terminal. \$2 non-wrapped contacts. three locking. Factory sealed (three surplus) Shipping 1 lbs.

### IBM 2980 SELECTRIC BANK TERMINAL \$250

The IBM 2980 terminal was designed to be located at each teller's station in a branch bank. The terminal was on line to a master computer. Information entered into the terminal would instantaneously adjust the customer's account on the computer. A record of the transaction would be entered into the customer's passbook and simultaneously recorded onto a continuous 10 column paper roll located within the terminal.

The heart of the 2980 is the IBM Selectric typewriter. Each unit is supplied with print roll, ribbon and full documentation.

A potential use for this I/O terminal is in business applications where information must be entered onto ledger cards at the same time data is recorded at the computer. USED surplus, 77 lbs.

### BSR SYSTEM X-10

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

BSR Timer \$85.00  
Master Console 34.95  
Ultrasonic Controller 18.85  
Modules: Appliance, Lamp or Wall Switch 13.85

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### TECHNICAL & CALIFORNIA

## 213 679-9001

VISA  
master charge

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All merchandise sold by California Digital is premium grade. Shipping: First five pounds \$2.00; each additional add \$1.40 Foreign orders 10% shipping. Excess will be refunded. California residents add 8% 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.

# Computers, Disk Systems

## SUPERBRAIN<sup>™</sup> By INTERTEC



32K or 64K (Double or Quad Density units available) Uses two Z-80 CPU's. Commercial-type terminal with 12" monitor. Dual double density minifloppies. Over 350 kilobytes of storage (twice that with quad density drives). Two serial RS232 ports, I/O ports standard. Expandable with optional S-100 S-100 interface. Comes with CP/M™ 2.2 operating system. MiniMicroMart includes BASIC interpreter and can supply a wide range of CP/M Development and Application software.

w/32K Double Density, List \$2995 **\$2685**  
w/64K Double Density, List \$3345 ..... \$2883  
w/64K Quad Density, List \$3995 ..... \$3595  
W/64K Quad — MiniMicroMart  
Upgrade Special..... \$3395

## MICROMATION



A 64K complete computer with dual density 8" floppies (1 megabyte). Rack or vertical mounting. Systems with double sided drives, hard disks, and multi-user (MP/M).  
Z + 100 64K RAM, Computer, \$2495. **\$2099**  
Z + 120 Includes two 8" disks, \$4995. **\$4199**  
"Z" system features new distributed processing multi user concept with one Z-80 per user, with Z-80 for MP/M (Master Satellite concept).  
**AS LOW AS \$11,899!**

## SD SYSTEMS

SDS 100, w/32K RAM, \$6995 **\$5945**  
SDS-200, List \$8995 ..... \$7645

## RADIO SHACK TRS-80™

**10% OFF!**



## INTERSYSTEMS formerly ITHACA AUDIO



DPS-1, List \$1795

**Call for Price!**

The new Series II CPU Board features a 4 MHz Z-80A CPU and a full-feature front panel. 20-slot actively terminated motherboard, with 25 amp power supply (50/60 Hz operation, incl. 68 cfm fan).

**COMPLETE SYSTEM** with InterSystem 64K RAM, I/O Board w/priority interrupt and double density disk controller board. Full 1-year warranty, List \$3595

**Call for Price!**

## HEWLETT-PACKARD HP-85A

Desk-Top  
Computer

**Call  
for  
Price**



## MORROW THINKER TOYS® DISCUS M26™

26 megabytes of  
formatted storage  
List \$4,995

**\$4,199**



## THINKER TOYS® DISK SYSTEMS

Now includes CP/M® 2.2

Discus 2D, List \$1199. .... **\$1019**

Discus 2D, dual-drive, List \$1994 ..... \$1694

Discus 2 + 2, Assem., List \$1549. .... \$1319

Dual Discus 2 + 2, Assem., \$2748. .... \$2335

All Morrow systems now include CP/M® 2.2

Circle 380 on Inquiry card.

## NORTH STAR MDS-A Double Density Mini Floppy Disk System

Double Density, Kit

List \$799

**OUR PRICE \$669**

Assembled and Tested, ..... \$719

Quad Version, Kit, List, ..... \$836

Assembled, List \$1099. .... \$896

Above MDS-A units do not include cabinet or power supply.

Shipping and Insurance: Add \$7.50.

## NEW! CROMIX FROM CROMEMCO

A New UNIX Like  
Disk Operating System.

With true multi-user,  
multi-tasking capabilities

List \$295 ..... **OUR PRICE \$249**

## NEW! DOUBLE DENSITY CONTROLLER BOARD FROM CROMEMCO

With built-in diagnostics

16 FDC Controller, List \$595 **OUR PRICE \$505**



## NEW! CROMEMCO SYSTEM ZERO

List \$995 ..... **OUR PRICE \$849**

**NEW! CROMEMCO SYSTEM ZERO/O**

A complete 64K Computer with Double  
Density Disk Controller ..... List \$2995

**OUR PRICES \$2545**

Companion Disk drive for above —

Quad Density — Total of 780 Kilobytes of  
storage on the two drives. .... List \$1295

**OUR PRICE \$1099**

Only \$3644 for a complete 64K Disk System

**MORROW  
Discus 2D's  
IN STOCK**

# Terminals and Printers!

## TELEVIDEO TVI-912C



Upper and lower case, 15 baud rates: 75 to 19,000 baud, dual intensity, 24 x 80 character display, 12 x 10 resolution. Numeric pad. Programmable reversible video, auxiliary port, self-test mode, protect mode, block mode, tabbing, addressable cursor. Microprocessor controlled, programmable underline, line and character insert/delete. "C" version features typewriter-style keyboard. List \$950

**OUR PRICE \$789**

920C (with 11 function keys, 6 edit keys and 2 transmission mode keys, List \$1030)  
**ONLY \$849**

## Intertec EMULATOR

Software compatible with a Soroc IQ-120, Hazeltine 1500, ADM-3A or DEC VT-52. Features block mode transmission and printer port; 12" anti-glare screen; 18-key numeric keypad; full cursor control. List \$895

**OUR PRICE \$749**



## NEW INTERTUBE III

List \$995 **ONLY \$749**

12" display, 24 x 80 format, 18-key numeric keypad, 128 upper/lower case ASCII characters. Reverse video, blinking, complete cursor addressing and control. Special user-defined control function keys, protected and unprotected fields. Line insert/delete and character insert/delete editing, eleven special line drawing symbols.

## SOROC



**IQ-120**  
List \$995  
**SPECIAL \$729**

IQ-140 List \$1495  
**SPECIAL \$1149**

## HAZELTINE

1500  
**ONLY \$879**



1410 w/numeric keypad, List \$900 ..... \$749  
1420 w/lower case and numeric pad ..... 849  
1510, List \$1395 ..... 1089  
1520, List \$1650 ..... 1389

## NEC SPINWRITER™



Terminal/Keyboard as well as RO Printer Only models available.

**CALL FOR PRICES!**

## CENTRONICS PRINTERS

**NEW 730**, parallel, friction, tractor ... **\$679**  
**NEW 737** parallel, friction, tractor ... **\$849**  
779-2 w/tractor (same as TRS-80 Line Printer II), List \$1350 ..... 1049  
702 120 cps, bi-direct., tractor, VFU ..... 1995  
703 185 cps, bi-direct., tractor, VFU ..... 2395  
704 RS232 serial version of 703, \$2350 .. **\$1995**

Above prices reflect a 2% cash discount (order prepaid prior to shipment). Add 2% to prices for credit card orders, C.O.D.'s, etc. Prices are f.o.b. shipping point. Prices are subject to change and offers subject to withdrawal without notice. **WRITE FOR FREE CATALOG.**

## TI-810



TI-810 Basic Unit, \$1895 . **ONLY \$1695**  
TI-810 w/full ASCII (Lower case), vertical forms control, and compressed print . \$1895  
TI-745 Complete printing terminal with acoustic coupler, List \$1695 .... **\$1399**

## PAPER TIGER®



**IDS-440 Paper Tiger**, List \$995 . **\$895**  
w/graphics option, incl. buffer, \$1194 .. \$989  
TRS-80 cable ..... 45  
**NEW IDS PAPERTIGER 460**List \$1295 . **\$1149**  
**NEW IDS PAPERTIGER 460G** List \$1394 **\$1199**

**NEW IDS 460**  
**QUALITY PRINTING AT MATRIX**  
**SPEED—LOGIC SEEKING**  
**PROPORTIONAL SPACING**  
w/auto text justification

## ANADEX DP9500 / DP9501 PRINTERS

DP-9500, List \$1650 ..... **\$1399**  
DP-9501, List \$1650 ..... **\$1399**

## OKIDATA Microline 80 **ONLY \$649**

Tractor Feed Option ..... \$99  
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**COMPRINT 912 w/parallel interf.** **\$559**  
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# MiniMicroMart, Inc.

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**If North Star or Cromemco offer it . . .**

**WE HAVE IT!!**

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32K Double Density  
Assembled and Tested  
List \$3095

**ONLY \$2619**

**ASSEMBLED**

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HORIZON 2, 32K, DD . . \$2619	48K, QD, List \$4090 . . . . . 3469
32K, QD, List \$3595 . . . . 3049	64K, DD, List \$3830 . . . . . 3239
48K, DD, List \$3590 . . . . 3039	64K, QD, List \$4330 . . . . . 3669

**NORTH STAR APPLICATIONS SOFTWARE**

(Exclusive for use with North Star Disk Systems — specify Double or Quad Density)

NORTHWORD, List \$399 . . . . .	\$339
MAILMANAGER, List \$299 . . . . .	249
INFOMANAGER, List \$499 . . . . .	419
GENERALLEDGER, List \$999 . . . . .	799
ACCOUNTSRECEIVABLE, List \$599 . . . . .	499
ACCOUNTSPAYABLE, List \$599 . . . . .	499

**NORTH STAR HARD DISK HD-18**

18 megabytes, plugs into parallel port of North Star Horizon. Utilizes tried-and-proven 14" Century Data Marksman. List \$4999.

**OUR PRICE \$4199**

**NORTH STAR MDS-A** — Double (or Quad) Density Disk System, Kit, List \$799. **OUR PRICE \$669**  
Assembled and Tested, List \$899 **SPECIAL \$719**

**NORTH STAR MEMORY BOARDS**

16K Dynamic RAM (RAM-16-A/A), Assembled, List \$499 . . . . .	\$420
Kit, List \$449 . . . . .	<b>SPECIAL \$299</b>
32K (RAM-32/A), Assembled, List \$739 . . . . .	\$620
Kit, List \$669 . . . . .	<b>ONLY \$499</b>

**INTRODUCTORY SPECIALS ON ...**

**PREMIUM QUALITY BASF DISKS  
CERTIFIED FOR QUAD SYSTEMS**

(Box of ten)

5 1/4" DOUBLE DENSITY DOUBLE SIDED List \$57.50 . . . . .	\$38.95
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Shipping \$2.50 — Free Shipping in Multiple Of Two Boxes

SHIPPING AND INSURANCE: Add \$15 on Horizons, \$2.50 for Boards and Software. Hard Disk Systems and Cromemco systems shipped freight collect. Advertised prices are for prepaid orders. Credit card and C.O.D. 2% higher. Deposit may be required on C.O.O. All prices subject to change and offers subject to withdrawal without notice.

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**NEW System 3**

by CROMEMCO

Now with Dual  
Double Sided  
Double Density  
(over 2 megabytes  
of Storage  
64K of RAM  
List \$7395

**LIMITED TIME  
INTRODUCTORY SPECIAL \$6199!**

**CROMEMCO SYSTEM 2** — Now double Density with Double Sided Drives, Quad Capacity mini floppy disc drives. List \$3990 . . . . . **Only \$3390**

**CROMEMCO Z-2H** Full 11-megabyte Hard Disk system. Fast Z-80A 4 MHz processor, two floppy disk drives, 64K RAM memory, RS232 special interface, printer interface, and extensive software available.  
List \$9995



**OUR PRICE \$8489**

**NEW DOUBLE DENSITY CONTROLLER BOARD**

From Cromemco

With built-in diagnostics — 16 FDC Controller

List \$595 . . . . . **OUR PRICE \$505**

Z-2 COMPUTER SYSTEM List \$995 . . . . . **\$845**

SINGLE CARD COMPUTER — SCC-W 4 MHz. List \$450 . . . . . **\$382**

NEW COLOR GRAPHICS INTERFACE — SOI List \$595 **OUR PRICE \$505**

CROMEMCO HDD — 11/22-megabyte Hard Disk for use with existing systems. DMA controller. Transfer rate of 5.6 megabytes/second.

HDD-11. List \$6995 . . . . . **OUR PRICE ONLY \$5939**

HDD-22. List \$11,995 . . . . . **\$10,189**

**MiniMicroMart, Inc.**

1618 James Street, Syracuse, NY 13203 (315) 422-4467

TWX 710-541-0431



Circle 382 on inquiry card.

# Try to beat our prices!

## SUPERBRAIN<sup>™</sup> by Intertec



Self-contained computer with dual disks and two RS232C ports. Complete with CP/M 2.2 and BASIC.

32K Double Density, List \$2995 **\$2685**  
 64K Double Density, List \$3345 **\$2883**  
 64K MiniMicroMart-upgraded to Quad Density **SPECIAL \$3395**

## NORTH STAR HORIZON<sup>®</sup>

**HORIZON 1 ASSEMBLED & TESTED**  
 32K, Double Density, List \$2695 **\$2279**  
 32K, Quad Density, List \$2995 **\$2539**

**HORIZON 2 ASSEMBLED & TESTED**  
 32K, Double Density, List \$3095 **\$2619**  
 32K, Quad Density, List \$3595 **\$3049**  
 48K, Double Density, List \$3590 **\$3039**  
 48K, Quad Density, List \$4090 **\$3469**  
 64K, Double Density, List \$3830 **\$3239**  
 64K, Quad Density, List \$4330 **\$3669**

LIMITED QUANTITY OF  
 HORIZON 2 KITS AVAILABLE

## FLOPPY DISK SYSTEMS

**NORTH STAR MDS-A**  
 Assembled, List \$899 **SPECIAL \$ 719**  
 Kit Version, List \$799 **\$ 669**

**MORROW THINKER TOYS<sup>™</sup> Discus 2D,**  
 List \$1199 **OUR PRICE \$1019\***  
 Discus 2D, dual-drive, List \$1994 **\$1694\***  
 Discus 2 + 2, A&T, List \$1549 **\$1319\***  
 Dual Discus 2 + 2, A&T, List \$2748 **\$2335\***  
 \*Now includes CP/M<sup>™</sup> 2.2

**MICROMATION Megabox, DD w/**  
 8" drives, 1 megabyte, List \$2295 **\$1949**  
 2-megabyte, List \$3095 **\$2629**

**MICROPOLIS 1041 MacroFloppy<sup>™</sup>**  
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**EDUCATORS:** Small private school in central Connecticut (K-8) is considering implementation of microcomputers into curriculum. If you've previously experienced such an endeavor in this age group and would be willing to share an evening enlightening faculty and concerned parents, please contact us. We're eager to make this a successful program, and would be interested in learning how your program was launched and pitfalls to avoid. The Independent Day School, Laurel Brook Rd, Middlefield CT 06455, Attn: William Murdoch, (203) 238-3994.

**FOR SALE:** Voltage regulator, SOLA BASIC 750 VA Unit #63 13-175. Never used, output two outlets, 6.25 A maximum. \$300, shipping additional. Jane Groene, 1 Harmony Ct, Syosset NY 11791, (516) 921-4900.

**WANTED:** KIM-1 or similar microcomputer for dedicated real-time system. Must be like KIM-1: easily expandable but otherwise a bare single-board system. Needed for temperature monitoring system in a solar greenhouse. Robert Heller, Star Route Box 51A, Wendell MA 01379, (617) 544-6416 between 8:30 and 5.

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**FOR SALE:** Eaton LRC 7000 plus 64-character printer; \$250. Radio Shack Quick Printer II 32-character (Catalog #26-1155); \$150. Send certified check or money order. William R Spencer Jr, 5421 Grandin Rd Ext, Salem VA 24153.

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**FOR SALE:** Hazeltine 1500 CRT terminal (less case, cable, XFMR); \$450. Anderson Jacobson acoustic coupler #242A; \$120, full ASCII keyboard; \$50. S Gladstone, 150 W Cedar St #6, Norwalk CT 06854, (203) 866-8930.

**WANTED:** Soft black leather case for the HP-45, 65, or 67. New or used. E King, 870 W 181 St, New York NY 10033, (212) 568-3309.

**FOR SALE:** Ithaca Audio 8 K, 250 ns static programmable-memory board for S-100 with protect; \$120. Ithaca Audio S-100 video-display board, 64-by-16 uppercase and lowercase with Greek symbols, normal or reverse video, 1 K on-board programmable memory; \$75. Mostek 4115N dynamic-programmable memories; eight for \$30. Ted Betz, Box 379A RD#1, Farmingdale NJ 07727, (201) 938-3722.

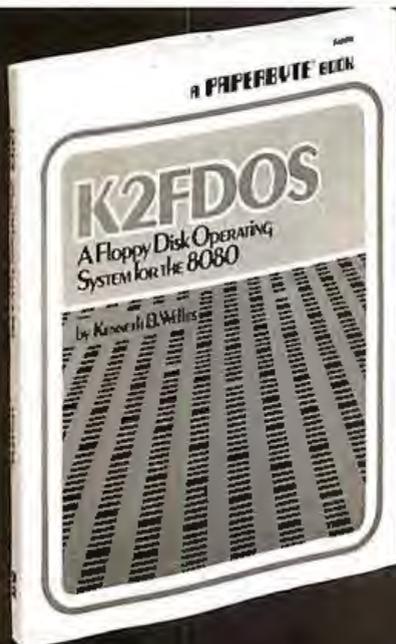
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**FOR SALE:** Apple II computer with 36 K memory, AppleSoft Firmware Card, disk drive with controller, all manuals, plus extras. Everything is in excellent condition. \$1200 or best offer. David J Bauman, 249 Taft St, Wind Gap PA 18091, (215) 863-5736.

**WANTED:** S-100 system: Z80 processor, 48 thru 64 K programmable memory, 15-slot mainframe, 5 V at 15 A, ± 18 V at 1 A power supply, video-display board, serial and parallel I/O. Optional: keyboard, cassette interface, and read-only memory monitor. Fred Tydeman, 3901 Northfield Rd, Austin TX 78759, (512) 255-9292 evenings.

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**WANTED:** Three to six 8080 hackers to work with machine-language Monitor, Editor, and Assembler that I have developed. You will get free software in exchange for user comments and suggestions. First letter should give programming experience, computer type, and input format required. Robert G Durnal, POB 68, Junior WV 26275.

**FOR SALE:** Radio Shack 16 K Level II TRS-80 microcomputer. With numeric keypad, expansion interface, cassette recorder, and several game cassettes including Microchess. List price is \$1200. I will sell for \$750. First cashier's check/money order takes it (I pay shipping). Include SASE for confirmation. Chris Willson, 8726 S Sepulveda Apt 91B, Westchester CA 90045.

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**NEEDED:** Information, kit, schematics, or advice on turning ITEL word-processor typewriter Model 84101010 into computer terminal or printer. Gordon Dohle, 414-34 Kleisinger Cr, Regina Saskatchewan, S4R 7M4 Canada.

**FOR SALE:** IMSAI mainframe with 10-slot motherboard, Ithaca Audio Z80 processor board (with 2708), SSM V81 video board, 32 K static-programmable memory, and Soroc 117-key professional keyboard. Best offer over \$600. Bob Watson, (602) 526-2312.

**WANTED:** Student experimenter wants integrated circuits, transistors, capacitors, resistors, LEDs, books, catalogs, magazines, diodes, switches, tubes, wire, printed-circuit boards, knobs, TTL circuits, keyboards, crystals, transformers, and parts-identification book. Please state price and what you have to offer in full detail. Judy Stapleton, POB 536, Pine Lake GA 30072.

**FOR SALE:** IMSAI 8080 with 16 K bytes, 3 P plus S Teletype I/O board, Tarbell cassette interface, case, panel, and 22-slot motherboard. 8 K BASIC and all standard software. Panasonic cassette unit. Perfect condition. \$600 plus shipping, or best offer. Also available: ASR33 teletypewriter. Dick Aronson, 61 Morton St, New York NY 10014, (212) 243-0623 home, (212) 758-6500 work.

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**FOR SALE:** Radio Shack TRS-80 Model I Level II. Equipped with 36 K programmable memory, 10-key pad, expansion interface. Unit is barely used, has been factory serviced, and can handle additional 16 K programmable memory. \$1000. Also, IBM Selectric Model 71-3 I/O device with TRS-80 printer-port interface. Gives letter-quality hard copy. \$650. Take both for \$1400. Doug Bowie, POB 3453, San Francisco CA 91449, (415) 861-6883.

**FOR SALE:** Diablo Hytype 1 Model 1200. Best of the daisy-wheel printers. Brand-new unit with in-feed friction platen and print wheel. Interface for Apple, TRS-80, and CP/M systems. Maintenance manual and additional interface information available. Scott Priester, 211 White Water Ct, Greer SC 29651, (803) 268-0678 after 6 PM.

**FOR SALE:** HP-41C calculator, card reader, two memory modules, and all manuals for \$425. All components essentially new. The system was replaced by an HP-85 before all HP-41C components were received. Ernest W Graham, POB 396, Shaw Island WA 98286.

**FOR SALE:** Fairchild PEP 3870 development board. In circuit emulation of 3870 series single-chip microcomputers. Programs 38E70 and 2718 PROM. Never used. Paid \$450; asking \$350. Ron Sutherland, POB 1147, Lawrence KS 66044, (913) 841-9433.

**FOR SALE:** Expando Black Box printer, 80-column, for connection to parallel port. Includes cable for connection to TRS-80 and maintenance manual with schematics. Cost over \$350 two years ago. Needs some attention, but otherwise in good condition. \$150 including UPS freight. Gary Taylor, Princeton Plasma Physics Laboratory, POB 451, Princeton NJ 08544, (609) 683-2573.

# BOMB

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### FORTH Is First

John James' introductory article on FORTH won the BOMB first place in our fourth annual August language issue. Steve Ciarcla came in second with his construction article about a homemade modem for under \$50. Kim Harris' unique article, "FORTH Extensibility," ran a close third. The BOMB cards for this month were unusually enthusiastic in their rating of individual articles, affirming the overall positive reaction to this issue. Several BOMB cards expressed support for the article on Khachiyan's algorithm. First place for August was 1.70 standard deviations above the mean, followed by second place at 0.95. ■

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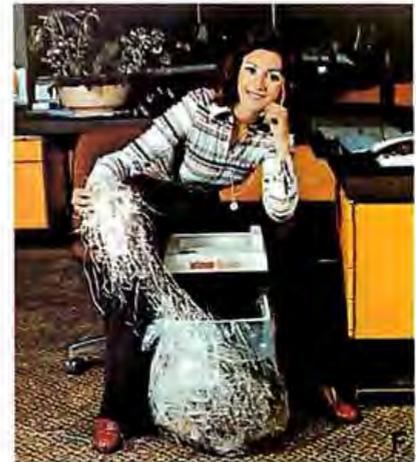
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