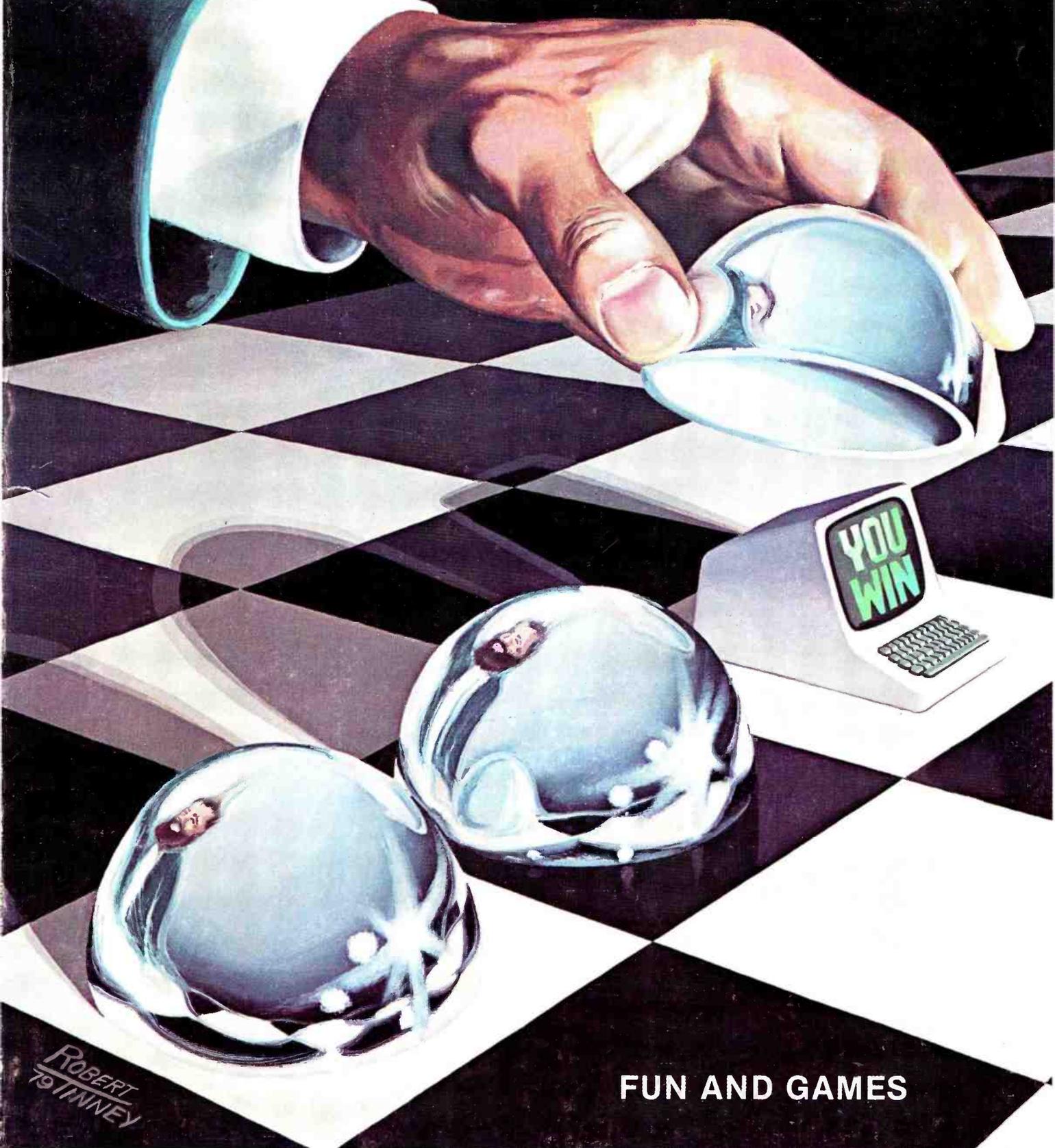


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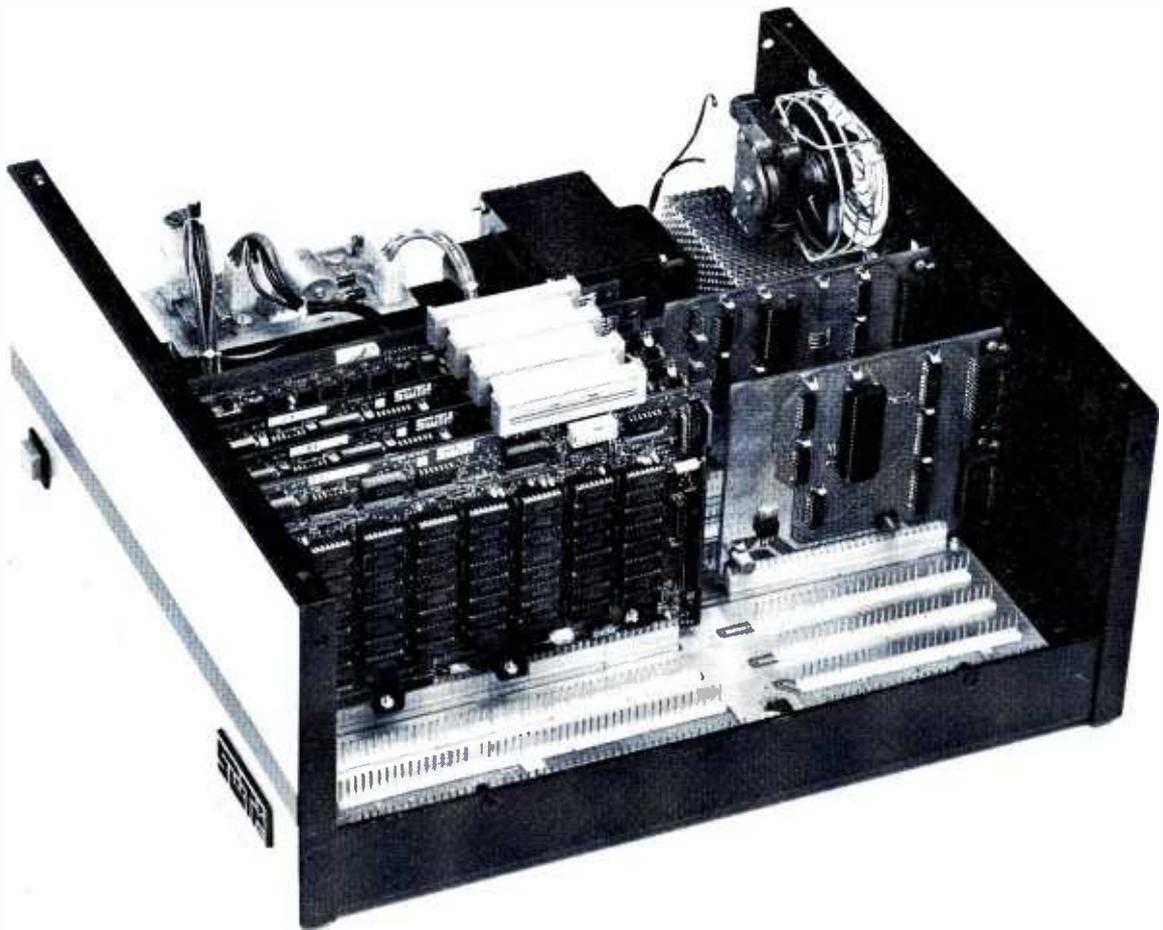
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FUN AND GAMES



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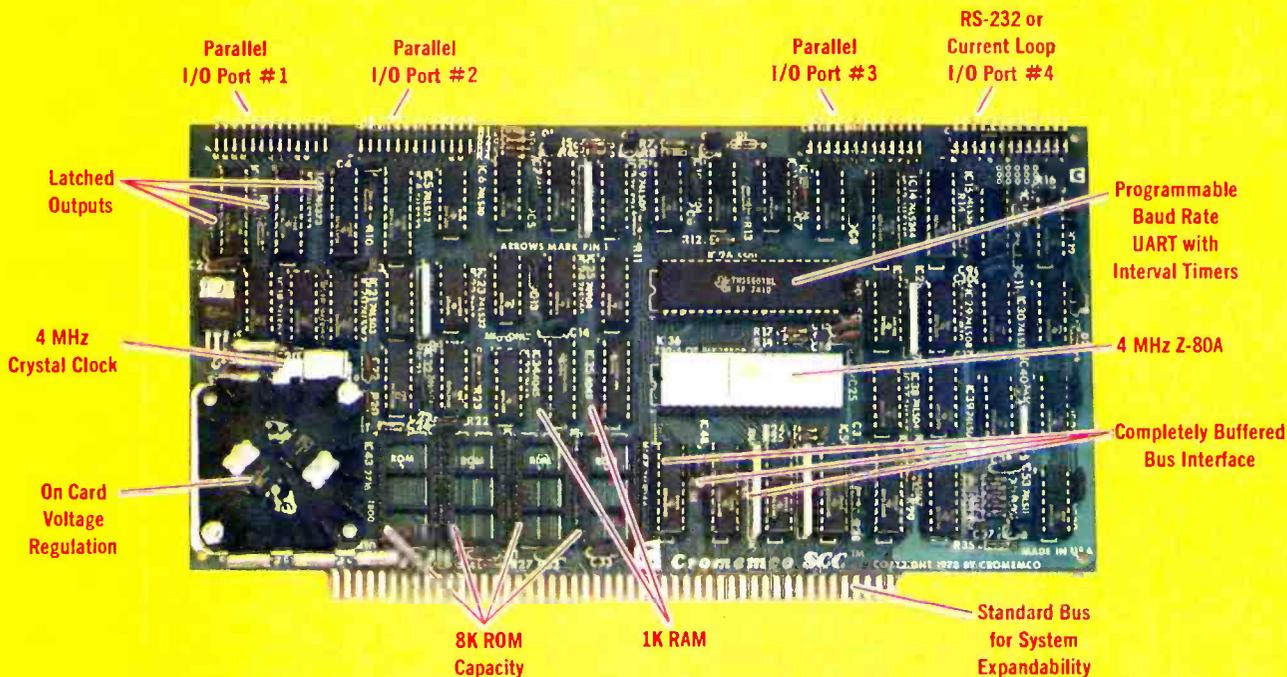
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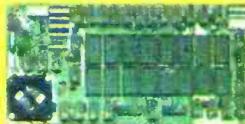
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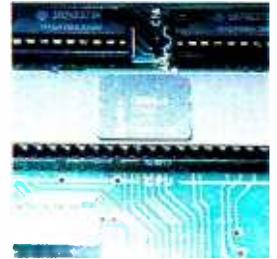
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Cover Art: The Magic of Computers *by Robert Timney*

BYTE is published monthly by BYTE Publications Inc, 70 Main St, Peterborough NH 03458, a wholly-owned subsidiary of McGraw-Hill, Inc. Address all mail except subscriptions to above address: phone (603) 924-7217. Address subscriptions, change of address, USPS Form 3579, and fulfillment questions to BYTE Subscriptions, PO Box 590, Martinsville NJ 08836. Second class postage paid at Peterborough NH 03458 and at additional mailing offices—USPS Publication No. 102410 (ISSN 0360-5280). Subscriptions are \$18 for one year, \$32 for two years, and \$46 for three years in the USA and its possessions. In Canada and Mexico, \$20 for one year, \$36 for two years, \$52 for three years. \$32 for one year air delivery to Europe. \$32 surface delivery elsewhere. Air delivery to selected areas at additional rates upon request. Single copy price is \$2.50 in the USA and its possessions, \$2.95 in Canada and Mexico, \$4.00 in Europe, and \$4.50 elsewhere. Foreign subscriptions and sales should be remitted in United States funds drawn on a US bank. Printed in United States of America.

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In This BYTE



About the Cover

The theme for this issue is "Fun and Games", using the personal computer to implement dynamic interactive forms of enjoyment not otherwise possible. In the cover by Robert Timney, entitled "The Magic of Computers", we find the essence of an ancient shell game applied with a desk top computer as the missing pea.

One of the quickest ways to gain experience with a processor is to actually program and interface to it. The Intel 8086 16-bit processor is now available for evaluation as the SDK-86 single board computer. Steve Ciarcia evaluates the SDK-86 board.

Page 14

The solution of games such as Soma Cubes and polyominoes presents the computer programmer with a nontrivial problem. Although the method of solution may seem quite straightforward, the actual implementation may use up excessive amounts of memory or time. This was one problem facing Douglas Macdonald and Yekta Gürsel when they started Solving Soma Cube and Polyomino Puzzles Using a Microcomputer. Their final program is capable of solving many problems of this

sort in reasonable lengths of time on an 8 K byte machine.

Page 26

Peter B Maggs takes readers behind the scenes to show how a programmer can design a board-game program using minimax theory, a technique used to maximize one's chances of winning a game. Read Programming Strategies in the Game of Reversi, a tutorial article with broad applicability in the field of computer games.

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Implementing the data structures needed to simulate a chess game is a task that the average programmer is quite capable of performing. However, developing an effective method of defining the respective priorities for all the possible moves is a

cumbersome task whose solution has eluded many programmers. W D Maurer illustrates the use of the game-tree diagram in a method called Alpha-Beta Pruning, a technique that offers a possible solution to this problem.

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Owners of Commodore PETs often wish to have hard-copy printouts of data appearing on their machine's video displays. P K Govind gives advice on how to obtain hard copy in Interfacing the PET to a Line Printer.

Page 98

Escape all your earthly restrictions and go into orbit with A Spacecraft Simulator. Gary Sivak has put together a BASIC program to put your celestial flight skills to the test.

Page 104

One type of popular computer-game activity is the simulation of sports events. If you have ever wondered if the best baseball team of today could beat the best team of some long-past season, you may now be able to get at least a theoretical answer. Joseph J Roehrig developed a system that uses real statistical data to simulate the play of baseball games, and he now shares it with us in The National Micropastime.

Page 113

Using stacks can help to simplify otherwise very complex programming problems. In Stack It Up,

Charlton H Allen demonstrates a simple procedure for evaluating mathematical expressions that employ stack control.

Page 140

Have your recent endeavors with your personal computer been all work and no play? Tony Estep discusses some of the basic principles involved in Writing Animated Computer Games. The software was written for the SOL-20, but with minor modifications will run on any VDM-based 8080 computer.

Page 152

Even if you own a minimum computer system, you can still do interesting things with it. Charles A Kapps gives Five Useful Programs for the SC/MP which are suitable for minimum systems. The routines can be converted to other systems, such as the COSMAC VIP and KIM.

Page 172

Do you need a simple device to show logic signals compared to the system clock? Frank DeCaro can help you to Build a Simple Digital Oscilloscope.

Page 222

Where most people are particular about the computer they buy, they don't think twice about the most frequently used component of a system: the keyboard. The Cherry PRO Keyboard is Dan S Parker's choice and he tells us why.

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Editorial

Is Pseudoscience Done by Computer Pseudo-Computer- Science?

by Carl Helmers

One of my main tasks each month is reading all the manuscripts which are sent to BYTE by authors, who are often our readers. The number of well-prepared manuscripts which come our way is fantastic, and for obvious reasons of space we can only accept so many in a given interval of time. Thus, when an unsolicited article is received, we look for a certain uniqueness of idea and appropriateness for our readers. The article content of BYTE magazine is approximately 90% the result of unsolicited articles. Of course, exceptions occur, for example, the 6809 series by Joel Boney and Terry Ritter (which required a bit of encouragement in advance of its writing), or several of the articles on LISP in our August 1979 issue, which were solicited explicitly by guest editor John Allen.

Thus, a magazine like BYTE has proven to be a self-generating forum, as the readers interact with authors and, as they write about their own particular experiences or pet concepts, even become authors.

This month our featured theme for the issue is loosely entitled "Fun and Games," ie, how computers can be used in various forms to implement mental recreations. We describe how to use computers to simulate mythical worlds and situations and to examine logically defined games and their states. All these topics and more fit under this general category of fun and games.

Readers who examine our table of contents, however, will find that not one of our recent articles has been devoted to the subject of "biorhythms," this in spite of the immense popularity of biorhythm programs at every convention or computer demonstration and a virtual flood of prospective article submissions on this topic. Far be it from me to belittle the concept of having harmless fun with computers by creating fantasy trips and games. Just because one can program a computation does not make that computation a valid representation or model of the real world — witness the fun and humor we get out of fantasy games. Humor is in large measure due to a gentle (or not so gentle) bending of reality in a specific and limited context.

But some biorhythm writers start out by pontificating the veritable truth of a hypothesis and its implications, and fail to make the point that it is all a fantasy simulation. Most people writing about the biorhythm algorithm assume that it corresponds to a proven, well-documented and scientifically valid field of endeavor.

I am reminded of the epistemology of a former associate of mine, who shall remain anonymous. His epistemology essentially boiled down to "if it is printed on paper it must be true . . ." Much has been printed about the alleged validity of the biorhythm mythology; there is an entire branch of the special-purpose computer industry devoted to cranking out biorhythm calculators. And biorhythm programs do indeed appear in much of the sales promotional literature of personal computing. But that does not make the results a science any more than the prevalence of adventure-style games in tomorrow's computers makes any statement about the real world, other than mankind's characteristic love of fantasy. A corollary of the "if it's printed" epistemology is the statement "if it is represented in a programmed calculation, it must be true . . ."

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As commonly stated, the biorhythm hypothesis has two major assertions. The first is that there exists a fixed point in time, namely the date of birth, when each individual's biological clock starts ticking. The second is that there are three well-defined periods which start in phase at that reference point and have an integer relationship to one another. The particular integers are unimportant. Then, by doing a Fourier summation with unit amplitudes on the three periodic waveforms, we come up with the time domain evaluation of one's state for any given date after birth. Much graphic display programming can be done to make the results of this meaningless calculation look beautiful on a color terminal.

The holes in this hypothesis are obvious. First, why are integer ratios used? After all, nature seems to abhor integers in physical constants, especially so in complicated systematic entities such as biological organisms. At the level of physical constants and ratios of physical constants, there is only one experimental near-integer of any prominence: the reciprocal fine structure constant (137.0360) — and even its "integerness" has become less significant of late as the limits of physical precision of measurement have improved.

Then, in a fallacy shared with astrology, biorhythm calculations assume that the date of birth somehow determines the whole of one's life. In view of even recent knowledge of biological organisms, why not use the date of conception? Replies the "biorhythmicianologist," "Oh, but we don't know that precisely! So let's use something we know instead!" Thus, if there were any validity to a lifelong cycle, the hypothesis would start off by picking a random phase point which is the date of

birth relative to the whole lifetime of the organism. But living systems do not fit ad hoc assumptions. It is true that we observe periodicities in life, even in our own personal lives. But, in order to study such rhythms, the spirit of the natural science investigator must be invoked, obviously aided by the tools of calculation which are now so widely available.

A detailed scientific dissection of biorhythms can be found in William Bainbridge's article "Biorhythms: Evaluating a Pseudoscience," in *The Skeptical Enquirer*, published by the Committee for the Scientific Investigation of Claims of the Paranormal. Editor Kendrick Frazier and the editorial board (which includes such luminaries as Martin Gardner and Philip J Klass) are fighting a valiant fight against the doctrines of pseudoscience in today's world. The magazine is published four times a year. Subscriptions are \$10 a year and are available from the Executive Editor, *The Skeptical Enquirer*, POB 5 Amherst Br, Buffalo NY 14226.

Thus, the dearth of biorhythm calculation articles in BYTE will continue. But, on quite a different plane, there is ample room for appropriate articles on personal information analysis — possibly with some attention to the idea of biological rhythms, which forms the basis for the genuine science of chronobiology. Here we make the hypothesis that there are obvious rhythms of some variables of daily life which go up and down.

To explore this hypothesis, we begin to take data on our daily personal lives using an appropriate measurement. This could be a single bit of information such as "today was a good day" or "today, on the balance, was not so good." Or it could be a series of integer evalua-

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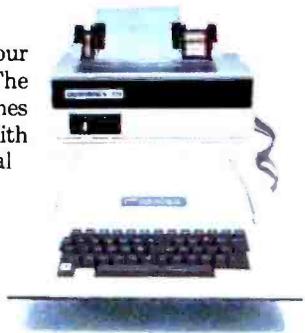
The RS-232 standard assures maximum compatibility with a variety of serial devices. For example, with the AIO you can connect your Apple* to a video terminal to get 80 characters per line instead of 40, a modem to use time-sharing services, or a printer for hard copy. The serial interface is software 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.

This interface can be used to connect your Apple* to a variety of parallel printers. The programmable I/O ports have enough lines to handle two printers simultaneously with handshaking control. The users manual includes a software listing for controlling parallel printers or, if you prefer, a parallel driver routine is available in firmware as an option. And printing is only one application for this general purpose parallel interface.

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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 price, including PROMs and cables, is \$135 in kit form, or \$175 assembled and tested. See the AIO at your local computer store or contact us for more information.



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To explore this hypothesis, we begin to take data on our daily personal lives using an appropriate measurement. This could be a single bit of information such as "today was a good day" or "today, on the balance, was not so good." Or it could be a series of integer evaluations of the form "on a scale of 1 to 10, today rated 8." The important idea here is to begin taking measurements. When a real sequence of data has been built up over several hundred days, we can begin to check the hypothesis for validity by using a Fourier analysis of the data to isolate periodic effects. Due to the sampling time of once per day, no periods could possibly be present shorter than two days, and the longest periodicity component would be half the number of days in the sample. But the result would be a calculated spectrum for this "how I feel" variable. Then, one could check this continuing curve for function for predictability. Besides the Fourier decomposition approach, other methods of analysis are of course possible. Any of the commonly used methods for stock market "prediction" could certainly be applied.

But the result of this "biological rhythm" exercise would be very specific and only applicable to the individual who makes the measurements. There would be no reason to assume that any period found in this data would be the same length as the period for any other person. I do not know what the results would be, but the method of checking the hypothesis is present, and the means of doing such an experiment are within the grasp of every reader who owns a personal computer and who can find access to a Fourier analysis program — such as the Fast Fourier Transform. (See BYTE December 1978 and February 1979 for articles on the Fast Fourier Transform technique.)

So, to answer the question raised by this editorial, I would conclude with several points. First, pseudoscience is pseudoscience. Second, pseudoscience done by computer is still pseudoscience, for the tools of implementation hardly affect the imprecision of thought used in ignoring reality.

Finally, what makes the pseudoscience a pseudoscience is its element of pious fraud, an attempt to ignore contrary data and purport that its premises describe and predict reality. When we remove any intention of purporting that the given hypothesis is anything other than a fantasy, then the pseudoscience classification goes away and we can enjoy it as a game or fantasy.

Thus, pseudoscience done by computer is most definitely not pseudo-computer-science, for even a biorhythm program can be correctly implemented from its premises! And, with the caveat of not purporting a false scientific validity to our fantasies, we can have lots of fun correctly implementing quasi-computer science fantasies and games which make absurd premises. ■

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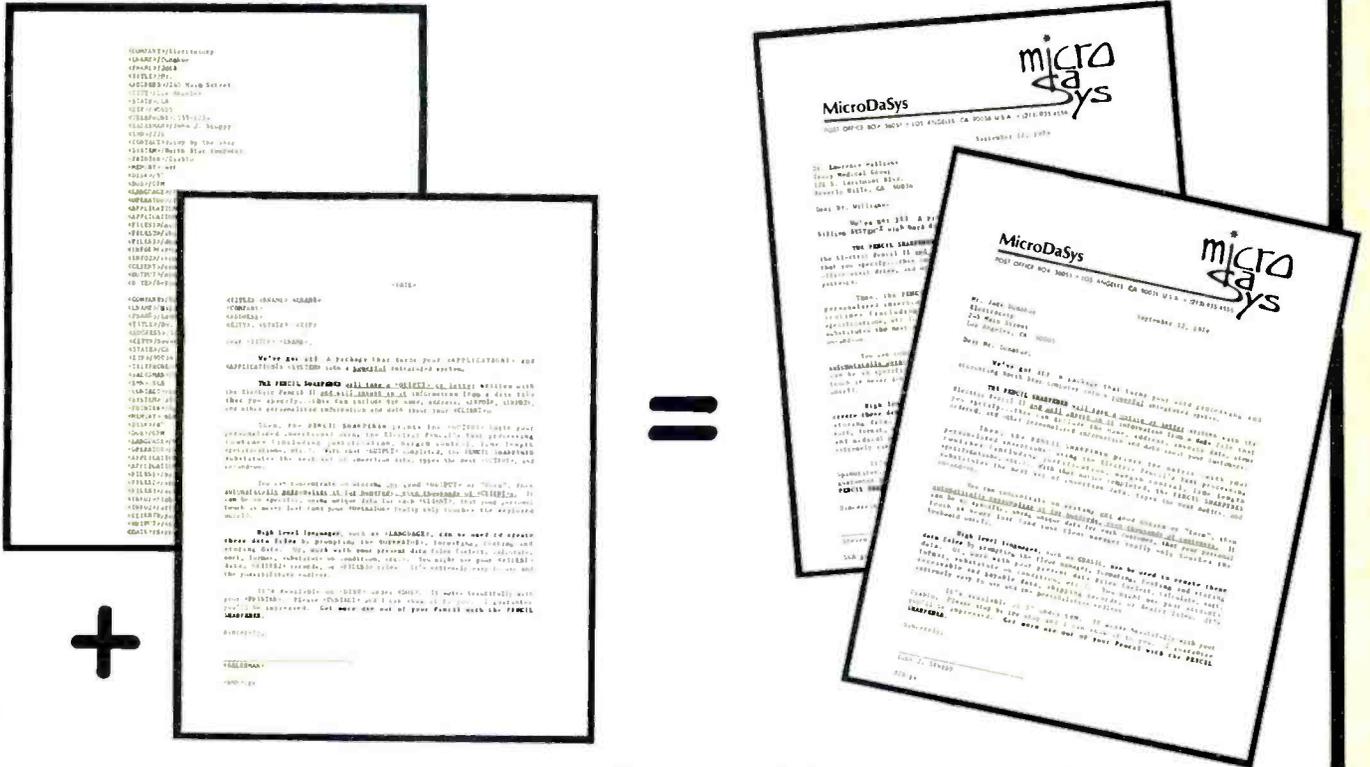
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Letters

Mind Over Matter Expansion

I found your article "Mind Over Matter" (June 1979 BYTE, page 149) very interesting. When all the components arrive, I hope to have an operational muscle monitor. A friend of mine has a great deal of enthusiasm for brain wave monitors, and, although I do not quite see the magic he sees in them, the idea is intriguing.

My difficulty with building the brain wave monitor is that my knowledge of electronics has never gotten past the reading the Heathkit-instructions-stage. You mentioned changing the 100 K ohm

resistor on IC2 to 1 M ohm for brain wave amplification, which is OK; however, then you said that bandpass filters must be added, and you have lost me.

I know it would be a time-consuming project, but I thought that I would try and trouble you for a circuit and parts list at the Heathkit-level for brain wave monitor expansion. I assume that, along with input to an oscilloscope (Heathkit, naturally), the analog output could be used as input to my Cromemco D+7A I/O board?

Frank Gizinski
2060 St Clair St
Racine WI 53402

Author Ciarcia Replies:

I hope you will have an operational muscle monitor by the time you read this. I regret, however, that I cannot comply with your request. Heathkit and the Muppets both have something in common: because the original is done so well and anything equivalent could only be accomplished with a similar effort, there are no copies. Except through the effort of a complete article on the subject, I hesitate to do only half the job by sketching out a

few filter circuits which ultimately demand a great deal of technical ability.

In addition to yours, many letters have requested expansion information. In actuality, the required circuitry would constitute a low-frequency spectrum analyzer. I will look into the design, and use it either as an article specifically on expansion of the "Mind over Matter" introduction, or as an additional supplement with one of my regular monthly offerings. I am aware of the obvious interest in expansion, and I do try to present circuits that can be readily constructed.

Finally, the biofeedback interface can be readily used with the Cromemco A/D board, if the analog output from the monitor is scaled down to 0 to 2.56 V. This can be done with a 500 K ohm potentiometer serving essentially as a volume control. Analysis of the acquired data is another subject entirely.

Perhaps your strength is really software, and you will achieve success better by this method. The ultimate goal is to analyze the low-frequency spectrum. This can be done either through hardware or software.

A Rejoycing LISPer

Had James Joyce been a computer scientist, he would have created LISPer.

Martin D Sandman
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San Diego CA 92124

Move Segmenting

I was gratified to see some evidence ("A Digital Alphanumeric Display," April 1979 BYTE, page 218) that someone is beginning to realize that 7 segments can portray alphanumerics, but noted that Daniel Chester's 7-segment set is confusing in these respects:

A "G" could be a "9,"
a "Q" could be a "9,"
an "S" could be a "5,"
and a "Z" could be a "2."

The following is a set which I devised two years ago:

A b c d E F G H I J K L M n o P q r S t u
V W (= or) Y and Z 0 1 2 3 4 5 6 7 8 9

You will note that none of these characters are ambiguous. Furthermore, they do not conflict with Mr Chester's set of special characters.

Alex Funk
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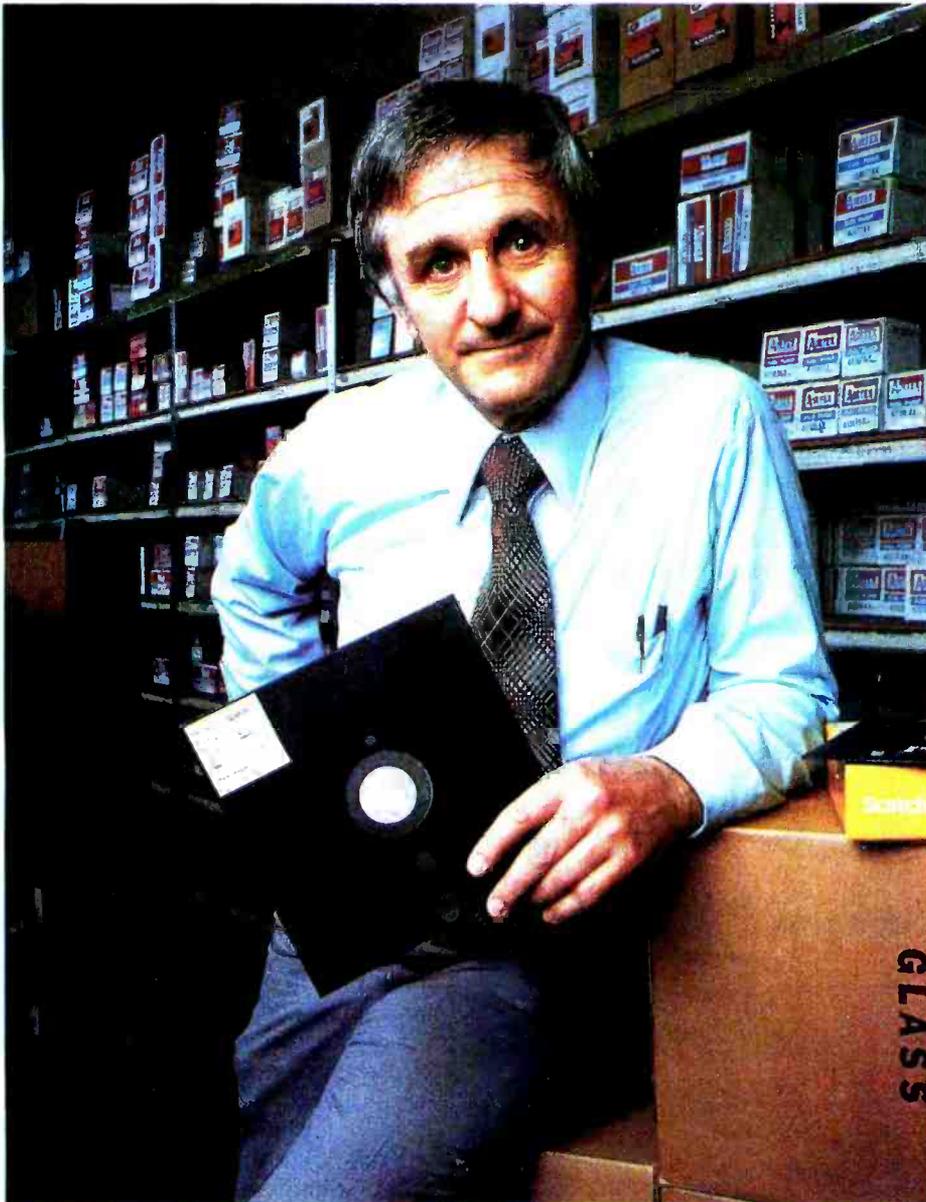
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The Intel 8086

Steve Ciarcia
POB 582
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There has been a lot of talk about 16-bit microprocessors lately. You are probably interested in how they work and how they differ from present 8-bit microprocessors. This may seem more important to someone designing systems for a living rather than to the casual computer experimenter; but ultimately personal computing will be affected.

The majority of systems currently available use 8-bit processors primarily because few cost-effective 16-bit processors were available when these systems were designed. As new

personal computers are conceived, the designers will have more 16-bit microprocessors to choose from, and in my opinion, the latter will win out.

Software development is much more expensive than hardware development. It is much cheaper to write one line of code executing a hardware multiply instruction than to write an algorithm to do the same function on a processor devoid of this direct capability. Reduced cost of development should be reflected in lower retail cost. There are always exceptions to the rule, but once amor-

tized and in volume production, the 16-bit microprocessor should prove to be the logical choice for medium to high-level applications.

The Intel 8086

It isn't necessary to wait any longer if you have a burning desire to learn about 16-bit microprocessors. The latest one available and in volume production is the Intel 8086. The 8086 is a 16-bit microprocessor which is upward-compatible from the 8-bit 8080/8085 series processors. The 8086 contains a set of powerful, new 16-bit instructions. This enables a system designer familiar with 8080 devices to start coding immediately and gradually gain expertise in using the additional 16-bit instructions. It is important to realize that when I refer to compatible instructions I mean functional compatibility. A program written for an 8080 would have different object code than an 8086. This is only a slight inconvenience considering that this former 8080 program should run about ten times faster on an 8086. The evolutionary step between the 8086 and 8080 is far greater than that between the 8080 and 8088.

The apparent goal of Intel designers was to extend existing 8080 features symmetrically and add a wide range of new processing capabilities. The added features include 16-bit multiply and divide, interruptible byte-string operations, 1 M byte direct addressing, and enhanced

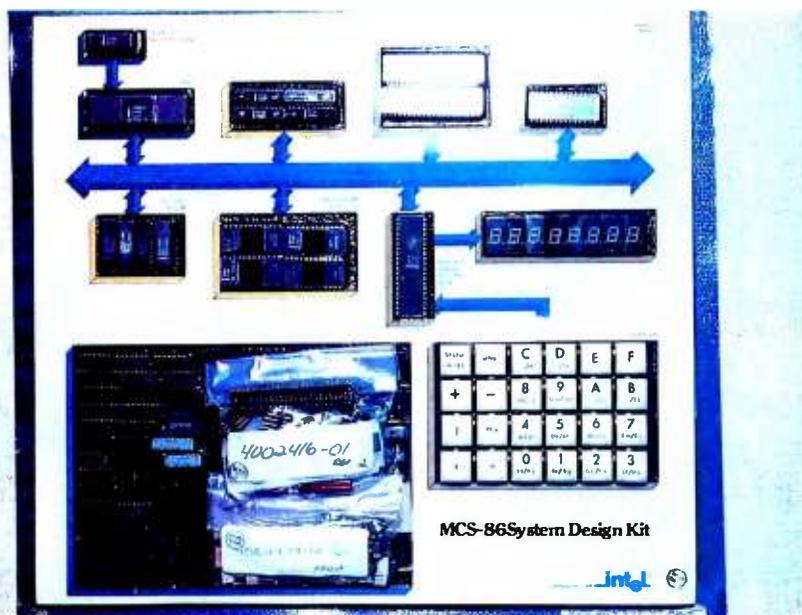
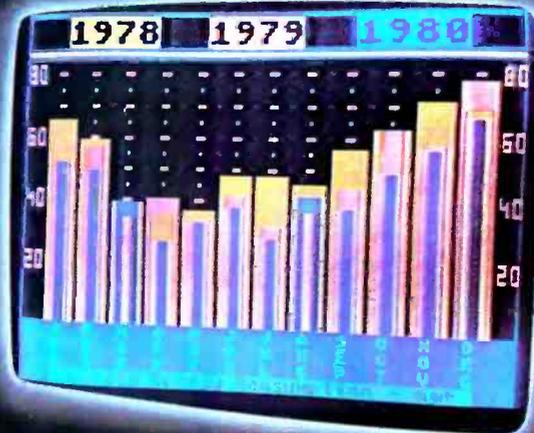
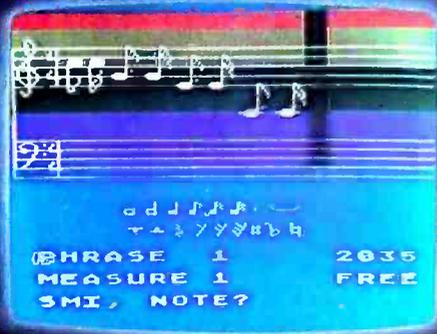


Photo 1: SDK-86 system as delivered from factory.

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bit manipulation. Arithmetic operations are accomplished in American Standard Code for Information Interchange (ASCII) or binary-coded decimal with a one-instruction hardware conversion.

In addition to the capability of handling data in bits, bytes, words, or blocks, the 8086 incorporates many features formerly found only in minicomputer architecture. It also supports such operations as reentrant

code, position-independent code, and dynamically relocatable programs.

The 8086 is fabricated with a newly developed, high-speed metal-oxide semiconductor (H-MOS) process which is considerably faster than standard MOS. Running up to 8 MHz, the 29,000-transistor 8086 is the fastest single-chip central processor currently available. Unlike the 8080/8085 processor's registers, the 8086's registers can process 16-bit as well as 8-bit data.

Figure 1a shows an internal block diagram of the 8086. The 16-bit arithmetic/logic instructions are handled within the general register files. This section contains four 16-bit general data registers, two 16-bit base pointer registers, and two 16-bit index registers. Figure 1b illustrates an 8086 register model for comparison to the 8080.

The four data registers, addressable also in 8-bit partitions, are primarily from the original 8080. There are twice as many general-purpose registers as there are on 8-bit processors.

The relocation register file is the other unique 8086 enhancement. This group is referred to as the segment register file, and extends direct addressing capability to a full megabyte of memory. This file has four address pointers which contain program relocation values for up to four 64 K byte program segments. In addition, a fifth pointer serves as an I/O (in-

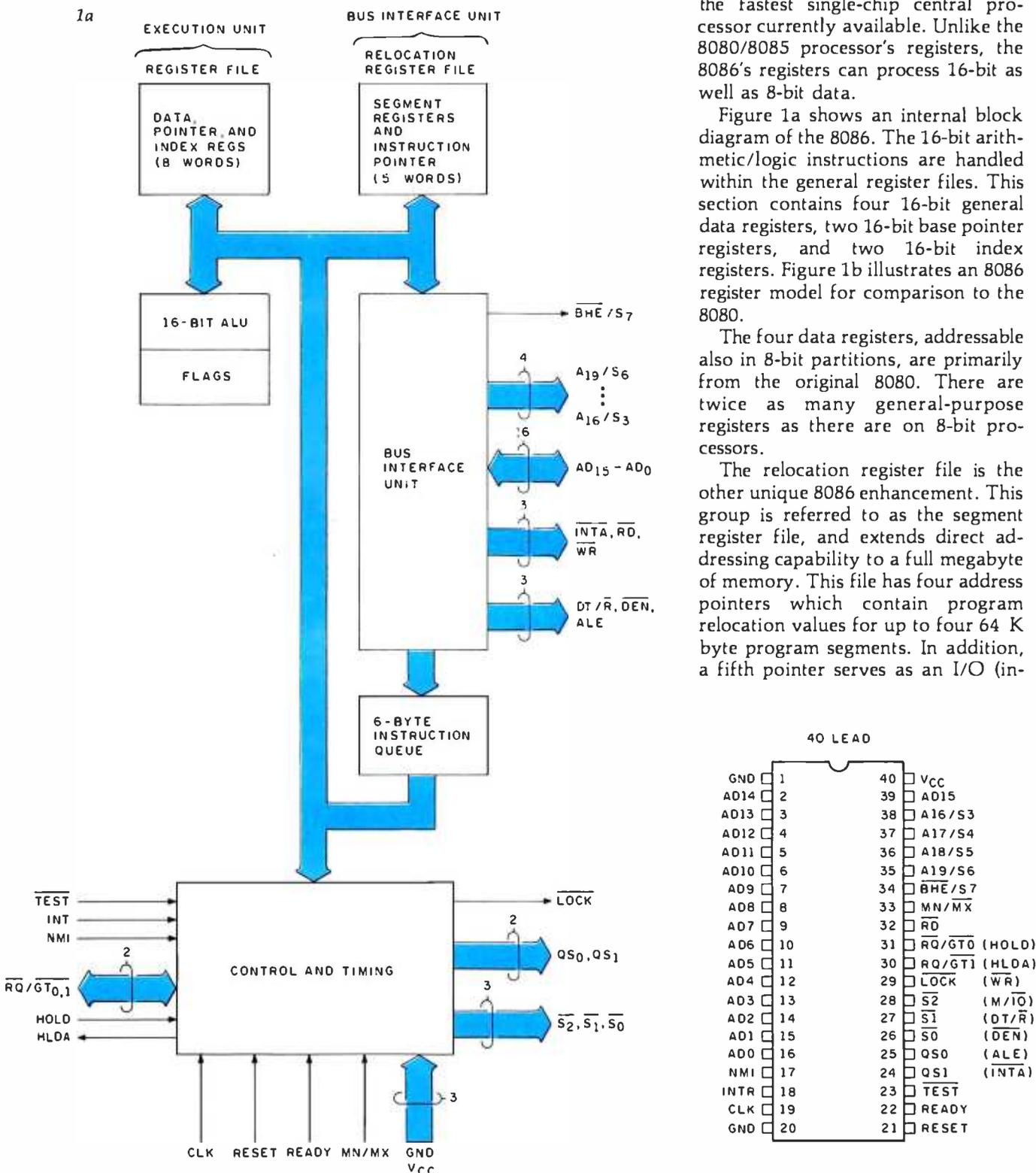


Figure 1: An internal block diagram and pinout specifications of the Intel 8086 (figure 1a). Figure 1b shows the 8086 register model illustrating the differences between the 8086 and the 8080. Figure courtesy Intel Corp.

put/output) control providing address space for a full 65,536 I/O ports.

Logically the 8086 operates more like larger computers than like a classical microprocessor. This is accomplished through independently controlled bus interface and execution units (figure 2). The major contribution is to speed processing by overlapping instruction fetch and execution. Up to six bytes of instruction are placed in a queue before execution. As each instruction is processed, the following instructions move up one position and a new instruction is fetched and placed in the queue. This simultaneous fetch and execute capability induces more efficient use of the memory bus. It is possible for two single-byte 8086 instructions to be executed within the time for one memory cycle. The result is improved performance, given the same bus bandwidth and memory speed as other systems.

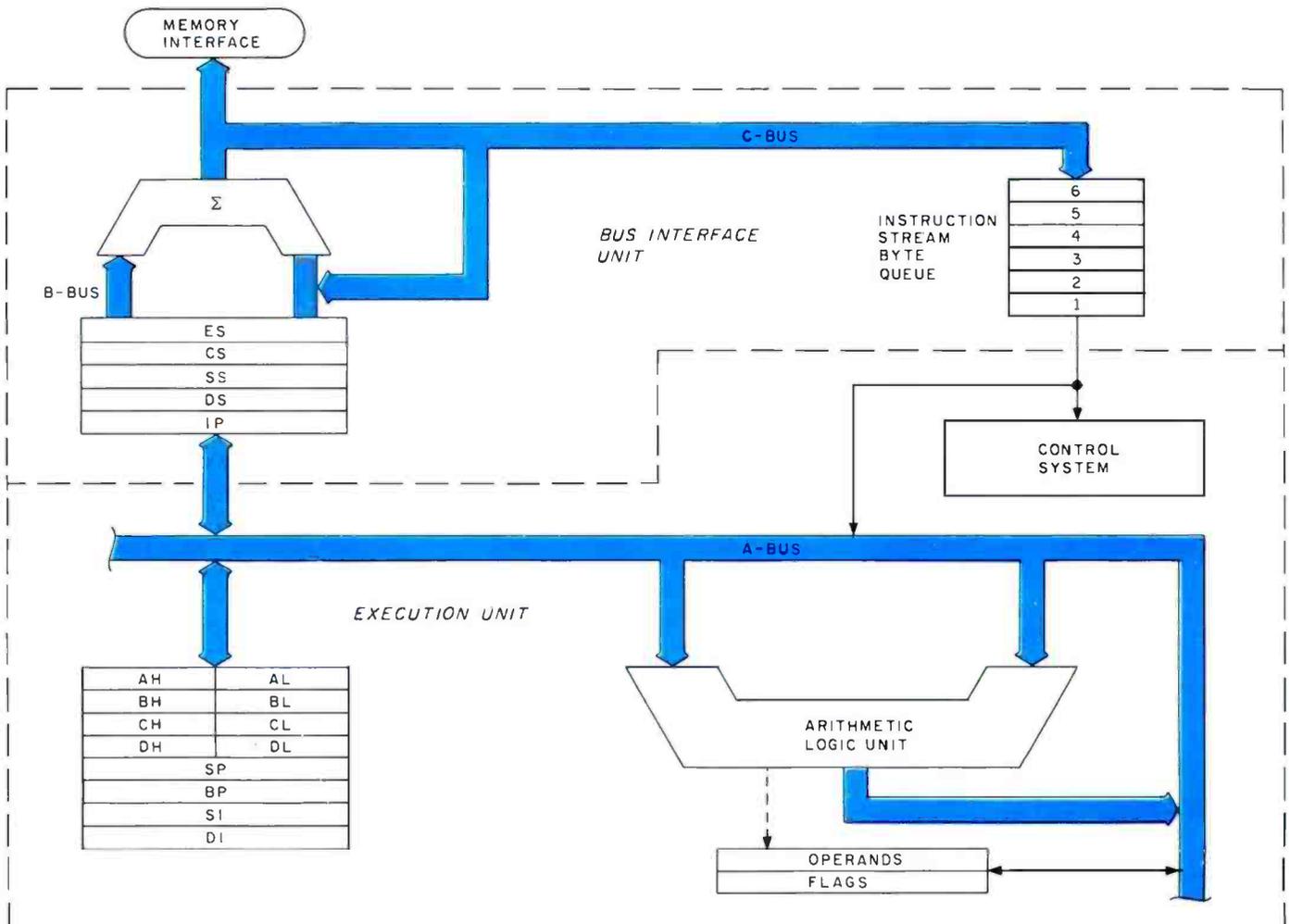
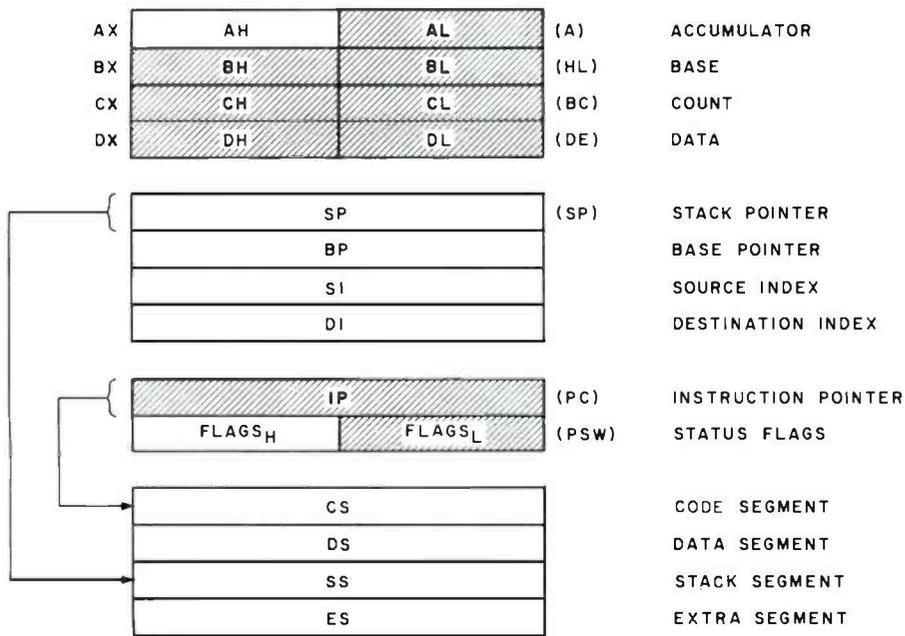


Figure 2: Functional block diagram of internal data paths of the 8086. Figure courtesy Intel Corp.

Table 1: Summary of specifications for the SDK-86 board.

Central Processor

Processor: 8086
 Clock Frequency: 2.5 MHz or 5 MHz (jumper selectable)
 Instruction Cycle Time: 800 ns (5 MHz)

Memory Type

Read-Only Memory: 8 K bytes
 Programmable Memory: 2 K bytes (expandable to 4 K bytes)
 (2 bytes equal one 16-bit word)

Memory Addressing

Read-Only Memory: FE000 thru FFFFF
 Programmable Memory: 0 thru 7FF (0-FFF with 4 K bytes)

Input/Output (I/O)

Parallel: 48 lines (two 8255As)
 Serial: RS232 or current loop (8251A)
 Data Transfer: Rate selectable from 110 to 4800 bps
 Display: On-board, 8-digit, light-emitting diode (LED) readout

Interface Signals

Processor Bus: All signals transistor-transistor logic (TTL) compatible
 Parallel I/O: All signals TTL compatible
 Serial I/O: 20 mA current loop or RS232

Interrupts

External: Maskable and nonmaskable; Interrupt vector 2 reserved for nonmaskable interrupt (NMI)
 Internal: Interrupt vectors 1 (single-step) and 3 (breakpoint) reserved by monitor

Direct Memory Access

Hold Request: Jumper selectable, TTL compatible input

Software

System Monitors: Preprogrammed 2316 or 2716 read-only memories
 Addresses: FE000 thru FFFFF
 Monitor I/O: Keypad and Serial (teletypewriter or video display)

Power Requirements

V_{CC} : +5 V ($\pm 5\%$), 3.5 A
 V_{TTY} : -12 V ($\pm 10\%$), 0.3 A (required if teletypewriter (TTY) or video display terminal connected to serial interface port)

The Intel SDK-86

Perhaps this brief introduction has sparked your curiosity and you wish to know more about the 8086. Of course, the best method of learning is to use one. Since at this writing the 8086 is still so new that it is not incorporated into any general-use personal computer, we are left to our own resources and construction abilities. Fortunately Intel realizes that the success of any new product depends on evaluation by as many potential users as possible. For this reason the System Design Kit (SDK) series of products were conceived.

The SDK-86, shown prior to assembly in photo 1, is a single-board, 8086-based computer. Intel's pricing policies make the purchase of the SDK-86 kit far more attractive than a single 8086 chip. It results, in the name of advertising, in one of the better computer offerings on the market. At \$780 the SDK-86 fits within most budgets. It is a complete computer including processor, programmable memory, read-only memory, I/O (input/output), and display. Table 1 is a more explicit listing of specifications and figure 3 is a detailed block diagram.

The SDK-86 is very easy to assemble. As shown in photo 2, it comes packaged so that all components are easily recognizable, even for a novice. Documentation includes an Assembly Manual, User's Manual, User's Guide, and Monitor listings (see photo 3). The assembly procedures are written at such a level that even a person having limited technical knowledge may assemble the kit. The assembly manual progresses from basic solder techniques and component identification to step-by-step assembly and checkout. The only microcomputer assembly literature I have read which was as easily understandable as this comes from the Heathkit people.

All major components are socketed, but to be on the safe side it is a wise idea to purchase additional integrated-circuit sockets. This will allow all integrated circuits to be removed in case troubleshooting is necessary. The fully constructed com-

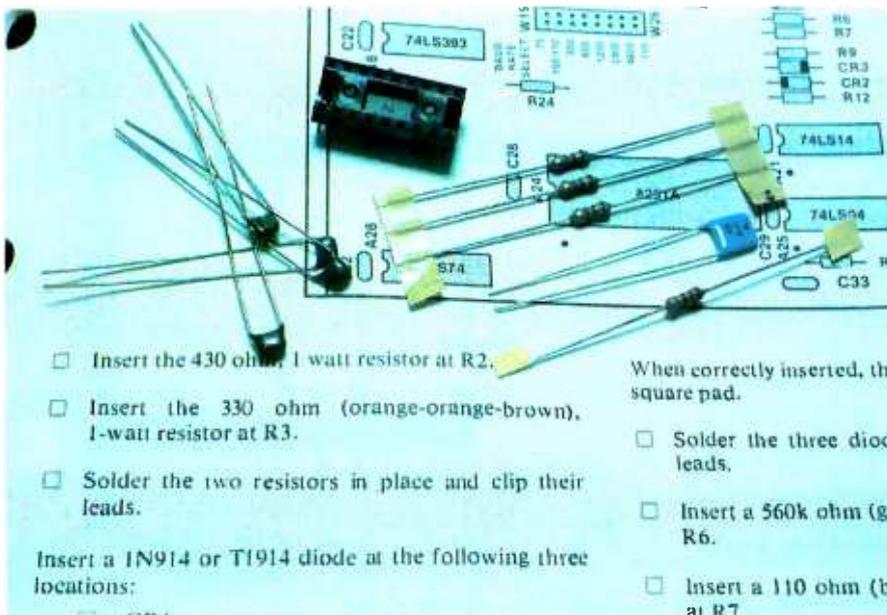


Photo 2: Typical page from the construction manual. Each instruction step is clearly explained and each component is accurately identified.

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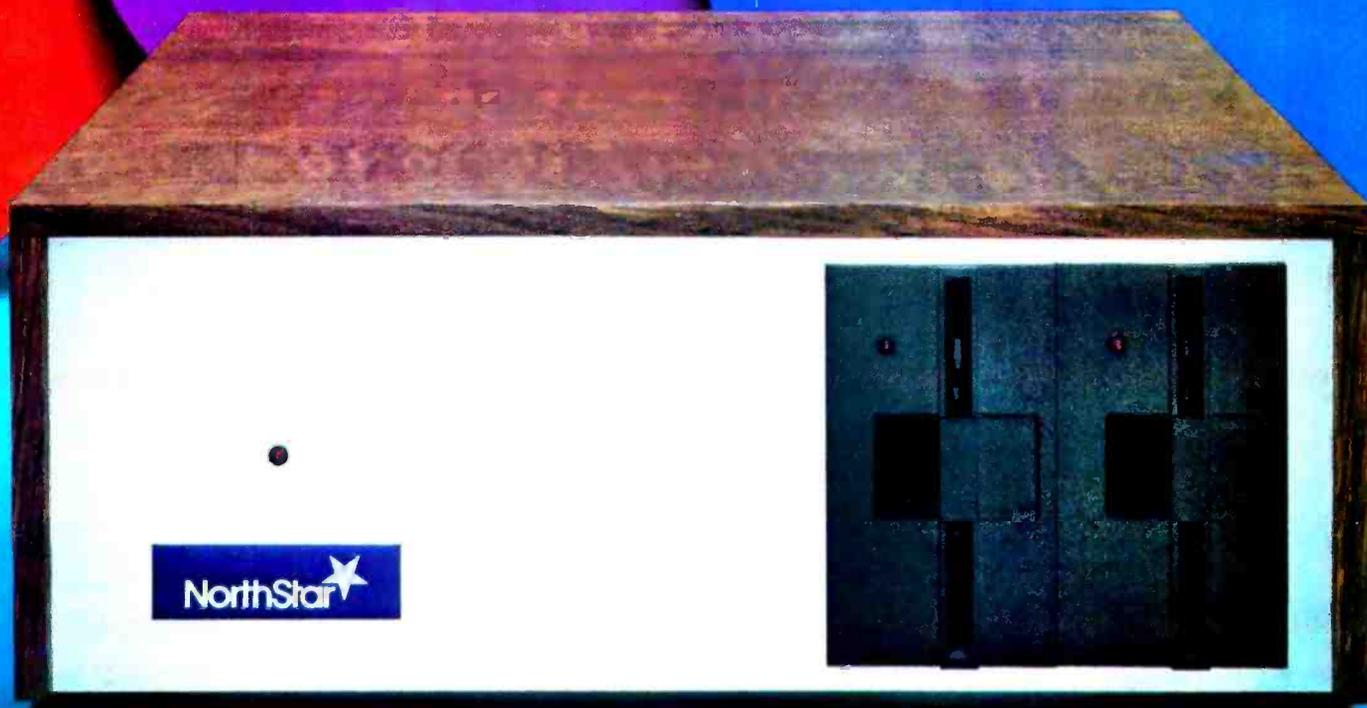
North Star Horizon Computer Prices (includes 32K RAM, one parallel and two serial I/O ports), assembled, burned-in and tested:

Horizon-1-32K-Q	\$2565
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puter is shown in photo 4. Checkout, after determining that there are no obvious errors, is simply a matter of

applying power and pressing the system reset button. When the SDK-86 is reset, the 8086

executes the instruction at hexadecimal location FFFF0. The instruction at this location is an intersegment direct jump to the beginning of the monitor program that resides in read-only memory, hexadecimal locations FF000 to FFFFF. The monitor is comprised of two programs resident in programmable read-only memory; one for use with the on-board keypad, and the other a serial monitor that supports a video display or teletypewriter connected to the Electronics Industries Association (EIA) serial interface connector. This latter communication mode is preferable if the SDK-86 is to be used efficiently for software development. Even though the system is constructed to vector to the keyboard monitor on power up, simply interchanging the two sets of programmable read-only memory will allow the unit to start up immediately in the serial mode.



Photo 3: The SDK-86 board comes complete with well-written documentation manuals for assembly and use.

The SDK-86 Monitor

Both monitors share similar command capability. The keyboard monitor is optimized for the 8-digit, light-emitting-diode (LED) display while the serial monitor is obviously for a video display or teletypewriter. The only dissimilarity is that the latter has the additional ability to read or write to a paper-tape punch, or with the addition of a Frequency-Shift-Keying (FSK) modulator/demodulator, cassette storage. Table 2 lists the serial monitor I/O commands.

Of particular importance are the single-step and go commands. Single step allows a program to be executed one instruction at a time, while the go command allows the user to specify a breakpoint which returns control to the monitor while preserving the machine's status. This allows a program to be run in segments facilitating checkout.

While the monitor does provide some powerful routines, the PL/M listings provided in the documentation do not directly give the addresses of the individual routines. Enough effort is required to extract this information, that rewriting particular routines in user memory is a worthwhile consideration.

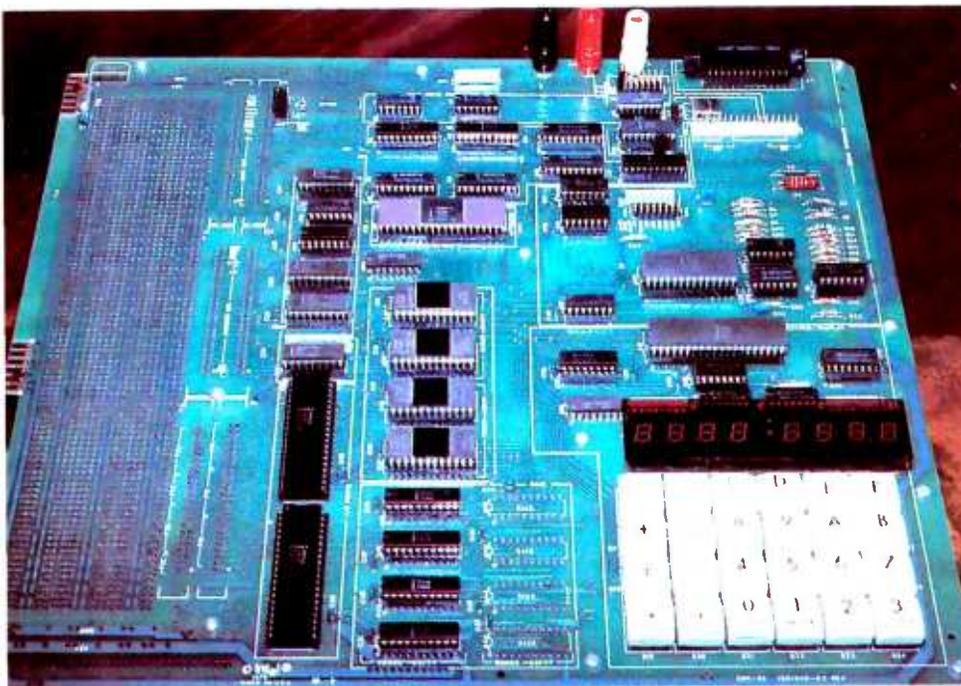


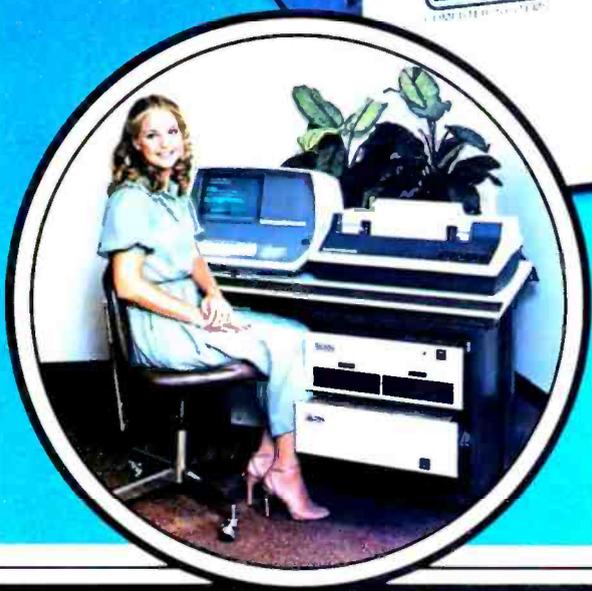
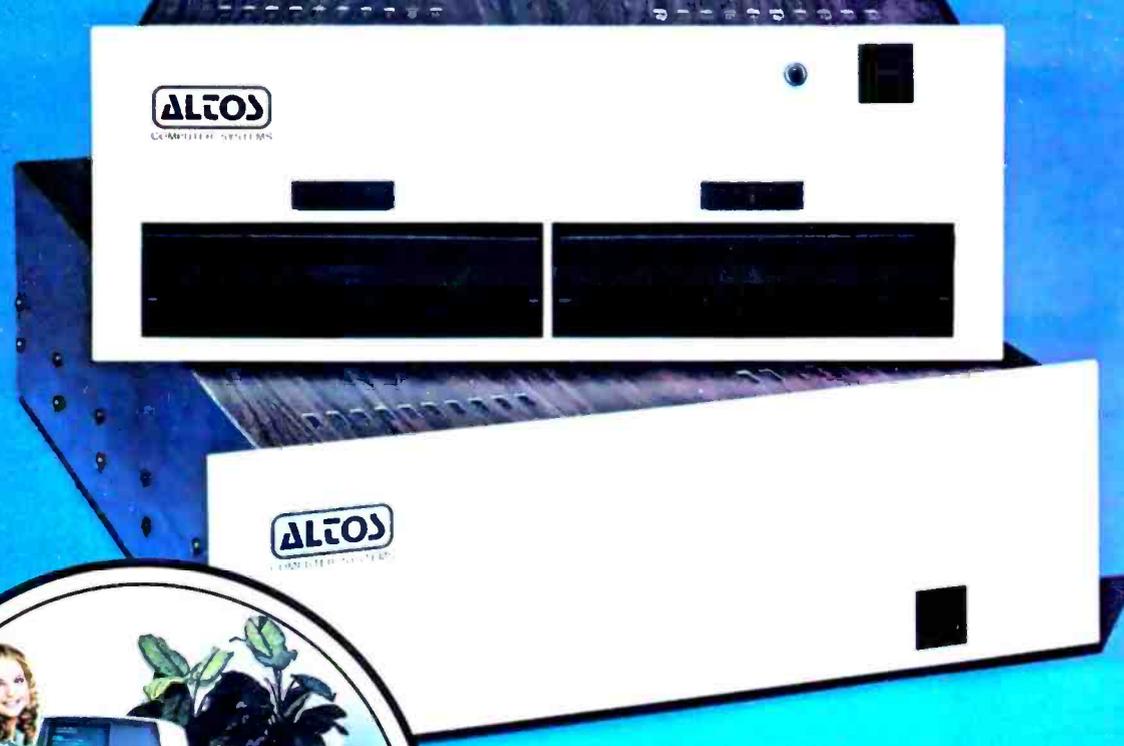
Photo 4: Assembled SDK-86 board. Note the prototyping area on the left-hand side.

Text continued on page 24

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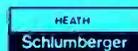
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Table 2: The commands which are available for use with the serial monitor.

Command	Monitor Command Summary FUNCTION/SYNTAX
S (Substitute Memory)	Displays/modifies memory locations S[W]<addr>,[[<new contents>],]*<cr>
X (Examine/Modify Register)	Displays/modifies 8086 registers X[<reg>][[<new contents>],]*<cr>
D (Display Memory)	Moves block of memory data D[W]<start addr>[,<end addr>]<cr>
M (Move)	Moves block of memory data M<start addr>,<end addr>,<destination addr><cr>
I (Port Input)	Accepts and displays data at input port I[W]<port addr>,[,]*<cr>
O (Port Output)	Outputs data to output port O[W]<port addr>,<data>[,<data>]*<cr>
G (Go)	Transfers 8086 control from monitor to user program G[<start addr>][,<breakpoint addr>]<cr>
N (Single Step)	Executes single user program instruction N[<start addr>][[<start addr>],]*<cr>
R (Read Hexadecimal File)	Reads hexadecimal object file from tape into memory R[<bias number>]<cr>
W (Write Hexadecimal File)	Outputs block of memory data to paper tape punch W[X]<start addr>,<end addr>[,<exec addr>]<cr>

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Solving Soma Cube and Polyomino Puzzles Using a Microcomputer

Douglas A Macdonald
Yekta Gürsel
130-33

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The genesis of this article was an inexpensive puzzle consisting of twelve plastic pieces which are supposed to be fitted into a rectangular cardboard box. Despite assurances by experts (see bibliography, Martin Gardner) that there are 2339 separate and distinct ways of solving the puzzle, a year's work by a veritable platoon of people (mainly Yekta) produced only slightly more than 150 solutions.

Introduction

Polyomino puzzles and Soma Cubes are examples of a class of problems which are particularly suited to solution on a small computer. The amount of data needed in each case is relatively small, but the amount of calculation needed to do an exhaustive search for solutions is staggering.

For a set of Pentominoes, for instance, you need only encode the shapes of the twelve pieces and provide an array of sixty spaces into which you try to fit them. For a Soma Cube there are only seven pieces, which fit into an array of twenty-seven spaces. In both cases, all of the necessary data will easily fit into 2 K bytes of memory. However, the number of individual situations that would have to be considered in an

unoptimized exhaustive search would be 3.2×10^{16} for the Pentomino puzzle and 4.7×10^{11} for the Soma Cube.

In this article, we will present a 6502 assembly language program which will solve a wide variety of puzzles of the sort where a given region, either two or three dimensional, must be filled with a given set of pieces. The program has been written in a general manner so that the shape of the region can be easily changed and certain pieces can be specified as fixed, in order to take advantage of symmetry. The number and shape of the pieces themselves can also be easily changed.

Due to a clever search method, the program given here actually considers many fewer cases than the unoptimized search mentioned above. Using a Commodore PET with a clock frequency of 1 MHz, most of the problems for which we have generated a complete set of solutions have taken from a few minutes to a few hours to run. The longest running problem we have considered, that of Pentominoes in a 10 by 6 rectangle, took slightly less than two days to generate all of the 2339 solutions.

If the program is run in BASIC, which we actually tried, this problem takes more than two months. The large difference in running speeds is due to the fact that BASIC on the PET is an interpreted language, each line of which must be decoded every time it is executed. This should serve as a caveat to anyone intending to write a

BASIC interpreter version of this program.

The search algorithm used in the program is extremely general, as is illustrated by the fact that there are only three places in the assembly code where a check is made to see if the region under consideration is two or three dimensional. Thus the user should find it easy to modify the program to consider more complicated or exotic problems, such as those involving oddly shaped pieces or more than three dimensions.

The program given here is written in the symbolic assembly language of the 6502 microprocessor, but users of other microprocessors should be able to adapt the fundamental algorithm to their own machines without much trouble. The accompanying BASIC routines are written in Commodore's version of BASIC (a Microsoft product), but they should also be easily adaptable to other machines. Since "safe" memory locations vary from machine to machine, users should be aware of the quirks of their own particular computer when they choose the addresses for the variables in the program.

Polyominoes

Polyominoes are planar objects consisting of a number of squares connected at their edges (see figure 1). The simplest such object is a monomino, which is just a single square. Next is the domino, consisting of two squares joined at a side, which has the shape of the familiar game pieces.

Acknowledgment

The authors would like to thank Mark Zimmerman for teaching them assembly language, and for allowing generous amounts of computer time to write and debug the program.

Both monominoes and dominoes have only one possible shape. Trominoes consist of three squares and there are two possible shapes, as shown. Similarly, there are five different tetrominoes, twelve different Pentominoes (photo 1), thirty-five different hexominoes, and so on. Interestingly, the formula for the number of n-ominoes as a function of n is not known.

The type of puzzle that we considered was the problem of using a given set of polyominoes to *tile*, or fill in, a region with a given boundary. For instance, the twelve Pentominoes can be used to tile a 20 by 3 rectangle (there are only two different ways of doing this), a 10 by 6 rectangle (2339 ways), a 15 by 4 rectangle (368 ways), or a 12 by 5 rectangle (1010 ways).

We do not even have to be restricted to rectangular shapes: we can give the computer some arbitrary region consisting of sixty squares, and ask it to find all the solutions or a subset of the solutions. One of the more interesting of the Pentomino problems is the case of an 8 by 8 chessboard with the four center squares filled in and not used (65 solutions).

A variety of problems can be developed using the various polyominoes, but the ones to which computer solution is most applicable seem to be those involving Pentominoes. The smaller polyominoes, especially monominoes and dominoes, are so few in number and simple in shape that any puzzle involving them is trivial and can be easily solved without a computer. On the other hand, for hexominoes and higher orders of polyominoes, the number of objects in a complete set is so great that an exhaustive search is impractical, even on a large computer. For this reason, the only examples that we have actually run on the computer have been Pentomino puzzles, although the program is general enough to consider other polyominoes.

In order to make a tractable problem using hexominoes or other higher-order polyominoes, a reasonably sized subset of the complete set of pieces should be chosen. For instance, one could try to tile a sixty square region using ten of the thirty-five hexominoes, or a seventy-two square region using twelve of the hexominoes.

Soma Cubes

The Soma Cube (trademark of Parker Brothers Inc, Salem MA) is a puzzle invented by Piet Hein, consisting of seven pieces which can be fitted together into a 3 by 3 by 3 cube (and other more exotic shapes). Each of the pieces consists of a number of cubes joined together at their faces. Six of the pieces are composed of four cubes, and the seventh piece is composed of three cubes, as shown in photo 2. Note that piece 2 is just a three-dimensional version of the second tromino in figure 1, and that pieces 5, 6, and 7 are three-dimensional versions of three of the tetrominoes.

There are 240 different ways of constructing a cube out of these pieces. If rotations and reflections of the cube itself and of individual pieces within the cube are treated as different solutions, this number is increased by a factor of 4608 to make a total of 1,105,920 solutions.

As with polyominoes, we can generalize the problem by using more than one set of pieces, or by trying to fill a noncubical region. The program can be easily adapted to consider these situations.

Encoding

In order to make the problem understandable to the computer, we represent the box into which we are trying to fit the pieces as an array in memory. Each of the pieces is assigned a number. An empty square in the box is represented by a zero in the appropriate array cell, and squares which are filled by piece number K are represented by the actual number K in the corresponding array cells. For convenience, the entire array is surrounded by a boundary of cells into which we put the number -1. This speeds up the search since the machine does not have to make a distinction between cells which are filled and cells which are off the edge of the board.

As an example, consider the Pentomino problem for the 10 by 6 rectangle. The pieces would be assigned numbers between one and twelve, and the array plus boundary would have dimensions of 12 by 8. The number -1 is also put into any square which is off-limits. Thus, an 8 by 8 square with the center four squares off-limits would be represented in memory by a 10 by 10 array

Figure 1: Polyominoes are planar objects consisting of a number of squares connected at their edges.

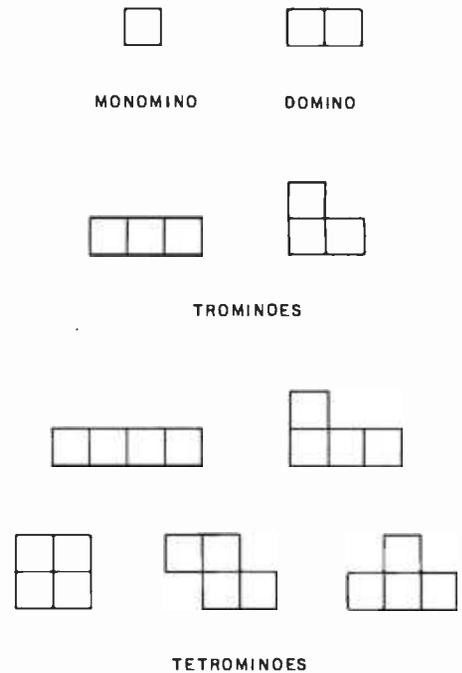


Photo 1: The twelve different Pentominoes, showing their assigned number and letter designations. Pentominoes is a registered trademark of Solomon W Golomb.

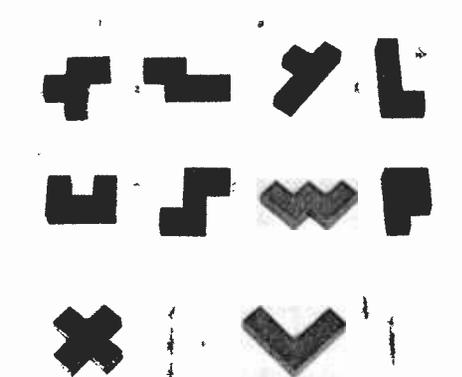
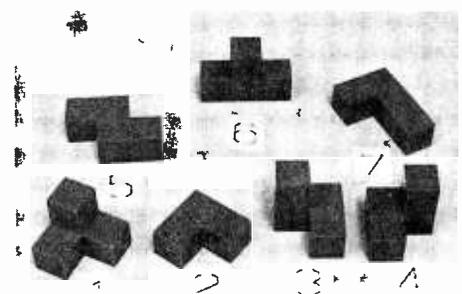


Photo 2: The seven Soma Cube pieces with their assigned numbers.



Solomon W Golomb originally introduced the terminology and many of the problems associated with polyominoes.

with -1s around the boundary and in the four center squares.

Unfortunately, things are not quite this simple, since we cannot specify a two-dimensional array in assembly language, and must therefore store it as a linear array in memory. The mechanics of how we encode and decode the coordinates of a particular square will be explained later.

The numbering of the pieces is somewhat arbitrary, but it is convenient to put the most symmetric pieces first. This makes it easy to have the computer fix one of the pieces on the board in order to take advantage of symmetry. Again using the Pentominoes as an example, the X Pentomino should always be assigned the number 1, since it has the fewest orientations of any of the pieces (ie: only one). If you look at a 10 by 6 board, it is easy to convince yourself that any solution can be rotated or reflected to get the X in the lower left-hand quarter of the board. Thus, a simple way to keep from generating rotations and reflections of already known solutions is to constrain the X to the lower left-hand quarter of the board. Furthermore, it is easy to see that only seven different positions of the X in this corner can possibly lead to solutions; so successive consideration of these seven cases is the quickest way to generate all of the 2339 solutions. For these reasons, the program allows the user to specify any number of pieces as fixed.

The numbering of the Pentominoes and the Soma Cube pieces shown in photos 1 and 2 will be used in the program. Also shown in photo 1 are mnemonic letters assigned to each of the twelve Pentominoes. These letters are used in printing out the solutions to make the output easy to read. For the Soma Cube we used the numbers one thru seven for the printout symbols, but you can easily change these to any symbols you choose.

The option of fixing pieces also

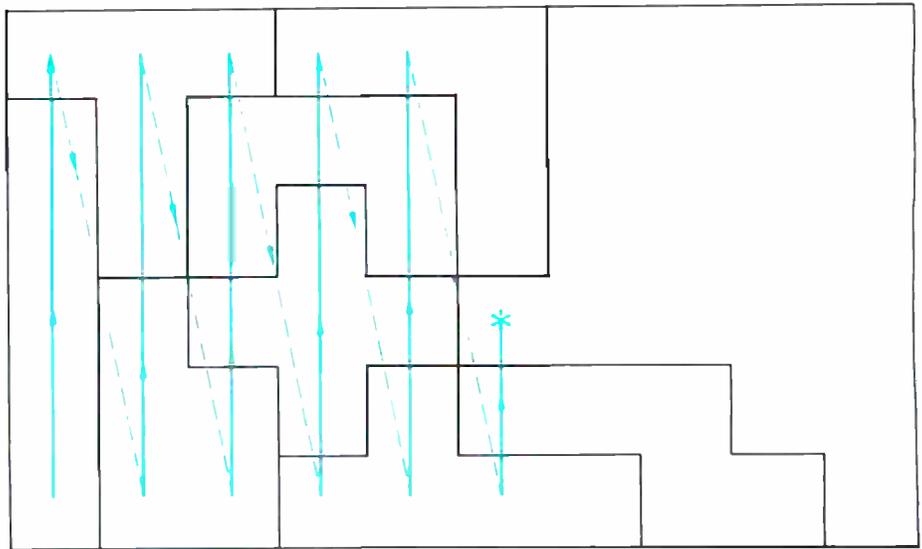


Figure 2: The scan procedure starts in the lower left-hand corner of the defined area and proceeds up the first column. When the top of the column is reached, the scan returns to the bottom of the second column, which is scanned from bottom to top. This procedure is repeated until an empty square is encountered. This empty square is then the base square. If no empty squares are found, the problem has been solved.

allows the user to specify part of the solution. For instance, if you want to know whether or not a solution exists when a certain number of the pieces are fixed, enter the positions of these pieces from the keyboard, and the computer will hold them fixed and fiddle around with the remaining pieces. The parts of the program which initialize the positions of the pieces and print out the solutions have been written in BASIC because they are not time-critical. These will be easy for the user to change.

Algorithm

The program has to order the solutions so that it knows what solutions have already been found and what possibilities are yet to be tried. The program does this by considering the permutations of the piece numbers in ascending order. The meaning of *ascending order* is best illustrated by considering a simple example. If we have three pieces, numbered 1, 2, and 3, then the permutations in ascending order are:

(123), (132), (213),
(231), (312), (321)

That is, considering the permutations as three-digit numbers, these three-digit numbers are in ascending order. The generalization of this example to higher numbers of pieces is self-evident.

The total number of permutations of N pieces is given by the product of all of the numbers between 1 and N, which is denoted by N! (read N-factorial):

$$N! = N \times (N-1) \times (N-2) \times \dots \times 3 \times 2 \times 1$$

Thus for the twelve Pentominoes, we have $12! = 479,001,600$ permutations to consider! This is not, however, cause for despair; an efficient search procedure will reduce the possibilities to a small fraction of this number.

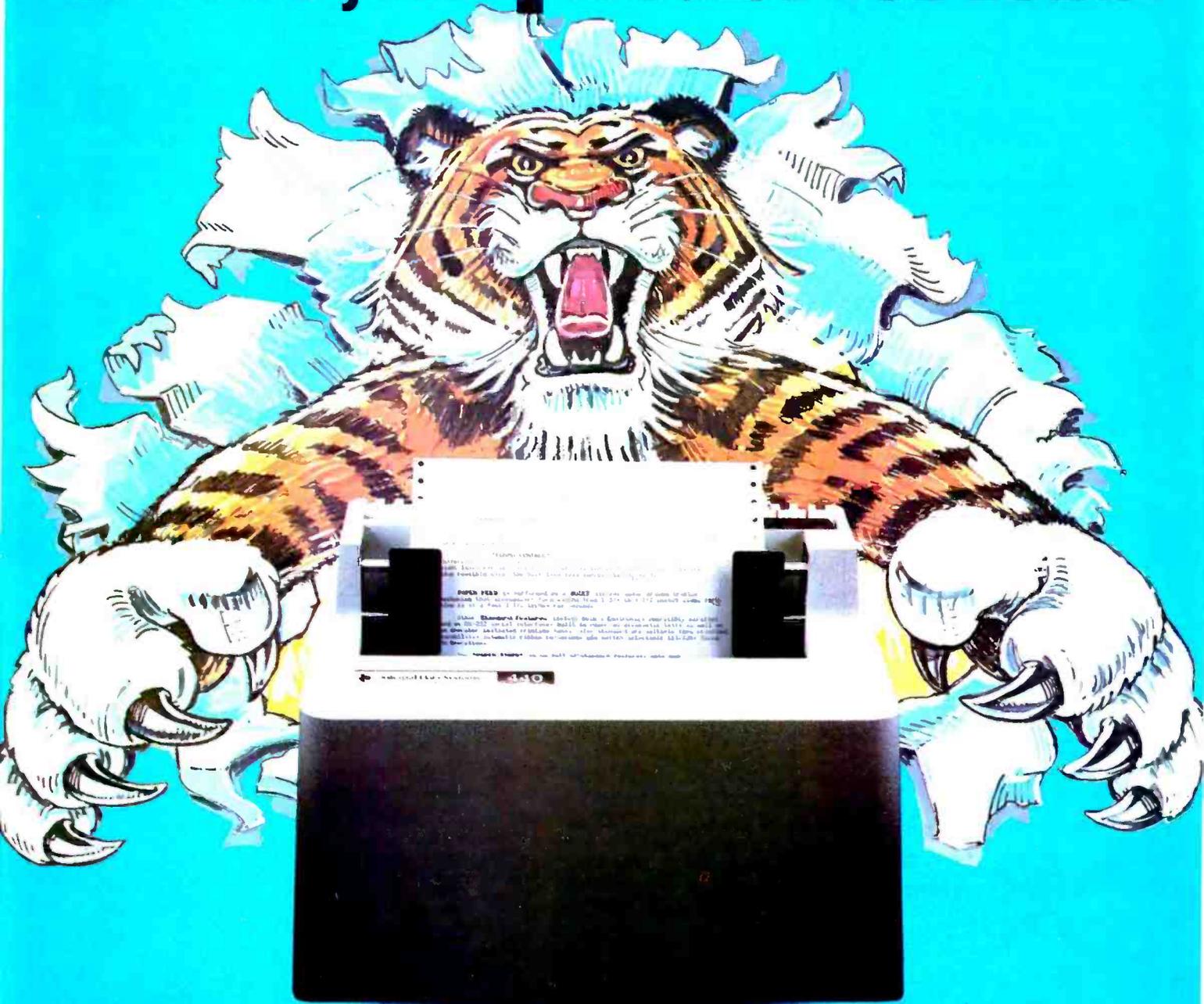
In order to make the search procedure clear, we will describe it for the special case of the 10 by 6 Pentomino puzzle. It will be obvious how the method can be generally applied to other cases.

The board is arranged with the long dimension placed horizontally and the short dimension placed vertically. The program applies a scan procedure which starts in the lower left-hand corner and scans up the first column, then goes to the bottom of the second column and scans up this column, and so on, for the third through tenth columns. The first empty square which it runs across in this search is called the *base square* (see figure 2).

The search procedure is summarized in the flowchart in figure 3. Just before the BASIC initialization routine is finished, it performs the search

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described above and finds the first base square. If the user has not specified any pieces as fixed, this is just the lower left-hand corner square. If fixed pieces were specified, it need not be this square (figure 2). The computer has in mind a particular permutation of the twelve pieces which was specified by the user. The program chooses the appropriate piece and

looks up its orientations in a table. If the first orientation that it tries does not fit, it goes on to the second, and keeps trying until one of two things happens:

- It finds an orientation which fits, in which case it puts the piece in the box and then scans as described above for the next base square. It then tests this new base square to see whether or not it is isolated (ie: whether or not it is completely surrounded by four filled squares). If the base square is isolated, it cannot serve as the new base square, so the program jumps to the isolated square routine which will be described later. If the new base square is not isolated, the program picks the next piece in the permutation and goes back to the begin-

ning to look up the orientations of this new piece.

- None of the orientations fit, in which case the program takes out the last piece it put in and tests that piece to determine if it has any orientations which have not yet been considered. If there are additional orientations, the program jumps back to the beginning to try these. If all orientations have been considered, the program removes the preceding piece and tests that piece for any more orientations. Pieces are removed in this manner until either a piece is found which has more orientations, in which case the program branches back to the beginning to consider them; or the program reaches the nucleus of pieces which the user specified as fixed. When this happens, the next

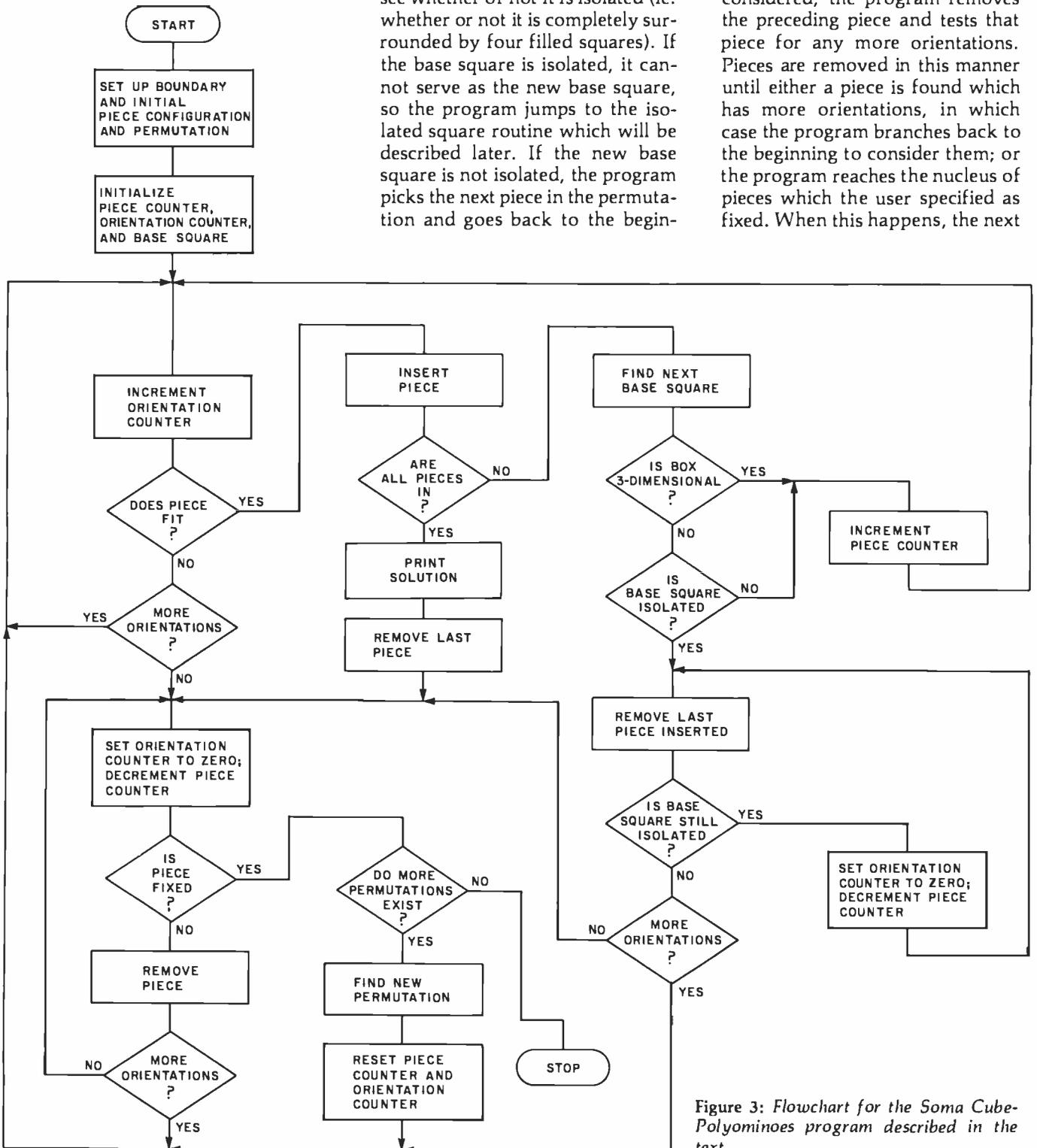
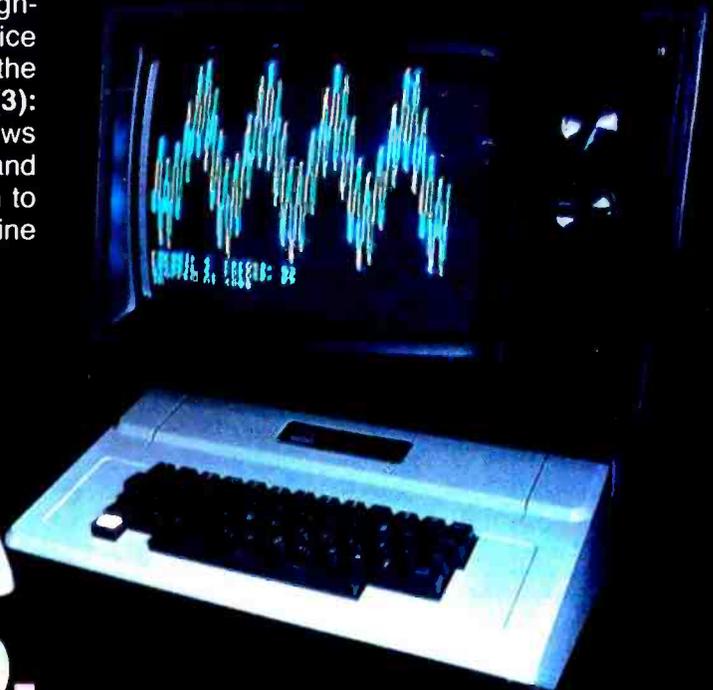


Figure 3: Flowchart for the Soma Cube-Polyominoes program described in the text.

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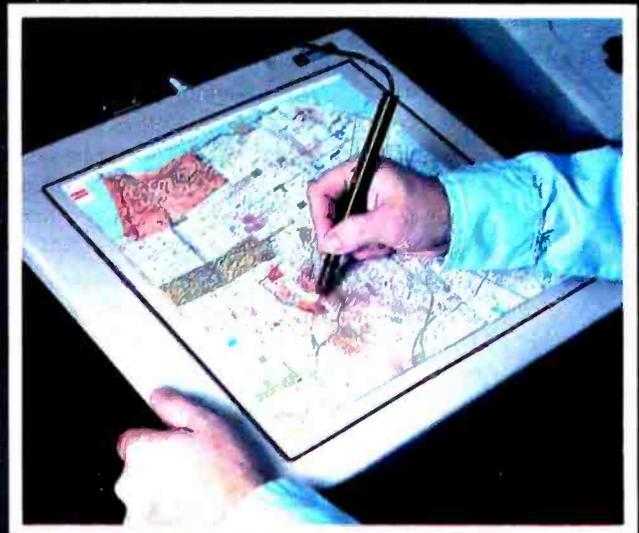
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permutation in the ascending sequence described above is generated and tested. If there are no permutations left, execution stops.

Immediately after any piece is placed, the program checks to see if the board is full. If the board is filled, control is transferred back to BASIC to print out the solution.

Two refinements have been added to the above bare-bones routine, which together result in a considerable savings of time:

The *isolated square* routine mentioned above saves time by immediately recognizing and rejecting isolated base squares. Otherwise, the machine would have to make many tests before rejecting an obviously invalid base square. The routine works by successively removing pieces until the square under consideration is no longer isolated. This routine results in a savings of time only in the two-dimensional case: in three dimen-

sions, it is no more efficient than the basic search described above. This is mainly due to the fact that an isolated square seldom occurs in the three-dimensional case because of the large number of cubes (six) which must be filled to isolate a given cube. For this reason, the isolated square routine is bypassed when the program is used to run the Soma Cube.

The other refinement allows the machine to avoid considering permutations of the pieces which are certain to lead to no solutions. For instance, if the machine never succeeded in fitting more than five pieces into the box in a particular permutation, it will do no good for the permutation routine to interchange the eleventh and twelfth pieces: no progress will be made until the position of the sixth piece is changed. The program takes account of this, and the result is that while the permutations are still done in the ascending order previously described, a large fraction are simply skipped since they cannot lead to solutions.

The method of scanning for the base square in the two-dimensional case is implemented in two loops: the Y-scan loop nested inside the X-scan loop. The scan method for the three-dimensional case is similarly defined by three nested loops: the Z-scan loop is nested inside the Y-scan loop, which is in turn nested inside the X-scan loop.

Orientation Table

We should explain the meaning of the phrase which was used above when we said that the computer "looks up" the orientations of the pieces. This phrase means exactly what it says: the machine looks up the orientation from a table in memory which has been entered by the user.

But why can't the computer figure the orientations itself? The answer is, of course, that it could. However this would increase the running time of the program by a factor of ten to one hundred. The orientation checker is the most often-used routine in the program, and it is important to have it run as quickly as possible.

The user does not actually have to enter the entire table. Listing 1 is a BASIC program which automatically generates the orientation table in memory. In using this program, the user need enter only one orientation for each piece. The computer automatically generates and encodes the rest of the orientations. This can result in a considerable savings in time and frustration, since a polymino can have as many as eight orientations, and a Soma Cube piece can have as many as twenty-four orientations.

Although this BASIC program makes it possible to use the program without understanding how the orientation table works, it is worthwhile for anyone who intends to use this program to learn how the table is set up, since it is fundamental to the operation for the entire program.

In a BASIC routine, the table would be a four-dimensional array $B(K, J, M, I)$. In the assembly language routine, the table is one-dimensional, but we will explain the mechanics of this shortly. At the moment, an explanation of the four-dimensional array will be more helpful.

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Listing 1: BASIC program to generate the orientation tables for polyominoes and Soma Cube. The computer generates all possible orientations after the first orientation has been entered.

```

1 424 1 19791117 1979 ORIENTATION TABLE GENERATOR
2  INPUT "NUMBER OF DIMENSIONS";D;G=1:IF D=3 THEN J=24
20 INPUT "NUMBER OF PIECES";P:INPUT "NUMBER OF SQUARES PER
    PIECE";S
30 PRINT "ENTER D: FIRST ADDRESS OF ARRAY OF LENGTH";P:INPUT R0
40 PRINT "ENTER U0: FIRST ADDRESS OF ARRAY OF LENGTH";(S-1)*P+D
    :INPUT D0
50 DIM X(20),Y(20),Z(20):T=0:N=P*O*(S-1):FOR L=0 TO U0+P
    :POKE L,0:NEXT L
60 FOR I=0 TO B0*(S-1)*P+D:POKE I,0:NEXT I
70 DIM X(1),Y,Z COORDINATES OF EACH SQUARE OF EACH PLCE
80 FOR %=1 TO P
90 FOR I=1 TO S:(I)=Y(I)=0:Z(I)=C:NEXT I
100 PRINT "PIECE #";K:FOR I=1 TO S:PRINT " SQUARE #";I
    :INPUT " ENTER X";X(I)
110 INPUT " ENTER Y";Y(I):IF D=3 THEN INPUT " ENTER Z";Z(I)
120 NEXT I:PRINT " STANDBY ....."
130 REM TRANSLATE PIECE SO THAT BASE SQUARE IS AT ORIGIN
140 A=0:U=0:C=0:K=0
150 U=J:FOR I=1 TO S:IF X(I)<U THEN U=X(I)
160 NEXT I:FOR I=1 TO S:IF Y(I)<U THEN U=Y(I)
170 U=100:FOR I=1 TO S:IF Y(I)<U AND X(I)=0 THEN U=Y(I)
180 NEXT I:FOR I=1 TO S:Y(I)+Y(I)-U:NEXT I:IF D=2 GOTO 220
190 U=170:FOR I=1 TO S:IF Z(I)<U AND X(I)=0 AND Y(I)=0 THEN
    U=Z(I)
200 NEXT I:FOR I=1 TO S:Z(I)+Z(I)-U:NEXT I
210 REM ORDER SQUARES ACCORDING TO THEIR DISTANCE FROM THE BASE
    SQUARE
220 FOR I=1 TO S:FOR J=1 TO S
    :O=X(I)+X(J)+Y(I)+Y(J)+Z(I)+Z(J)
230 W=(J)+X(J)+Y(J)+Z(J)+Z(J)*2:IF G<W GOTO 270
240 IF S=H AND X(I)<X(J) OR X(I)=X(J) AND Y(I)<Y(J) OR Y(I)=Y(J)
    AND Z(I)<Z(J) GOTO 270
250 IF S=H AND X(I)=X(J) AND Y(I)=Y(J) AND Z(I)=Z(J) GOTO 270
260 W=(I)+X(I)+Y(I)+Z(I):W=X(I)+Y(I)+Z(I)+Y(J)+Z(J)+W+2(I)
    :Z(I)=Z(I)+Z(J)
270 NEXT J:NEXT I:IF A=0 GOTO 380
280 REM COMPARE ORIENTATION TO THOSE ALREADY ORIENTED
290 FOR I=1 TO A:FOR J=1 TO S-1:U=0:J-1*(S-1)*(J*(K-1)+I-1)
300 V=Y(J+1):IF V<0 THEN V=V+256
310 IF X(J+1)<PEEK(U) OR V<PEEK(U+H) GOTO 360
320 IF D<3 GOTO 350
330 W=Z(J+1):IF W<0 THEN W=W+256
340 IF W<PEEK(U+2*H) GOTO 360
350 NEXT J:GOTO 440
360 NEXT I
370 REM PUT ENTRIES IN TABLE
380 J=0:A=+1:FOR I=2 TO S:J=J+1:U=0:J-1*(S-1)*(J*(K-1)+I-1)
390 V=Y(I+1):IF V<0 THEN V=V+256
400 W=Z(I+1):IF W<0 THEN W=W+256
410 O=X(I+1)+Y(I+1)+Z(I+1):IF D=3 THEN P=K+U+2*V+W
420 NEXT I
430 REM ROTATE TO NEW ORIENTATION
440 B=0+1:IF B=4 THEN B=0:GOTO 460
450 FOR I=1 TO S:W=X(I):X(I)=Y(I):Y(I)=W:NEXT I:GOTO 150
460 C=C+1:IF C<>2 GOTO 520
470 C=0:IF D=2 GOTO 530
480 E=Y+1:IF E>1 GOTO 500
490 FOR I=1 TO S:W=Z(I):Z(I)=X(I):X(I)=W:NEXT I:GOTO 150
500 F=Y+1:IF F>1 GOTO 540
510 FOR I=1 TO S:V=Y(I):Y(I)=Z(I):Z(I)=V+W:NEXT I:GOTO 150
520 FOR I=1 TO S:K(I)=X(I)+Z(I)+2(I):NEXT I:GOTO 150
530 REM PRINT NUMBER OF ORIENTATIONS AND PUT IT IN ARRAY R
540 PRINT A,"ORIENTATIONS":POKE R0,K:IF T=1 GOTO 570
550 NEXT K
560 REM GO BACK AND CORRECT MISTAKES
570 T=1:INPUT "ENTER I.D. NUMBER OF A PIECE YOU WZED TO
    CORRECT (0 IF NONE)";K
580 IF K<0 GOTO 90
590 PRINT " ***** DONE *****"
600 PRINT "RECORD ARRAYS R AND B ON TAPE TO SAVE":END

```

The first index, K, is the assigned number of the piece whose orientations are being considered. Thus, for the case of Pentominoes, K ranges from one to twelve, and for the Soma Cube pieces it ranges from one to seven.

The second index, J, labels the individual squares or cubes that make up the piece under consideration. The positions of these squares will be defined in the table by their Cartesian coordinates relative to the base square, which is taken at the origin, ie: at (0,0) in the two-dimensional case, and at (0,0,0) in the three-dimensional case. Since the coordinates of the base square are fixed in this way, we need only tabulate the positions of the other squares relative to it. Thus, for Pentominoes, J ranges from one to four (not five), and for the Soma Cube it ranges from one to three (not four).

The ordering of the J values assigned to the various squares is determined by their distance from the base square. It is important that the squares nearest the base square have the lowest values of J because of the method we use to define the boundary of the box (ie: putting -1s around it). Unless the J values are in ascending order with increasing distance from the base square, there is a chance that the program might try to access a memory location which is not a part of the box. The BASIC table-generating program automatically takes care of this ordering.

The third index, M, labels which Cartesian coordinate is referred to by a given table entry. M=1 refers to an X-coordinate, M=2 refers to a Y-coordinate, and M=3 refers to a Z-coordinate. For any polyominoes M can be either one or two, and for the Soma Cube M can be one, two, or three.

The fourth index, I, labels which orientation is being described. The number assigned to a given orientation has no significance except for labelling purposes. The range of I is given by the maximum number of orientations of the pieces under consideration, which is eight for all polyominoes, and twenty-four for the Soma Cube pieces.

To sum up this information with an example, the table element B (1, 2, 3, 4) gives the Z-coordinate of square number 2 in the fourth orientation of

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K=9	J		M				
	I		1	2	3	4	
	1		1	1	1	2	1
			0	-1	1	1	2
	2		1	1	2	2	1
			0	1	0	-1	2
	3		1	1	1	2	1
			0	1	2	1	2
	4		0	1	1	2	1
			1	0	-1	0	2
	5		1	1	2	2	1
			0	-1	0	1	2
	6		1	1	1	2	1
			0	-1	1	-1	2
	7		0	1	1	2	1
			1	1	2	1	2
	8		1	1	1	2	1
			0	-1	-2	-1	2

Table 1: Orientation table entries for example of Pentomino 9. In the diagrams, the base square is labeled B and the other squares are labeled by their J values. The base square is always the lowest square in the leftmost column of the figure, and the table gives the coordinates of the other squares with respect to it.

piece number 1. Table 1 clarifies this by showing all of the orientations of Pentomino number 9 and the table entries which go with each figure.

The main program looks up values in the orientation table by calling a subroutine called LOOKUP. This subroutine is called many times during each loop of the main program and is therefore the most time-critical portion of the program.

In the program given here, a certain amount of speed has been sacrificed for the sake of generality. If the user is interested only in a particular problem, the subroutine can be speci-

fically rewritten for this problem, and the running time may be cut considerably. For instance, the first program that we wrote considered only the Pentomino problem for a 10 by 6 box, and ran almost twice as fast as the general routine given in this article. Clearly, however, it is most desirable to start with a completely general program like the one given here.

Definition of Variables

As mentioned before, any arrays of more than one dimension must be stored as linear arrays in memory.

The array A, representing the playing region, is two-dimensional when we are considering polyominoes and three-dimensional when we are considering Soma Cubes. In both cases the linearized array is arranged in memory so that the scan procedure described above goes through the linear array in ascending order. For instance, the Soma Cube array is stored with the Z index varying fastest and the X index varying slowest:

A(1,1,1), A(1,1,2), . . . , A(1,1,5),
 A(1,2,1), A(1,2,2), . . . ,
 A(1,2,5) , A(5,5,1),
 A(5,5,2), . . . A(5,5,5)

(Remember that we put a boundary of -1s around the box, so the dimensions of the array are 5 by 5 by 5 rather than 3 by 3 by 3.) The dimensions of array A vary depending on the problem being considered, but a reserved memory space of about 300 bytes is sufficient for most reasonably sized problems. Array A begins at an address denoted by A0 in the BASIC and assembly listings, and is indexed by the value stored in variable L.

In the linearization of the orientation table, the elements B(K, J, M, I) are stored with the index J varying fastest, I varying next fastest, K next, and finally M, varying slowest. More specifically, if we define the following quantities:

- P: number of pieces,
- S: number of squares or cubes per piece,
- Q: maximum number of orientations for any one piece (eight for polyominoes and twenty-four for Soma Cube pieces),
- D: number of dimensions (two for polyominoes, three for Soma Cube),
- B0: beginning address of orientation table,

then the location in memory of the element B(K, J, M, I) is given by $B0 + J - 1 + (S - 1) \times \{ Q \times [P \times (M - 1) + K - 1] + I - 1 \}$, and the number of elements in the table is given by $(S - 1) \times Q \times P \times D$. In assigning array space, the user should provide enough space for this table. Note that in the symbolic assembly program, the letters P, S, Q, D, I, J, K are used to denote the addresses of these quantities rather than the quantities themselves. Henceforth we will

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Listing 2: BASIC driver and printout routine for Soma Cube — Polyominoes program. The "blackout" in line 1070 indicates use of the PET Shift-& graphics character.

```

1 REM POKE 135,20 TO PROTECT MACHINE CODE FROM BASIC INTERPRETER
2 REM 95 HOLDS PRINTOUT SYMBOLS FOR PIECES
3 B$="XIVTUS4PRZYL"
10 REM COPYRIGHT 1979 SOMA-POLYMINO DRIVER PROGRAM
11 INPUT "ENTER NUMBER OF DIMENSIONS";D
12 POKE 31,D
13 INPUT "ENTER THE NUMBER OF PIECES";P
14 POKE 27,P
15 INPUT "NUMBER OF SQUARES PER PIECE";S
16 POKE 25,S
17 PRINT "ENTER DIMENSIONS OF THE BOX":INPUT "WX";WX:INPUT "WY";WY
18 WZ=-1:IF D=J THEN INPUT "WZ";WZ
19 AX=AX+2:WY=WY+2:WZ=WZ+2:POKE 28,WX:POKE 29,WY:POKE 30,WZ
20 REM ASSIGN VALUES TO A0,E0,B0,C1,C2,E0 AGREEING WITH
    ASSEMBLY PROGRAM
21 A0=6300:R0=6580:B0=6600:C1=6200:C2=6220:E0=6240
30 REM A$ HOLDS EACH SOLUTION FOR PRINTOUT
40 REM ARRAYS R AND B ARE PRODUCED BY TAB. GEN. PROGRAM AND
    LOADED FROM TAPE
50 POKE 26,S-1:POKE 32,P-1
60 Q=N:IF D=3 THEN Q=24
70 POKE 33,):SPACE=Q*P*(S-1):I=INT(SPACE/256):J=SPACE-256*I
    :POKE 36,J:POKE 37,I
80 INDEX=B0-1-(S-1)*(Q+1):I=INT(INDEX/256):J=INDEX-256*I
    :POKE 39,J:POKE 39,I
90 FOR L=A0 TO A0+WX*WY*WZ-1:POKE L,0:NEXT L
100 FOR I=C2 TO C2+P:POKE I,0:NEXT I
110 REM PLACE BOUNDARY OF (-1)'S AROUND BOX
120 J=(AX-1)*WY*WZ:K=(WY-1)*WZ:M=WY*WZ
130 FOR I=A0 TO A0+M-1:POKE I,255:POKE I+J,255:NEXT I
    :FOR L=1 TO WZ
140 FOR I=A0+M+L-1 TO A0+J+L-M-1 STEP M:POKE I,255:POKE I+K,255
    :NEXT I:NEXT L
150 IF D=J THEN FOR I=A0+M+WZ TO A0+J-2*WZ STEP WZ:POKE I,255
160 POKE I+WZ-1,255:NEXT I
170 PRINT "ENTER COORDINATES OF DIFF. LIMITS SQUARES."
    :PRINT "WHEN DONE ENTER 999 FOR X"
180 INPUT "X";X:IF X=999 GOTO 210
190 INPUT "Y";Y:Z=0:IF D=3 THEN INPUT "Z";Z
200 POKE A0+WZ*(WY*X+Y)+Z,255:PRINT:GOTO 180
210 PRINT:PRINT "ENTER INITIAL PERMUTATION OF PIECES":PRINT
220 FOR I=1 TO P:INPUT X:POKE C1+I,X:NEXT I
230 INPUT "ENTER NUMBER OF PIECES FIXED";Z
240 POKE 15,Z:POKE 0,Z+1:POKE 14,Z+1:IF Z=0 GOTO 300
250 REM PUT IN FIXED PIECES, IF ANY
260 FOR I=1 TO Z:PRINT "ENTER COORDS. OF EACH SQUARE OF
    PIECE";PEEK(C1+I)
270 FOR J=1 TO S:PRINT "SQUARE";J:INPUT " X";X:INPUT " Y";Y:Z=0
    :IF D=J THEN INPUT " Z";Z
280 PE=PEEK(C1+I):POKE A0+WZ*(WY*X+Y)+Z,PE:NEXT J:NEXT I
290 REM INITIALIZE BASE SQUARE
300 FOR I=1 TO WX*WY*WZ-1:IF PEEK(A0+I)=J THEN POKE 11,I
    :GOTO 320
310 NEXT I
320 POKE 13,1
330 SYS(5120)
999 C=0
1000 REM PRINT A SOLUTION
1010 IF PEEK(18)=0 THEN PRINT:PRINT " DONE !!!!":END
1020 C=C+1:PRINT:PRINT "SOLUTION #";C:PRINT
1030 Z=J:A$="":FOR Y=WY-2 TO 1 STEP -1
    :IF D=3 THEN FOR Z=1 TO WZ-2
1040 FOR X=1 TO WX-2:A=PEEK(A0+WZ*(WY*X+Y)+Z
1050 IF X=1 AND Z<>0 AND Z<>WZ-2 THEN A$=A$+" "
1060 IF A=0 THEN A$=A$+"0":GOTO 1090
1070 IF A=255 THEN A$=A$+"blackout":GOTO 1090
1080 A$=A$+MID$(B$,A,1)
1090 NEXT X:IF D=3 THEN NEXT Z
1100 NEXT Y
1110 U=WX-2:IF D=3 THEN U=(WX-1)*(WZ-2)+1
1120 FOR I=1 TO WY-2:PRINT MID$(A$,U*(I-1)+1,U):NEXT I
1130 REM TYPING "S" WILL CAUSE EXECUTION TO STOP ON NEXT RETURN
    TO BASIC
1140 GET YG$:IF YG$="S" THEN PRINT:PRINT " STOP":END
1150 SYS(5759)
1160 GOTO 1010

```

use (P) with parentheses to denote the contents of memory location P, etc.

Other symbolic addresses appearing in the program include:

N: address containing 1 plus the number of pieces currently in the box,
Z: address containing the number of pieces specified as fixed by the user,
T: address containing the maximum number of pieces fitted into the box during the current permutation,

WX, WY, WZ: addresses containing the width of the box in the X, Y, and Z directions respectively (including the boundaries of -1s). For two-dimensional problems, WZ is set equal to 1,

C1: first address of an array containing the piece numbers in the order given by the current permutation, (P) is the length of this array,

C2: first address of an array containing the orientation numbers of the pieces in the order corresponding to that in the table beginning at C1, (P) is length,

R0: first address of an array, the N-th element of which is the number of possible orientations of piece number N. This table is automatically generated by the BASIC program which generates the orientation table B, (P) is length,

E0: first address of an array, the N-th element of which gives the position of the base square of piece number N, (P) is length.

The user should choose absolute addresses for the arrays so that they do not overlap; note that the array at B0 is particularly long. Since the arrays at R0 and B0 are both generated by the BASIC orientation-table routine, it simplifies matters if R0 is about 30 bytes in front of B0 so that the two arrays can be recorded on tape as a single file.

Although the assembly language part of the program (listing 3) is completely symbolic and therefore relocatable, the BASIC driver routine in listing 2, which contains the initialization and printout routines, must refer to the *absolute* addresses of some of the variables. Table 2 is a list of the absolute hexadecimal addresses used in running the program on a Commodore Pet with 8 K bytes of memory. In relocating the program, the user should be careful to make the addresses referred to by the two routines consistent. Listing 4 (see

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Table 2: Absolute hexadecimal addresses used in running the Soma Cube — Polyominoes program on an 8 K byte Commodore Pet. This table includes the addresses of all symbolic variables used in listing 3.

Variable or Location Name	Location (Hexadecimal)	Variable or Location Name	Location (Hexadecimal)
N	0	REMOVE	14CD
I	1	SAVE	14ED
K	2	LOOP3	1508
J	A	JUMP1	1524
L	B	ISOSQ	1527
U	D	LOOP4	1547
T	E	LEAVE	159C
Z	F	JUMP2	15A8
SAFE	10	REPEAT	15AB
V	11	PERMUTE	15C2
FLAG	12	ILOOP	15CC
BXLO	13	JLOOP	15D7
BXHI	24	MAX	15F4
BYLO	25	SWITCH	1612
BYHI	26	ZEROC2	162B
BZLO	27	ORDER	1643
BZHI	28	NEXTJ	164A
S	29	NEXTU	1651
SM1	2A	NOSWITCH	166C
P	2B	LSTPCE	167F
WX	2C	TAKEOUT	168F
WY	2D	LOOKUP	168C
WZ	3E	TOP	16CD
D	3F	MULT1	16D7
PM1	20	STEP1	16DE
O	21	STORE1	16E5
OLDK	22	MULT2	16EB
OLDI	23	STORE2	16FB
SPACELO	24	MIDDLE	1721
SPACEHI	25	MULT3	1729
INDEXLO	26	STEP3	1730
INDEXHI	27	ADD	1737
TEMP	28	DIM3	174F
START	1400	MULT4	1753
LOOP1	1413	STEP4	175A
TEST	142B	END	1761
INSERT	1437	C1	1838
LOOP2	143B	C2	184C
NXTBASE	146D	E0	1860
INXC	148F	A0	189C
ISOTEST	148C	R0	19B4
REPLACE	14B4	B0	19C8
JSTART	14C8		

Listing 3: Symbolic 6502 assembly code listing for Soma Cube — Polyominoes program. The unrelative variables addressed are given in table 2. Listing 4 is a hexadecimal dump of the program for people who do not have an assembler available.

```

START: LOX #
        INC C2,X      :increment orientation counter
        LDA C2,X
        STA I         :(I)=orientation number
        LDA C1,X
        STA K         :(K)=piece number
        LDY #1
        STY J

LOOP:   JSR LOOKUP   :check if orientation (I) of
        LDA A0,X     :piece (K) will fit into box
        BNE TEST     :if no, check for other orientations
        INC J
        LDA SR1
        CMP J
        BCS LDDP1
        JMP INSBAT   :if yes, insert it
TEST:   LOX #         :check if piece (K) has any
        LDA I         :more orientations
        CMP R0,X
        BCC START   :if yes, go check them out
        JMP REMOVE   :if no, remove previous piece
INSBAT: LDY #1
        STY J
    
```

Listing 3 Continued on page 62

page 52) is a hexadecimal object code dump of the main assembler routine of listing 3.

Using the Program

The assembly language program (listing 3), the BASIC driver routine (listing 2), and the table-generating routine (listing 1) should each be recorded on tape in separate files.

Once a specific problem has been chosen, the table-generating program should be loaded and run. As input, this program requires the number of dimensions (D), the number of pieces (P), the number of squares or cubes per piece (S), and the array addresses R0 and B0, defined above. The computer then asks for the X and Y (and Z if (D)=3) coordinates of each square of each piece. When entering these, the chosen location of the origin of coordinates is not important. For instance, the second tromino in figure 1 could be entered in either of these two ways:

(X,Y)=(1,0) (X,Y)=(4,2)
 (0,0) or: (3,2)
 (0,1) (3,3)

After the data for each piece has been entered, the computer pauses, prints out the total number of different orientations of that piece, and then asks for the data on the next piece. After all of the pieces have been entered, the program asks if any were entered incorrectly, and gives the user an opportunity to go back and correct any mistakes. Once the program stops, the arrays beginning at R0 and B0 should be recorded on tape. They can be recorded as one file if R0 and B0 were chosen close together as suggested.

There is one slight difficulty. In running the Soma Cube, the program will ask for the positions of four cubes for each of the seven pieces, even though one piece, the second, is made up of only three cubes. This problem can be sidestepped by simply entering one of the cubes of this piece twice. A slight redundancy during running will result, but the increased generality in the problems that can be run will more than compensate.

Once the orientation table has been generated and saved, the assembly language module and the BASIC driver routine should be loaded into memory along with the table. In the

Text continued on page 48

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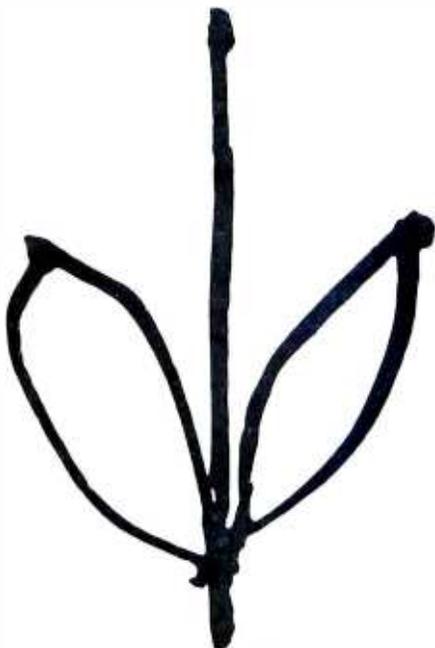
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Listing 3 continued:

```

LOOP2: JSR LOOKUP ;insert piece (K) by putting the
        LDA K      ;number (K) into the appropriate
        STA A0,X   ;squares of the box
        INC J
        LDA SM1
        CMP J
        BCS LOOP2
        LDX L
        LDA K
        STA A0,X
        TAX
        LDA L
        STA E0,X   ;save base square of piece (K)
        LDA P      ;if all of the pieces are in the box,
        CMP N      ;return to BASIC to print solution
        BNE NXTBASE ;otherwise, find next base square
        RTS
NXTBASE: LDX L     ;scan for next base square
        INCX: INX
        LDA A0,X
        BEQ ISOTEST
        JMP INCX
ISOTEST: STX J     ;put new base square in location J
        LDA D
        CMP #3
        BEQ REPLACE ;if (D)=3, skip isolated square test
        TXA        ;test if new base square is isolated
        CLC
        ADC #1
        TAX
        LDA A0,X
        BEQ REPLACE
        TXA
        CLC
        ADC WY
        TAX
        DEX
        LDA A0,X
        BEQ REPLACE ;if it is not, go to REPLACE
        JMP ISOSQ   ;if it is, go to isolated square routine
REPLACE: LDA J
        STA L      ;set new base square
        INC N      ;increment piece counter
        LDA T      ;(T)=greatest number of pieces
        CMP N      ;successfully fitted into box in
        BCS JSTART ;current permutation
        LDA N
        STA T
JSTART:  JMP START ;return to START
REMOVE:  LDX N     ;remove last piece inserted
        LDA #0
        STA C2,X   ;set orientation number to zero
        DEX        ;decrement piece counter
        STX N
        LDA C1,X
        STA K
        LDA C2,X
        STA I
        LDA Z      ;check if new piece is fixed
        CMP N
        BCC SAVE   ;if no, take it out
        JMP PERMUTE ;if yes, go to next permutation of pieces
SAVE:    LDY K     ;recover base square of the
        LDX E0,Y   ;piece to be taken out
        STX L
        LDA #0
        STA A0,X
        LDY #1
        STY J
LOOP3:   JSR LOOKUP ;take out piece by putting zeroes
        LDA #0     ;in each square it occupies
        STA A0,X
        INC J
        LDA SM1
        CMP J
        BCS LOOP3
        LDX K     ;check if piece has any more orientations
        LDA I
    
```

```

CMP R0,X
BCS JUMP1 ;if no, remove a further piece
JMP START ;if yes, go check them out
JUMP1: JMP REMOVE
ISOSQ: LDY K ;recover base square of piece to be taken
LDX EO,Y out to cure isolation of new base square
STX L
LDA #0
STA AO,X
LDA J
STA SAFE ;store base square in safe place
LDY #1
STY J
LOOP4: JSR LOOKUP ;remove last piece inserted
LDA #0
STA AO,X
INC J
LDA SM1
CMP J
BCS LOOP4 ;recover base square
LDA SAFE
STA J
CLC ;test if it is still isolated by checking
ADC #1 if each of the four squares around it is
TAX filled
LDA AO,X
BEQ LEAVE
DEX
DEX
LDA AO,X
BEQ LEAVE
TXA
SEC
SBC WY
TAX
INX
LDA AO,X
BEQ LEAVE
TXA
CLC
ADC WY
ADC WY
TAX
LDA AO,X ;if it is not still isolated,
BEQ LEAVE prepare to return to normal routine
JMP REPEAT ;if it is, repeat isolated square routine
LEAVE: LDX K ;check if piece (K) has any
LDA I more orientations
CMP R0,X
BCS JUMP2 ;if no, remove previous piece
JMP START ;if yes, go check them out
JUMP2: JMP REMOVE
REPEAT: LDX N
LDA #0
STA C2,X ;set orientation number to zero
DEX ;decrement piece counter
STX N
LDA C1,X ;set new values of (K) and (I)
STA K
LDA C2,X
STA I
JMP ISOSQ ;repeat isolated square routine
PERMUTE: LDA T ;find new permutation, making sure that
STA I the re-permutation goes at least as far
CMP P back as the (T)-th piece of the old
BNE ILOOP permutation
DEC I
ILOOP: LDA #127 ;the nested I and J loops pick two elements
STA U of the permutation to be interchanged.
LDA I These are: the last element of the
CLC permutation, which has a larger element
ADC #1 following it, and the smallest element
STA J following this element which is greater
JLOOP: LDX I than it
LDY J
LDA C1,Y
CMP C1,X
BCC MAX

```

Listing 3 continued on page 46

X-RATED

Revolutionary Computerized Math!

```

Enter ? SOLVE (X^3 A^2*X, X)
muMATH Responds
@ X A
  X A
  X 0
Enter ? TAN (X) * COS (X) + 1 CSC (X).
Response
@ 2 * SIN(X)
Symbolic Integration!
? INT (X * COS(A * X^2), X):
@ SIN(X^2 * A) (2 * A)
Symbolic Matrix Inversion!
? |1 X|
  |0 A| + 1
  |1 X A|
  |0 1 A|
Exact Arithmetic!
? 99! * 9 + (1/2) / 40 + 35:
@ 296438922463401814427834899493
256205695871443300411356128843
2083904069287504517225987785930307
497936652596433351 / 12500000000

```

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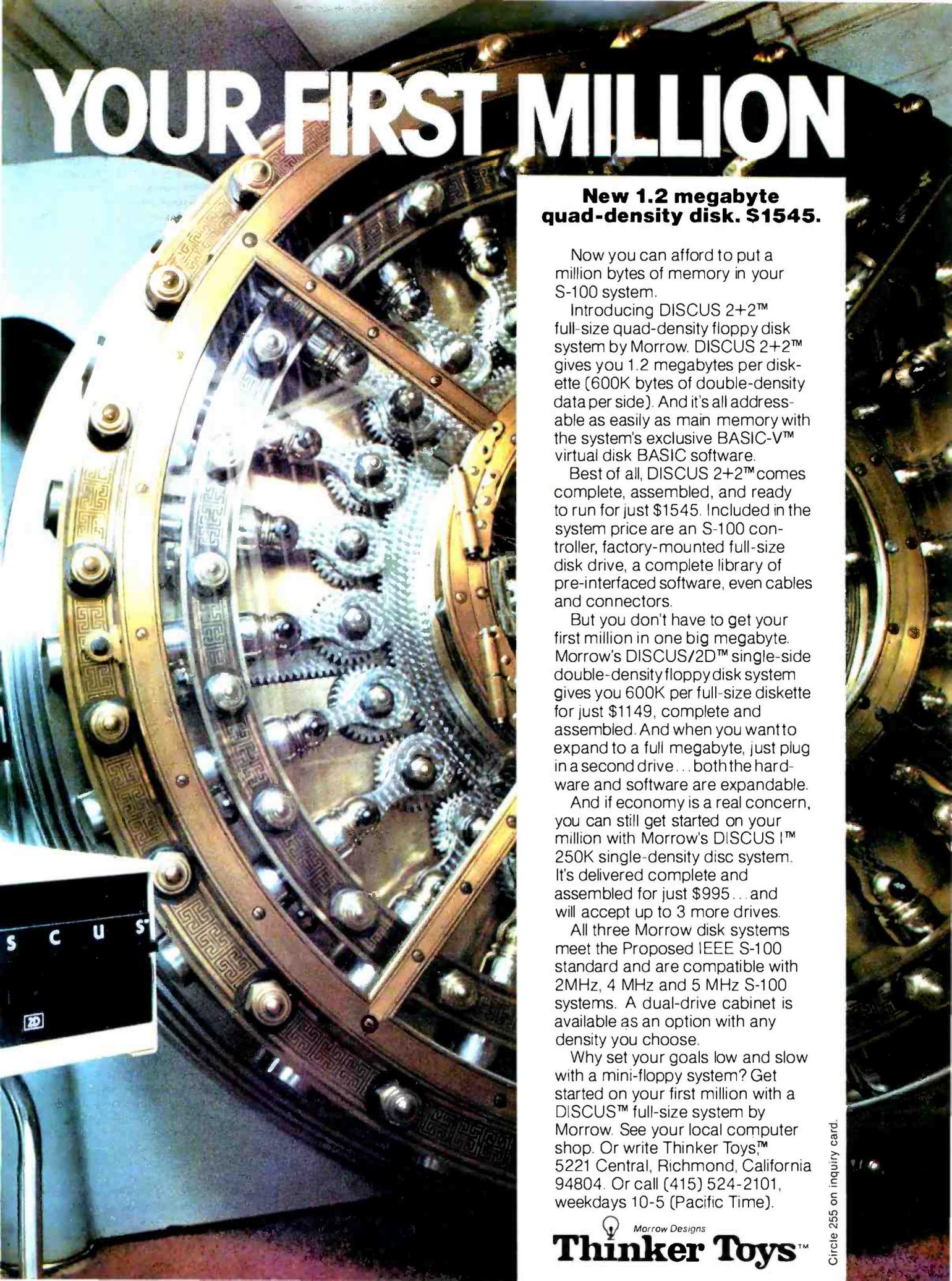
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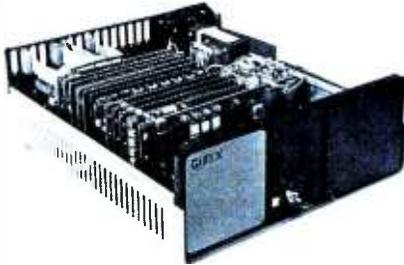


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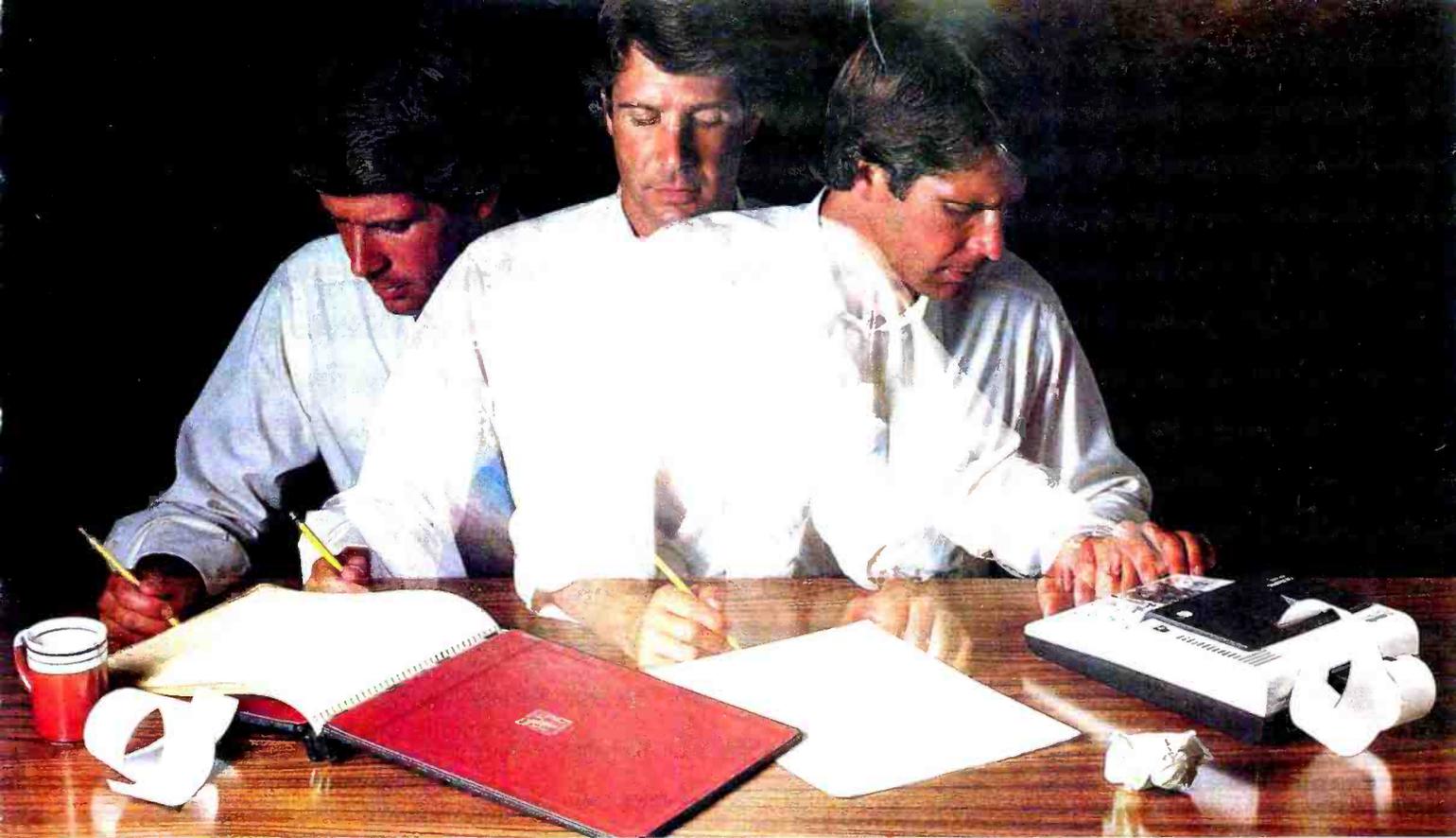
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Listing 3 continued:

```

LDA U
CMP C1,Y
BCC MAX
STY V
LDA C1,Y
STA U
MAX: INC J
LDA P
CMP J
BCS JLOOP
LDA U
CMP #127
BNE SWITCH
DEC I
LDA Z
CMP I
BCC ILOOP
LDA #0 ;if such elements cannot be found, clear
STA FLAG FLAG and return to BASIC to stop
RTS
SWITCH: INC N ;interchange elements found by
LDA N I and J loops
STA T
LDX I
LDA C1,X
LDY V
STA C1,Y
LDA U
STA C1,X
LDA N
STA J
ZFROC2: LDA #0 ;reinitialize orientation numbers
LDX J
STA C2,X
INC J
LDA P
CMP J
BCS ZEROC2
LDA PM1 ;if repermuation only interchanged last
CMP I two pieces, return to START
BNE ORDER
JMP START
ORDER: LDA I ;otherwise, reorder new permutation
CLC into ascending order
ADC #1
STA J
NEXTJ: LDA J
CLC
ADC #1
STA U
NEXTU: LDX J
LDY U
LDA C1,X
CMP C1,Y
BCC NOSWTC
STA V
LDA C1,Y
STA C1,X
LDA V
STA C1,Y
NOSWTC: INC U
LDA P
CMP U
BCS NEXTU
INC J
LDA PM1
CMP J
BCS NEXTJ
JMP START ;return to START
LSTPCR: LDX K ;BASIC returns control to here after
LDA E0,X printing a sclusion so that the (P)-th
STA L piece can be taken out
LDA #1
STA J
TAKEOUT: JSR LOOKUP
LDA #0
STA A0,X
INC J
    
```

Listing 3 continued on page 48



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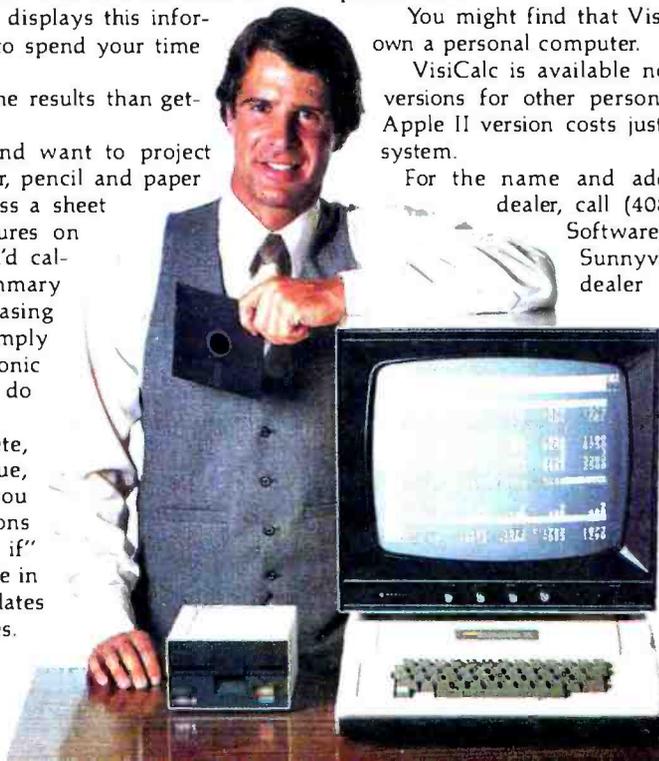
Or say you're an engineer working on a design problem and are wondering "What if that oscillation were damped by another 10 percent?" Or you're working on your family's expenses and wonder "What will happen to our entertainment budget if the heating bill goes up 15 percent this winter?" VisiCalc responds instantly to show you all the consequences of any change.

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VisiCalc was developed exclusively for Personal Software by Software Arts, Inc., Cambridge, Mass.

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Listing 3 continued:

```

LDA S#1
CRP J
BCS TAKEOUT
LDA I
LDA I0
STA A0,K
JMP BZNOVE
LOOKUP: LDI J          ;input square number in I register
LDA I          ;if (I) and (K) are the same as in the
CRP OLOI      ;previous call to LOOKUP, go to MIDDLE,
BNE TOP       ;otherwise to TOP
LDA K
CRP OLOK
BNE TOP
JMP MIDDLE
TOP: LDA 0
STA 0XLO
LDA I0
STA 0XHI
LDI #8
MULT1: ASL 0XLO      ;one byte multiplication
BCC STEP1     ;routine figures (Q)*K
CLC
ADC K
STEP1: DEI
BEQ STORE1
ASL A
JMP MULT1
STORE1: ADC I        ;add (I) to it
STA 0XLO      ;store result in 0XLO
LDI S#1
MULT2: DEI          ;multiply this by (S)-I and store the
BEQ STORE2    ;two-byte result in 0XLO and 0XHI
ADC 0XLO
BCC MULT2
EWC 0XHI
CLC
JMP MULT2
STORE2: ADC I*0XLO   ;add the two-byte quantity (I*0X) to (0X)
STA 0XLO
LDA 0XHI
ADC I*0XHI
STA 0XHI
LDA SPACELO   ;add the two-byte quantity (SPACE) to (0X)
ADC 0XLO      ;to get (0Y)
STA 0YLO
LDA SPACEHI
ADC 0XHI
STA 0YHI
LDA 0         ;if (C)≠0, go to MIDDLE
CRP J
BNE MIDDLE
CLC
LDA SPACELO   ;add the two-byte quantity (SPACE) to (0Y)
ADC 0YLO      ;to get (0Z)
STA 0ZLO
LDA SPACEHI
ADC 0YHI
MIDDLE: LDA (0XLO),Y ;load X coordinate of square
STA TEMP
LDA #0
LDX #8
MULT3: ASL TEMP      ;multiply it by (WY)
BCC STEP3
CLC
ADC WY
STEP3: DEI
BEQ ADD
ASL A
JMP MULT3
ADD: CLC
ADC (0YLO),Y   ;add Y coordinate of square
STA TEMP      ;store result in TEMP
LDI 0         ;if (0)=0, go to 0FN3
CPX J
BEQ 0FN3
CLC

```

Test continued:

case of the Commodore PET, the BASIC driver should be loaded last. Before it is loaded, the page number on which the assembly routine starts should be placed into location 135 decimal, using the POKE statement. This insures that the arrays defined by BASIC will not interfere with the assembly routine or the table.

Before running, the user should check lines 3 and 21 of the BASIC driver routine, to determine whether or not they are correct for the problem under consideration. When run, the driver routine asks the user for input with prompts that are fairly self-explanatory. However, a few specific hints may be helpful.

Although the program will work no matter how the box is oriented, it will run fastest if the dimensions WX, WY, and WZ are chosen to be in descending order (ie: WX>WY>WZ), due to the mechanics of the search procedure. Failure to do this may lengthen the running time by a factor of ten or more.

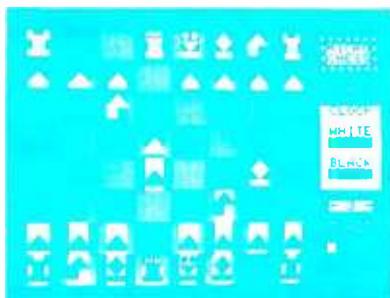
When entering the off-limits squares, and also the coordinates of any fixed squares, the coordinates are defined for polyominoes so that the lower left-hand corner of the box (excluding boundary) has the coordinates (1,1); and for Soma Cubes the corner with the lowest coordinate values has coordinates (1,1,1).

In entering the initial permutation of pieces, the order in which the machine goes through the permutations should be kept in mind. Thus, entering the piece numbers in ascending order: 1,2,3,...,P will result in an exhaustive search, whereas any other initial permutation will cause only a subset of the complete set of permutations to be considered.

Any pieces which are to be specified as fixed should be put at the beginning of the initial permutation. For example, to find all of the solutions with pieces 2 and 4 fixed in particular locations, the initial permutation array should have 2 and 4 at the beginning, and the rest of the numbers in ascending order, (ie: 2, 4, 1, 3, 5, 6, 7, ..., P). The number of fixed pieces should then be entered as two, after which the computer will ask for the coordinates of each square of pieces 2 and 4.

The program does not check to see if the coordinates entered by the user for a fixed piece correspond to a legal

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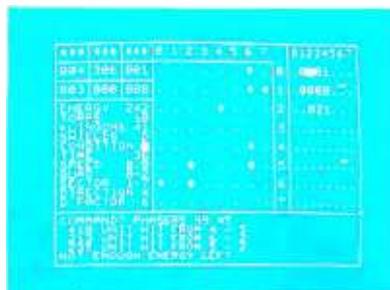
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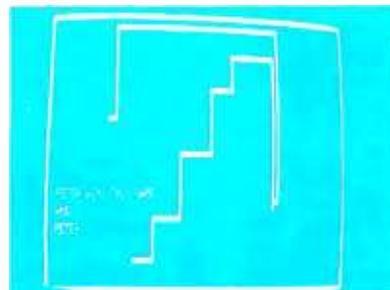
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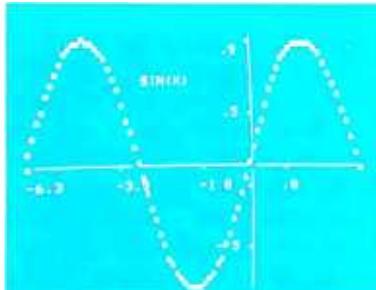


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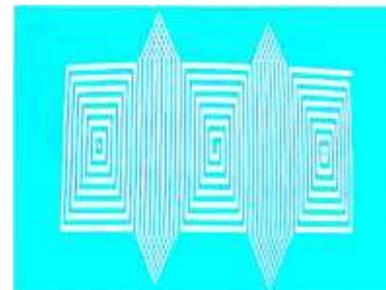
shots as they come towards you—lower your shields just long enough to fire your phasers, betting that you can get them back up in time! With nine levels of difficulty, this challenging game is easy to learn, yet takes most users months of play to master. **ADD SOUND EFFECTS** with a simple two-wire hookup to any audio amplifier; the **TRS-80** also produces sound effects directly through the keyboard case, to accompany spectacular graphics explosions! You won't want to miss this memorable version of a favorite computer game **\$14.95**



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Listing 3 continued:

```

ADC L           ;otherwise, add base square index
TAX            ;transfer result to X register
LDA K          ;store old (K) and (I) values
STA OLDK
LDA I
STA OLDI
RTS            ;return to main routine

DIM3: LDA #0
LDX #8

MULT4: ASL TEMP ;multiply (TEMP) by (#Z)
BCC STEP4
CLC
ADC WZ

STEP4: DEX
BEQ END
ASL A
JMP MULT4

END: ADC L           ;add base square index
ADC (DZLO),Y   ;add Z coordinate of square
TAX            ;transfer result to X register
LDA K          ;store old (K) and (I) values
STA OLDK
LDA I
STA OLDI
RTS            ;return to main routine
    
```

routine depends so little on the dimensionality of the pieces under consideration, the user could extend it to consider analogous problems in four or more spatial dimensions. Hard as these might be to visualize, the computations involved are not fundamentally different from those encountered in two and three-dimensional problems.

Another possibility is to assign colors to the various pieces and look for interesting properties of the resulting solutions. For example, the plastic Pentomino puzzle which provided the inspiration for this article had the following piece colors:

X,P,Y : Red
 I,T : Yellow
 V,U,S, : Blue
 W,R,Z,L : Green



Photo 3: All of the solutions for Pentominoes in a 20 by 3 box. Solutions three and four are mirror images of solutions one and two, so there are only two fundamentally different solutions.

orientation of that piece, so care should be taken to insure that all of these numbers are entered correctly.

To stop the program in mid-run, the S key may be pressed at any time. This will cause execution to stop on the next return to the BASIC printout routine.

Photo 3 is a typical output of the Soma Cube — Polyominoes problem solver. The solutions are for Pentominoes in a 20 by 3 box.

Conclusion

As general as this program is, it by no means exhausts the possibilities inherent in problems such as these.

In addition to squares, it is possible to tile the plane with other figures such as triangles and hexagons. It should not be hard to modify the program to consider figures made out of these shapes. At a more abstract level, since the assembly language

There is one and *only* one 10 by 6 solution using this set which is a true four-coloring (ie: a solution in which no two pieces of the same color touch each other). Can you find it?

These are only suggestions. The capabilities of the program and the uses to which it can be put depend ultimately on the interests and ingenuity of the user.

BIBLIOGRAPHY

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3. Philpott, Wade E, *Polyomino and Polyiamond Problems*, Journal of Recreational Mathematics, 10:1, pages 2 thru 14 and 10:2, pages 98 thru 105, Baywood Publishing Company Inc, 1977-78.
4. *Introducing Soma*, Parker Brothers Inc, Salem MA, 1969.

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Listing 4: Hexadecimal object code dump for the Soma Cube — Polyominoes program given in listing 3.

HEX DUMP OF

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```

.: 1400 A8 05 1E 4C 18 B0 4C 18
.: 1408 85 01 80 38 18 85 02 A0
.: 1410 01 84 0A 20 8C 16 B0 9C
.: 1418 18 00 0D E6 7A A5 1A C5
.: 1420 0A 80 F0 4C 37 14 EA EA
.: 1428 A6 02 A5 01 B0 B4 19 90
.: 1430 CF 4C CD 14 EA EA EA A0
.: 1438 01 84 0A 20 8C 16 A5 02
.: 1440 9D 9C 18 E6 0A A5 1A C5
.: 1448 0A 80 F0 A6 0B EA EA EA
.: 1450 EA EA EA A5 02 9D 9C 18
.: 1458 A6 02 A5 0B 9D 60 18 EA

```

```

.: 1460 EA EA EA EA A5 18 C5 00
.: 1468 D0 03 60 EA EA A6 0B E8
.: 1470 B0 9C 18 F0 17 4C 6F 14
.: 1478 EA EA EA EA EA EA EA EA
.: 1480 EA EA EA EA EA EA EA EA
.: 1488 EA EA EA EA 86 0A A5 1F
.: 1490 C9 03 F0 20 8A EA EA EA
.: 1498 EA EA EA 18 69 01 AA B0
.: 14A0 9C 18 F0 10 EA EA 8A 18
.: 14A8 65 10 AA CA 6D 9C 18 F0
.: 14B0 03 4C 27 15 A5 0A 85 0B
.: 14B8 EA EA EA EA E6 00 A5 0E
.: 14C0 C5 00 80 04 A5 00 85 0E
.: 14C8 4C 00 14 EA EA A6 00 A9
.: 14D0 00 9D 4C 18 CA 86 00 BD
.: 14D8 38 18 85 02 BD 4C 18 85
.: 14E0 01 A5 0F EA EA EA C5 00
.: 14E8 90 03 4C C2 15 A4 02 EA
.: 14F0 EA EA EA EA BE 60 18 86
.: 14F8 0B EA EA EA EA EA EA A9
.: 1500 00 9D 9C 18 A0 01 84 0A
.: 1508 20 8C 16 A9 00 9D 9C 18
.: 1510 E6 0A A5 1A C5 0A 80 F0
.: 1518 A6 02 A5 01 D0 B4 19 B0
.: 1520 03 4C 00 14 4C CD 14 A4
.: 1528 02 EA EA EA EA EA BE 60
.: 1530 18 86 0B EA EA EA EA EA
.: 1538 EA A9 00 9D 9C 18 EA A5
.: 1540 0A 85 10 A0 01 84 0A 20
.: 1548 BC 16 A9 00 9D 9C 18 E6
.: 1550 0A A5 1A C5 0A B0 F0 A5

```

```

.: 1558 10 85 0A EA EA EA EA EA
.: 1560 18 69 01 EA EA AA BD 9C
.: 1568 18 F0 31 CA CA EA EA EA
.: 1570 EA EA EA EA EA EA EA EA
.: 1578 EA EA EA EA EA BD 9C 18
.: 1580 F0 1A 8A 38 E5 1D AA E8
.: 1588 BD 9C 18 F0 0F 8A 18 65
.: 1590 1D 65 1D AA BD 9C 18 F0
.: 1598 03 4C AB 15 A6 02 A5 01
.: 15A0 1D B4 19 B0 03 4C 00 14
.: 15A8 4C CD 14 A6 00 A9 00 9D
.: 15B0 4C 18 CA 86 00 BD 38 18
.: 15B8 85 02 BD 4C 18 85 01 4C
.: 15C0 27 15 A5 0E 85 01 C5 1B
.: 15C8 D0 02 C6 01 A9 7F 85 0D
.: 15D0 A5 01 18 69 01 85 0A A6
.: 15D8 01 A4 0A B9 38 18 D0 38
.: 15E0 18 90 11 A5 0D D9 38 18
.: 15E8 90 0A 84 11 B9 38 18 85
.: 15F0 0D EA EA EA E6 0A A5 1B
.: 15F8 C5 0A B0 B8 A5 0D C9 7F
.: 1600 D0 10 C6 01 A5 0F EA EA
.: 1608 EA C5 01 D0 BF A9 00 85
.: 1610 12 60 E6 00 A5 00 85 0E
.: 1618 A6 01 BD 38 18 A4 11 99
.: 1620 38 18 A5 0D 9D 38 18 A5
.: 1628 00 85 0A A9 00 A6 0A 9D
.: 1630 4C 18 E6 0A A5 1B C5 0A
.: 1638 B0 F1 A5 20 C5 01 D0 03
.: 1640 4C 00 14 A5 01 18 69 01
.: 1648 85 0A A5 0A 18 69 01 85
.: 1650 0D A6 0A A4 0D BD 38 18
.: 1658 D9 38 18 90 0F 85 11 B9
.: 1660 38 18 9D 38 18 A5 11 99
.: 1668 38 18 EA EA E6 0D A5 1B
.: 1670 C5 0D B0 D0 E6 0A A5 20
.: 1678 C5 0A B0 CE 4C 00 14 A6
.: 1680 02 BD 60 18 85 0B EA EA
.: 1688 EA EA EA A9 01 85 0A 20
.: 1690 BC 16 A9 00 9D 9C 18 E6
.: 1698 0A A5 1A C5 0A B0 F0 A6
.: 16A0 0B EA EA EA EA EA EA A9
.: 16A8 00 9D 9C 18 4C CD 14 EA
.: 16B0 EA EA EA EA EA EA EA EA
.: 16B8 EA EA EA EA A4 0A A5 01
.: 16C0 C5 23 D0 09 A5 02 C5 22
.: 16C8 D0 03 4C 21 17 A5 21 85
.: 16D0 13 A9 00 85 14 A2 08 06
.: 16D8 13 90 03 18 65 02 CA F0
.: 16E0 04 0A 4C D7 16 65 01 85
.: 16E8 13 A6 1A CA F0 0A 65 13
.: 16F0 90 F9 E6 14 18 4C EB 16
.: 16F8 65 26 85 13 A5 14 65 27
.: 1700 85 14 A5 24 65 13 85 15
.: 1708 A5 25 65 14 85 16 A5 1F
.: 1710 C9 03 D0 0D 18 A5 24 65
.: 1718 15 85 17 A5 25 65 16 85
.: 1720 18 B1 13 85 28 A9 00 A2
.: 1728 08 06 28 90 03 18 65 1D
.: 1730 CA F0 04 0A 4C 29 17 18
.: 1738 71 15 85 28 A6 1F E0 03
.: 1740 F0 0D 18 65 0B AA A5 02
.: 1748 85 22 A5 01 85 23 60 A9
.: 1750 00 A2 08 06 28 90 03 18
.: 1758 65 1E CA F0 04 0A 4C 53
.: 1760 17 65 0B 71 17 AA A5 02
.: 1768 85 22 A5 01 85 23 60 20

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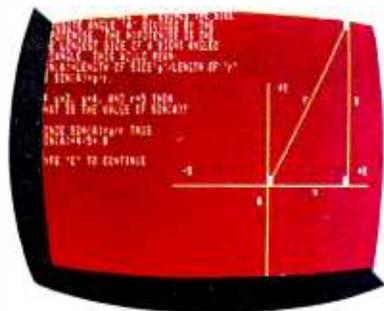
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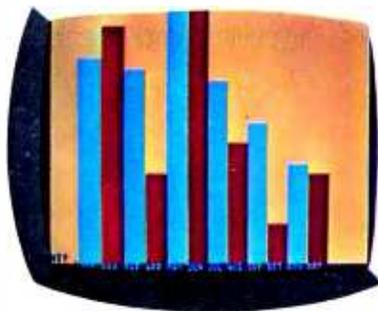
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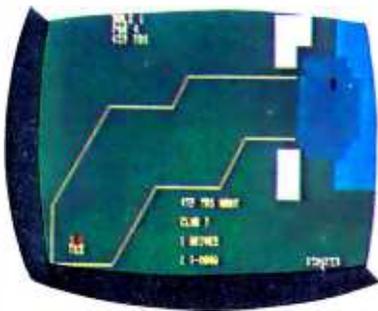
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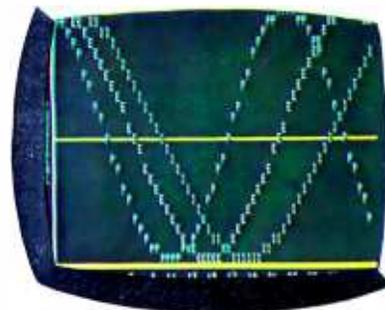
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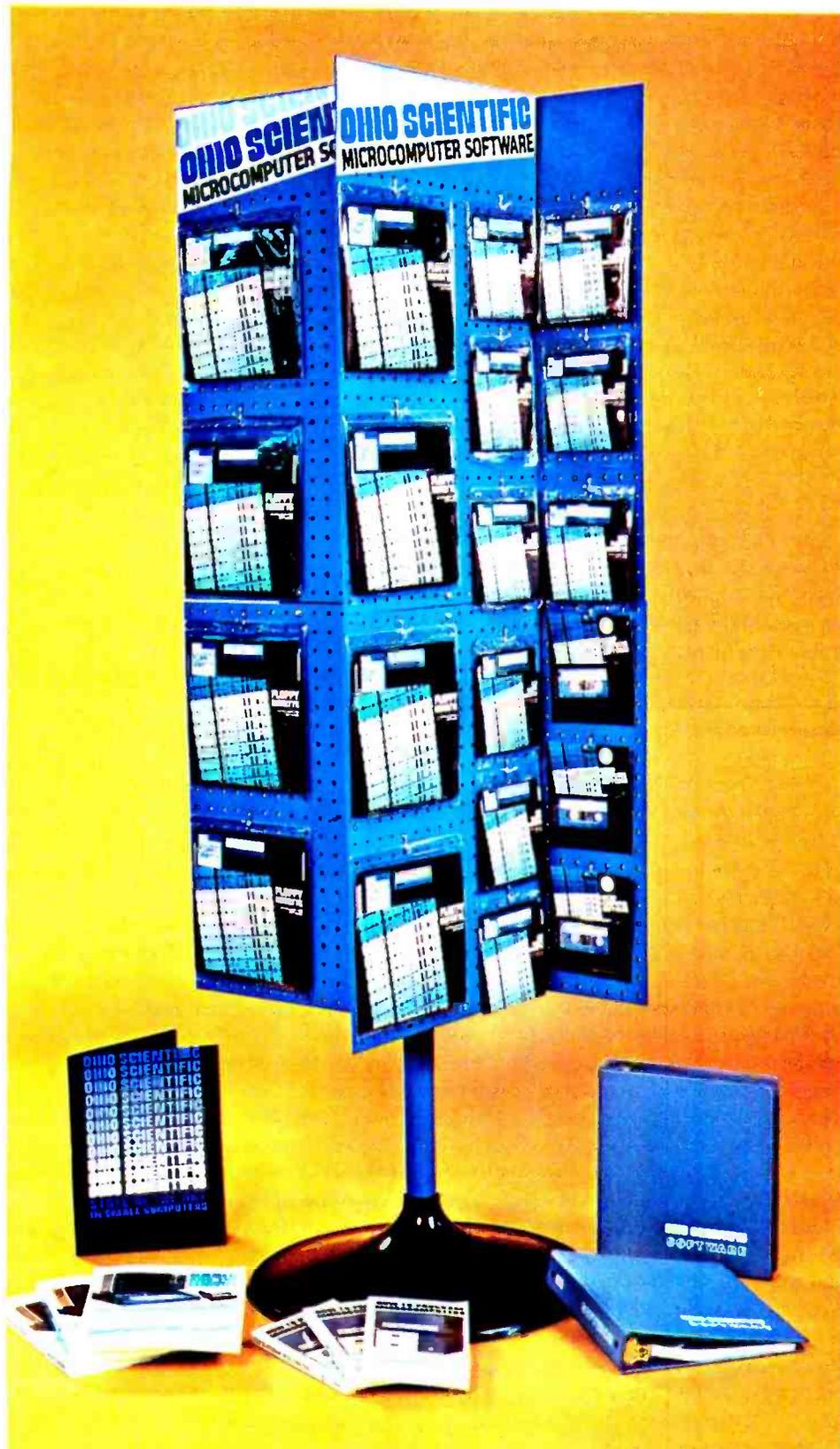


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BASIC Game: GOBANG

John Allwork, 21 Brook Rd, Heaton Chapel,
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GOBANG is, as far as I can tell, a traditional game of the Orient. It is a large game of tic-tac-toe (noughts and crosses), played on a 19 by 19 inch board. The object of the game is to get 5 adjacent markers in a row horizontally, vertically or diagonally.

The program in listing 1 is written in BASIC; the only deviation from standard BASIC being that of the IF...THEN IF... rather than the less flexible IF...GOTO. The BASIC I used is a version of the MicroBASIC supplied by SwTPC, and the program was run on an EXOR-ciser system. The program and BASIC interpreter fit into 8 K bytes of memory, if the remark statements are omitted. Alternatively, the size of arrays T and M can be reduced, but reducing them too much inhibits the game. A 9 by 9 board appears to be the smallest size possible for a reasonable game. (Listing 2 shows a sample output of the 19 by 19 board.)

MICROTEK OUTPERFORMS CENTRONICS



CHECK THE CHART

SEE PAGE 71

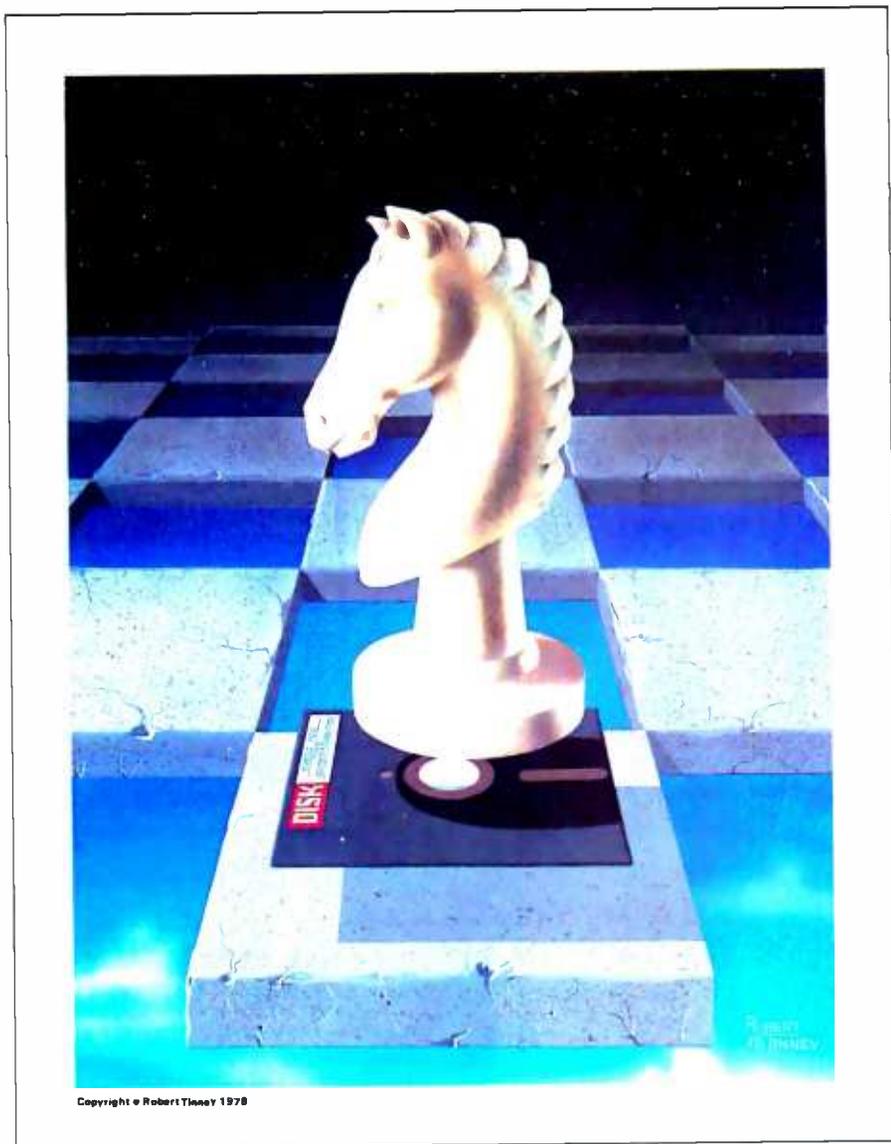
Listing 1: BASIC listing of the GOBANG game.

```

0001 REM GOBANG
0002 REM M IS ARRAY HOLDING BEST MOVE
0003 REM T IS BOARD, S IS PRIORITY OF THAT POSITION
0004 DIM M[19,19],T[27,27],S[81]
0005 REM SET UP PRIORITIES—SEE TABLE 1
0006 FOR I= 1 TO 81
0010 LET S[I]= 0
0015 NEXT I
0019 LET S[20]= 1
0020 LET S[10]= 40
0021 LET S[12]= 30
0022 LET S[13]= 47
0023 LET S[27]= 15
0024 LET S[28]= 20
0025 LET S[29]= 10
0026 LET S[30]= 40
0027 LET S[31]= 50
0028 LET S[32]= 30
0029 LET S[24]= 1
0030 LET S[36]= 39
0031 LET S[37]= 65
0032 LET S[38]= 40
0033 LET S[39]= 70
0034 LET S[40]= 100
0035 LET S[41]= 60
0036 LET S[42]= 30
0037 LET S[43]= 30
0038 LET S[44]= 30
0040 LET S[62]= 41
0041 LET S[72]= 31
0042 LET S[73]= 11
0043 LET S[74]= 41
0044 LET S[78]= 51
0045 LET S[80]= 90
0046 LET S[26]= 21
0047 LET S[79]= 40
0048 LET S[60]= 21
0049 LET S[61]= 11
0050 REM CLEAR BOARD AND BEST MOVE ARRAYS
0051 FOR I= 1 TO 27
0055 FOR J= 1 TO 27
0060 IF I < 19 THEN IF J < 19 THEN LET M[I, J]= 0
0065 REM MAKE FIRST MOVE
0070 NEXT J
0075 NEXT I
0076 LET C= - 1
0085 LET W= 14
0086 LET N= 14
0087 LET O= 14
0090 LET X= 14
0091 GOTO 0300
0095 GOSUB 0800
0096 REM REQUEST MOVE AND CHECK FOR VALIDITY
0097 INPUT Z,Y
0099 LET Y= Y+ 4
0100 LET Z= Z+ 4
0101 IF Y > 23 THEN GOTO 0097
0102 IF Z > 23 THEN GOTO 0097
0103 IF Y < 5 THEN GOTO 0097
0104 IF Z < 5 THEN GOTO 0097
0106 IF T[Y,Z] > 0 THEN GOTO 0097
0110 LET T[Y,Z]= 2
0115 LET I= Y
0120 LET J= Z
0125 REM STUDY LAST TWO MOVES
0127 GOSUB 1000
0128 IF C < > - 1 THEN GOTO 0310
0129 REM IF C = 0 COMPUTER HAS LOST
0130 LET I= W
0131 LET J= X
0141 GOSUB 1000
0145 REM SCAN BOARD FOR BEST MOVE
0150 REM NOTE LIMITS TO SPEED UP PROGRAM
0160 LET Q= - 1
0161 FOR I= N- 1 TO O+ 1
0162 FOR J= 5 TO 23
0200 IF T[I,J] > 0 THEN GOTO 0220
0201 LET A= M[I- 4, J- 4]
0205 IF A < Q THEN GOTO 0220
0210 LET W= I
0215 LET X= J
0216 LET Q= A
0220 NEXT J
0225 NEXT I

```

Listing 1 continued on page 58



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Listing 1 continued:

```

0299 PRINT "MY MOVE";X-4;"";W-4
0300 LET T[W,X]=1
0301 IF M[W-4,X-4]<100 THEN GOTO 0095
0307 PRINT "I WIN"
0310 IF C=0 THEN PRINT "YOU WIN"
0330 GOTO 0050
0799 REM SUBROUTINE TO DISPLAY BOARD
0800 PRINT "      1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19"
0805 FOR I=5 TO 23
0810     IF I-4<10 THEN PRINT I-4;" ";
0811     IF I-4>9 THEN PRINT I-4;
0815     FOR J=5 TO 23
0820         IF [I,J]=0 THEN PRINT " .";
0825         IF [I,J]=1 THEN PRINT " X";
0830         IF [I,J]=2 THEN PRINT " O";
0835     NEXT J
0840     PRINT " "
0845
0850 NEXT I
0850 RETURN
0990 REM SUBROUTINE TO CALCULATE BEST MOVE
0991 REM SCAN THRU MOVE AT I,J
0992 REM FOR FIVE SQUARES EITHER SIDE OF MOVE
0993 REM IN EIGHT DIRECTIONS,
AND UPDATE BEST MOVE ARRAY
1000 LET K=1
1001 LET L=-1
1002 IF I<N THEN IF I>5 THEN LET N=I
1003 IF I>O THEN IF I<23 THEN LET O=I
1004 REM UPDATE SCAN LIMITS
1005 LET U=I
1006 LET V=J
1007 REM I,J IS MOVE TO CHECK,D IS LOOP COUNT
1008 REM K,L ARE X AND Y DIRECTIONS THRU MOVE
1010 LET D=0
1011 LET D=D+1
1013 LET P=81
1020 REM CHECK STILL ON BOARD
1026 IF U>23 THEN GOTO 1090
1027 IF V>23 THEN GOTO 1090
1028 IF U<5 THEN GOTO 1090
1029 IF V<5 THEN GOTO 1090
1030 LET E=U-4
1031 LET G=V-4
1032 LET A=M[E,G]
1033 LET Q=T[U+K,V+L]
1034 REM CALCULATE PRIORITY OF POSITION
1035 LET R=T[U-K,V-L]*27+T[U-2*K,V-2*L]*9
1036 LET R=R+T[U-3*K,V-3*L]*3+T[U-4*K,V-4*L]
1037 LET B=Q*27+T[U+2*K,V+2*L]*9+T[U+3*K,V+3*L]*3
1038 IF R=80 THEN IF T[U,V]=2 THEN LET C=0
1039 IF T[U,V]<>0 THEN GOTO 1075
1040 REM S(R) IS PRIORITY: THE FOLLOWING ARE EXCEPTIONS
1041 REM SEE TABLE 2
1042 IF R<14 THEN IF R>11 THEN IF Q=1 THEN LET P=37
1044 IF R>71 THEN IF B>53 THEN IF B<63 THEN LET P=80
1046 IF R>71 THEN IF B>71 THEN LET P=80
1048 IF R>53 THEN IF R<63 THEN IF Q=2 THEN LET P=72
1050 IF P=72 THEN IF R=60 THEN LET P=31
1052 IF Q<>2 THEN GOTO 1058
1053 IF R=78 THEN LET P=80
1054 IF R=79 THEN LET P=80
1056 IF R=41 THEN LET R=81
1058 IF R<42 THEN IF R>35 THEN IF Q=1 THEN LET P=41
1059 IF R<33 THEN IF R>29 THEN IF Q=1 THEN LET P=41
1060 IF R>53 THEN IF R<63 THEN IF B>71 THEN LET P=80
1061 IF R>38 THEN IF R<42 THEN IF Q=1 THEN LET R=40
1062 IF R>35 THEN IF R<45 THEN IF B>35 THEN
IF B<45 THEN LET R=40
1063 IF R>27 THEN IF R<54 THEN IF B>38 THEN
IF B<42 THEN LET R=40
1064 IF R=79 THEN IF A=51 THEN LET M[E,G]=41
1065 IF R=0 THEN LET R=81
1066 IF S[P]>S[R] THEN LET R=P
1067 IF S[R]-S[R]/10*10=1 THEN IF A-A/10*10=1 THEN
IF S[R]<41 THEN LET R=74
1068 IF S[R]-S[R]/10*10=9 THEN IF A-A/10*10=9 THEN
IF S[R]<65 THEN LET R=37
1069 REM UPDATE BEST MOVE ARRAY
1070 IF S[R]>M[E,G] THEN LET M[E,G]=S[R]
1075 IF D>4 THEN GOTO 1090
1081 LET U=U+K
1082 LET V=V+L
1085 GOTO 1011
1089 REM CHANGE DIRECTION
1090 IF K=0 THEN IF L=-1 THEN RETURN
1095 IF K=-1 THEN IF L=-1 THEN LET K=0

```

```

1100 IF K=-1 THEN IF L=0 THEN LET L=-1
1105 IF K=-1 THEN IF L=1 THEN LET L=0
1110 IF K=0 THEN IF L=1 THEN LET K=-1
1115 IF K=1 THEN IF L=1 THEN LET K=0
1120 IF K=1 THEN IF L=0 THEN LET L=1
1125 IF K=1 THEN IF L=-1 THEN LET L=0
1130 GOTO 1005

```

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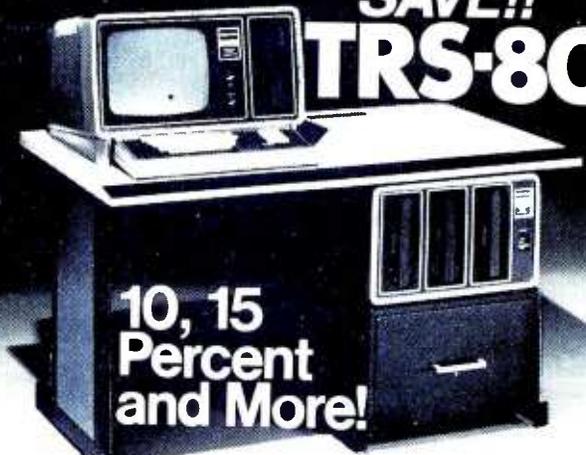
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ASSEMBLED & TESTED		\$2549	\$2039
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HORIZON-2-32K		\$2999	\$2399
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Listing 2: Sample output of the 19 by 19 board.

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?9,9
MY MOVE 10, 11

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?10,9
MY MOVE 11, 9

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?9,10
7,6
MY MOVE 11, 10
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```

?6,5
YOU WIN

I hope I have eradicated most of the bugs, but some may still exist (as with all programs); for example, I do not check to see if the board is full, because I have never encountered this situation with a 19 by 19 board.

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CHECK THE CHART

SEE PAGE 71

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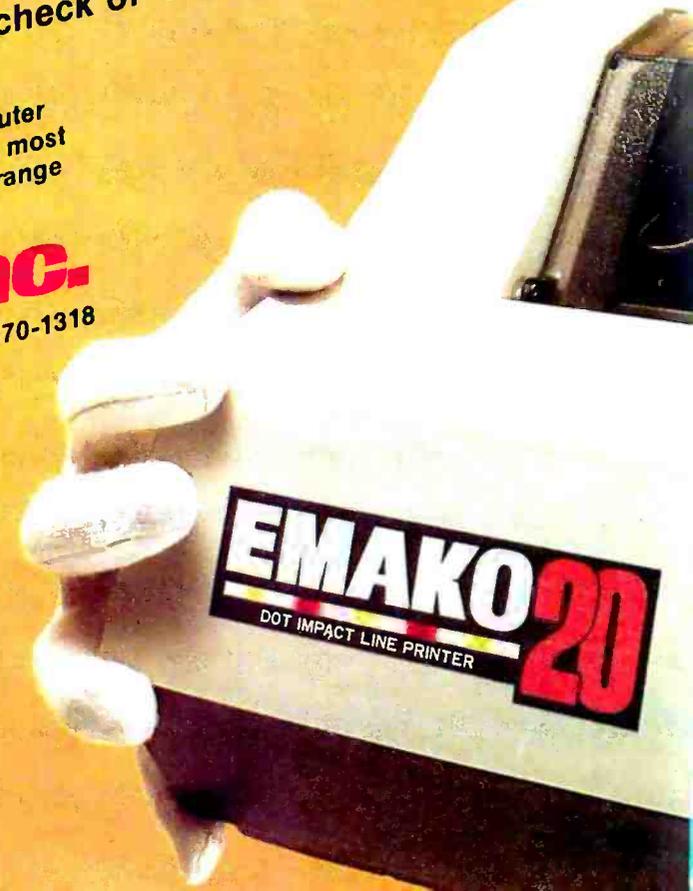
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Table 2: Some exceptions encountered by the computer that necessitate redefining its strategy.

LINE NUMBER	PATTERN	PRIORITY
1047	X+-XX	65
1044	-0+00	90
1046	00+00	90
1048	0+0-	31
1050	0+0-0-	50
1053	0+000-	90
1054	0+000x	90
1056	0+xxxx0	0
1058	x+xx-	60
1058	x+xxx	60
1059	x+x-x	60
1060	00+0-	90
1061	x+xxx	100
1062	xxx+x	100
1063	xxx+x	100
1064	REDUCES PRIORITY OF -000- TO 01 IF BLOCKED AT ONE END	
1067	INCREASES PRIORITY OF INTERSECTING ROWS OF 0'S	
1068	INCREASES PRIORITY OF INTERSECTING ROWS OF X'S	

Table 1: A lookup table that defines the computer's strategy.

0	+----	0	27	+x---	15	54	+0---	0
1	+---x	0	28	+x--x	20	55	+0--x	0
2	+---0	0	29	+x--0	10	56	+0--0	0
3	+--x-	0	30	+x-x-	40	57	+0-x-	0
4	+--xx	0	31	+x-xx	50	58	+0-xx	0
5	+--x0	0	32	+x-x0	30	59	+0-x0	0
6	+--0-	0	33	+x-0-	0	60	+0-0-	21
7	+--0x	0	34	+x-0x	0	61	+0-0x	11
8	+--00	0	35	+x-00	0	62	+0-00	41
9	+x--	0	36	+xx--	39	63	+0x--	0
10	+x-x	40	37	+xx-x	65	64	+0x-x	0
11	+x-0	0	38	+xx-0	40	65	+0x-0	0
12	+xx-	30	39	+xxx-	70	66	+0xx-	0
13	+xxx	47	40	+xxxx	100	67	+0xxx	0
14	+xx0	0	41	+xxx0	60	68	+0xx0	0
15	+x0-	0	42	+xx0-	30	69	+0x0-	0
16	+x0x	0	43	+xx0x	30	70	+0x0x	0
17	+x00	0	44	+xx00	30	71	+0x00	0
18	+0--	0	45	+x0--	0	72	+00--	31
19	+0-x	0	46	+x0-x	0	73	+00-x	11
20	+0-0	1	47	+x0-0	0	74	+00-0	41
21	+0x-	0	48	+x0x-	0	75	+00x-	0
22	+0xx	0	49	+x0xx	0	76	+00xx	0
23	+0x0	0	50	+x0x0	0	77	+00x0	0
24	+00-	1	51	+x00-	0	78	+000-	51
25	+00x	0	52	+x00x	0	79	+000x	0
26	+000	21	53	+x000	0	80	+0000	90

The program relies on a lookup table (entry S, table 1) and some exception conditions (table 2) to determine the priority of move of the square in question. The last 2 moves (by nought and cross) are scrutinized, scanning through these squares for 4 squares either side of the move in all 8 directions. The priority is calculated and updated if greater than previously calculated. Finally the board is scanned for the highest priority and the move made in this square.

The computer always goes first, and is X, although this can easily be modified. On the EXORciser, it takes about 40 seconds to think of the best move, compared with 10 seconds on a NOVA 2 using the same program and a BASIC interpreter, so do not worry if there is not an immediate response.

The program plays a very good game, occasionally almost beating the author, and has beaten several people who have played. Changing the strategies radically alters the way the computer plays, and the strategies in table 1 and exceptions in table 2 are the best I have found so far, but try changing S(12) to 29, and S(13) to 49. I would be interested to hear from anybody who finds better strategies. ■

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Shape Table Conversion for the Apple II

Dave Partyka, 1707 N Nantuckett Dr, Lorain OH 44053

If you own an Apple II with high-resolution graphics, I'm sure you have tried using the shape table. If you are like me, you converted the points to their hexadecimal values, ran the shape subroutine, and got a completely different shape from what you wanted. After two or three tries and a lot of time, you finally got the shape the way you wanted it.

There has to be a better way, and there is. The program in listing 1 performs the plot conversion to hexadecimal and puts the values in the table starting at the decimal location you specify. After using this program, you will find it very easy to build shape tables. Instead of drawing arrows, you can use just the points.

This program follows the rules of the *Apple II Reference Guide*: a double move up or 00 will end the program and put a 0 at the end of the table. The value of the moves are the same as in the *Reference Guide*:

- 0 = Move up
- 1 = Move right
- 2 = Move down
- 3 = Move left
- 4 = Plot and move up
- 5 = Plot and move right
- 6 = Plot and move down
- 7 = Plot and move left

The program does not require that the user press the return key while entering the plot values. You can try this program using the example given in the *Apple II Reference Guide* on page 53. Assign the correct values to the shape vectors at the top of the page and the hexadecimal values given will be in your table. Remember that this program requires a decimal location, while the shape subroutine requires the hexadecimal value. ■

Listing 1: Shape table program for the Apple II.

```

10 INPUT "STARTING DECIMAL LOCATION",L
20 N=N+1:PRINT "PLOT ";N:" "
30 Z=PEEK(-16384):IF Z<176 OR Z>183 THEN 30:
   POKE -16368,0:Z=Z-176:PRINT Z:
   IF N#1 THEN RETURN
40 E=1:IF Z=0 THEN D=1:A=Z:GOSUB 20
50 IF Z#0 THEN 60:IF D=1 THEN 90:E=0:GOTO 70
60 D=0:IF Z=2 OR Z=4 OR Z=6 THEN 70:
   Z=Z-1:A=A+8
70 B=Z/2:GOSUB 20:IF Z#1 AND Z#2 AND Z#3
   THEN 80:B=Z*4+B:E=1:GOSUB 20
80 B=B*16+A:POKE L,B:L=L+1:IF E#0 THEN 40:
   A=0:D=1:E=1:GOTO 50
90 PRINT "END OF TABLE":POKE L,0:END
    
```

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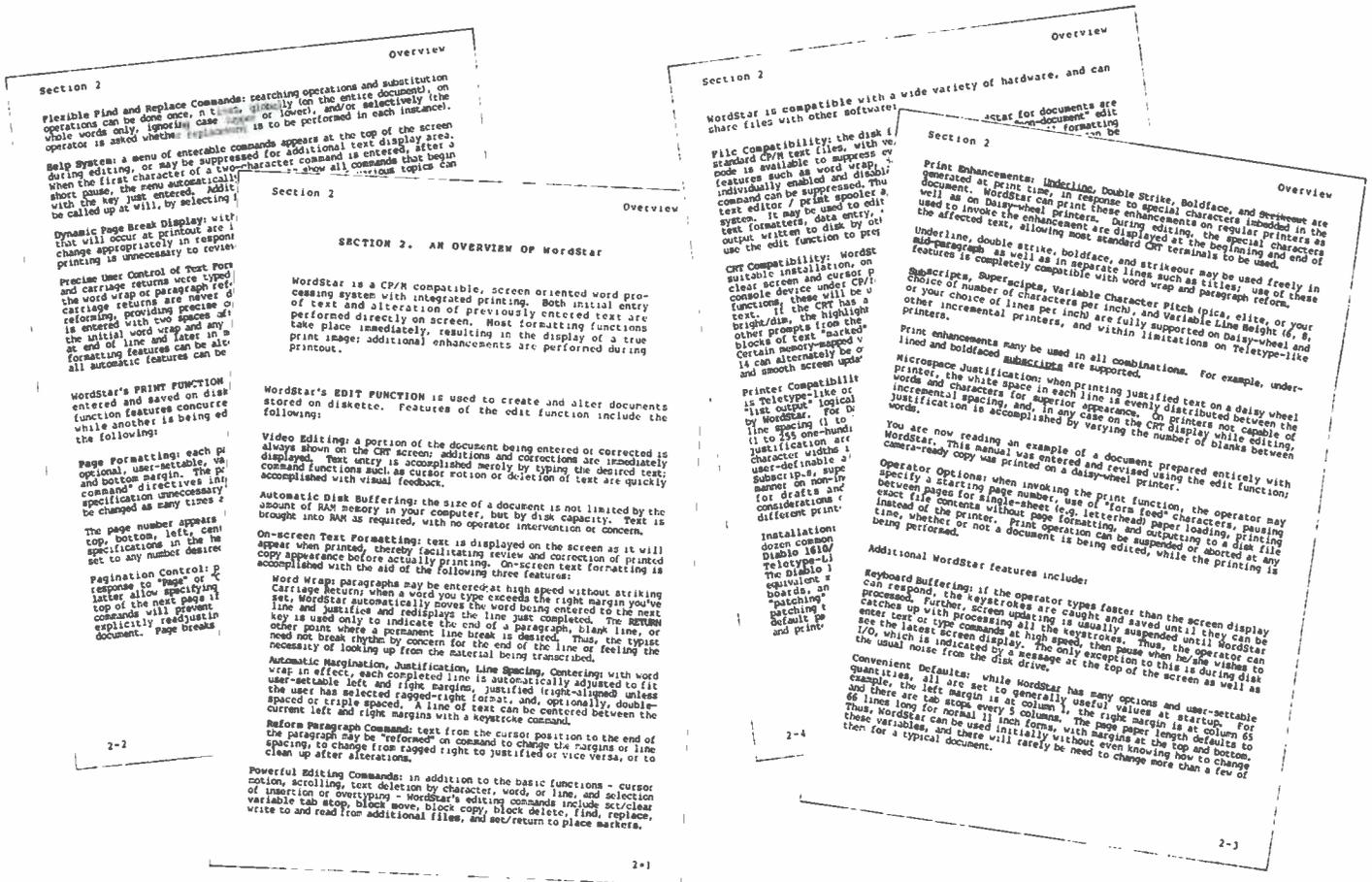
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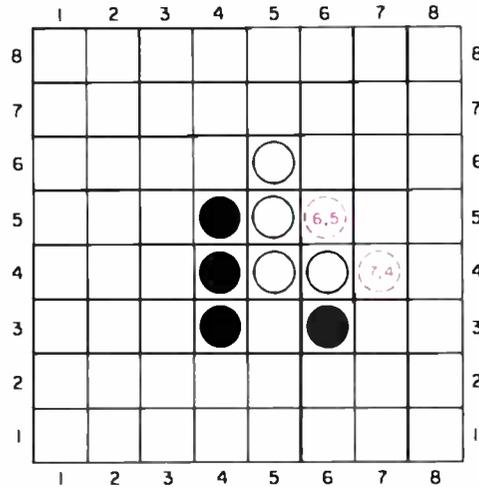
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Programming Strategies in the Game of Reversi

Figure 1: Typical position in the game of Reversi. The game is played with counters having two different colors, one on each side. A player's turn consists of placing a counter (with the player's color face up) on the board so that it traps one or more enemy pieces between it and another friendly piece in a straight line. The trapped enemy pieces are then reversed in color. Thus, a play by Black to square (6,5), with the horizontal coordinate given first, would allow Black to turn over White's pieces at (6,4), (5,4) and (5,5). A play by Black to square (7,4) would allow Black to turn over White's pieces at (6,4) and (5,4). Play ends when neither player can make a legal move. The player with the greater number of counters showing wins the game.

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 Urbana IL 61801

Board games such as checkers or chess can be fun and challenging to play, and programs that play these games can be fun and challenging to write. This article covers some of the decisions I made and methods I used in the programming of a board game called Reversi. It examines in turn the choice of a game, the programming language, the data structure and the details of the program structure.

Choosing a Game

There are both legal and practical considerations in choosing a game to program. Since I earn a living teaching law, and program as a hobby, I will start with the legal aspects. Many games present no legal problems. For instance, chess and checkers are in the public domain and anyone is free to write programs for them, but copyrighted games could pose serious legal problems. While writing a program to play a copyrighted game solely for your own amusement at home would probably fall within the fair use exception to the copyright law, any attempt to distribute, publish or sell the program could be made only with the permission or tolerance of the copyright and trademark owner. There is a third category of game wherein the game itself is in the public domain, but playing equipment is sold under a trademark. Thus, while no one has any rights to three-dimensional tic-tac-toe, the manufacturer who sells sets for playing three-dimensional tic-tac-toe under a trademark has the right to prevent you from distributing a computer game with the same name. So, you are free to program and even sell three-dimensional tic-tac-toe, but you will have to make up your own name for it.

There are also practical problems in

choosing a game. The game you select should not only be free of serious legal complications, it should also be complex enough to be challenging, yet simple enough to be implemented with the hardware and software at your disposal (taking account of your own programming ability and free time). If you are clever enough, you can choose an extremely complex game like chess or Go. If you are a novice programmer with only a small programmable calculator, you might want to begin with something simple like tic-tac-toe.

Since my own equipment (A SOL-20 computer with 16 K of programmable memory, video monitor, Teletype, two cassette drives, BASIC and assembler languages) and my own programming ability both fall somewhere between the two extremes, I sought a moderately difficult game to program.

The game I selected is called "Reversi." According to the *Oxford English Dictionary*, Reversi was first mentioned in print in the 1880s and its rules were first published in the 1890s; thus the game has long been in the public domain. It is now enjoying a revival because of the marketing of a board and set of playing pieces for the game by Gabriel Industries under that firm's trademark, "Othello," and the publication of a well written book on the game. [See "Othello, a New Ancient Game," October 1977 BYTE, page 60, and the bibliography at the end of this article.]

The rules of the game are simple, but play can be quite complicated. The game is played on an 8 by 8 square board like a standard chess or checkerboard. The players start with a supply of 64 playing pieces, each shaped like a checker piece, but black on one side and white or red on the other. Players take alternate turns. If a player has no legal play, he or she loses his turn. When neither player has a legal play, the game ends.

A play consists of placing a piece on an unoccupied square on the board with the player's color up. Each of the first two plays by each player must be made to one of the four center squares. Thereafter, each player may place a piece on any unoccupied square that will result in the formation of an unbroken line (horizontal, vertical, or diagonal) of pieces, with one of his own pieces on each end and one or more of his opponent's pieces in the middle. The opponent's pieces in the middle are then turned over (see figure 1). At the end of the game, the player with the most pieces showing his color wins.

Strategy for the game can be complex — only the most basic ideas are covered in the

200 page book by Hasegawa mentioned in the bibliography. However, the various writers on the game do agree on some basic points: Corner squares are very valuable because they can never be taken; squares next to corners are dangerous because they can make it possible for one's opponent to take corners. Edge squares are usually valuable because they can be used to force turnovers of large numbers of opponent's pieces in middle squares. Control of strategic squares in the middle of the game is more important than having a substantial material advantage at that time.

Programming Language

After I chose the game, the next step was to choose a programming language for the game. I really had only two choices because of the limitations of my own software library — BASIC or assembler. I chose BASIC because I can program much more easily in BASIC and because BASIC programs are more generally transferable to other computers than are assembler language programs, which will work with only one type of processor. With transferability in mind I made considerable efforts to avoid the use of the fancy special features available in the BASIC interpreters I have, since their use would make transfer a nightmare. Now that I have finished the programming, I am still happy with my choice, though I am now tempted to convert a few of the critical subroutines (which I will discuss later) into assembler language. This conversion would make the program run faster or to allow it to make a deeper analysis of its plays while running at the same speed.

Data Structure

Before starting programming I had to choose a suitable data structure. Following methods used in one of the leading computer chess programs (see the article by Gillogly in the bibliography), I decided to represent the standard 8 by 8 chessboard as being surrounded by a border of out-of-bounds squares, thus making a 10 by 10 board. For computer purposes, this augmented board could most naturally be represented as a 10 by 10 array dimensioned by the BASIC statement DIM B(10,10). However, because many BASIC interpreters for microcomputers allow only one-dimensional arrays, and because use of a one-dimensional array simplified my program in various ways, I decided instead to represent the board by a single array of 100 elements: DIM B(100). (See figures 2 and 3.) Another array, DIM E(100), was

Text continued on page 70

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Figure 2: Integer numbers used to identify Reversi squares. These numbers correspond to the elements of one-dimensional 100 element BASIC arrays used by the author in his program to store a given Reversi board pattern.

91	92	93	94	95	96	97	98	99	100
81	82	83	84	85	86	87	88	89	90
71	72	73	74	75	76	77	78	79	80
61	62	63	64	65	66	67	68	69	70
51	52	53	54	55	56	57	58	59	60
41	42	43	44	45	46	47	48	49	50
31	32	33	34	35	36	37	38	39	40
21	22	23	24	25	26	27	28	29	30
11	12	13	14	15	16	17	18	19	20
1	2	3	4	5	6	7	8	9	10

3	3	3	3	3	3	3	3	3	3
3	0	0	0	0	0	0	0	0	3
3	0	0	0	0	0	0	0	0	3
3	0	0	0	0	0	0	0	0	3
3	0	0	0	2	2	0	0	0	3
3	0	0	0	2	2	0	0	0	3
3	0	0	0	0	0	0	0	0	3
3	0	0	0	0	0	0	0	0	3
3	0	0	0	0	0	0	0	0	3
3	3	3	3	3	3	3	3	3	3

Figure 3: Initial board position. These values are stored in the one-dimensional 100 element matrix B (see listing 1). They enable the program to tell where the four center squares and out-of-bounds squares are located. (The first four moves of the game must be made to the four center squares.)

0	0	0	0	0	0	0	0	0	0
0	64	-30	10	5	5	10	-30	64	0
0	-30	-40	2	2	2	2	-40	64	0
0	10	2	5	1	1	5	2	-30	0
0	5	2	1	1	1	1	2	5	0
0	5	2	1	1	1	1	2	5	0
0	10	2	5	1	1	5	2	10	0
0	-30	-40	2	2	2	2	-40	-30	0
0	64	-30	10	5	5	10	-30	64	0
0	0	0	0	0	0	0	0	0	0

Figure 4: Initial strategic values of the board squares stored in the E matrix (see listing 1), used by the program to evaluate it using a minimax strategy. The higher the value, the more desirable the square.

Text continued:

declared for storage of the strategic value of each square (see figure 4). Two more 100 element arrays were declared for use in saving different versions of the board while the computer was considering possible plays.

This rather lavish use of storage was made possible by the fact that I was using a 5 K BASIC package in a 16 K memory. If memory were at a premium, it would have been necessary to use a much more complex board representation which could pack each square into a few bits (see the article by Yost in the bibliography) and perhaps necessary to develop a method for storing changes in board positions without storing whole boards. However, if you have the storage you might as well use it.

Several simple techniques could be used to adapt my program for users with less memory space. If a BASIC with strings is available, board squares can be stored in

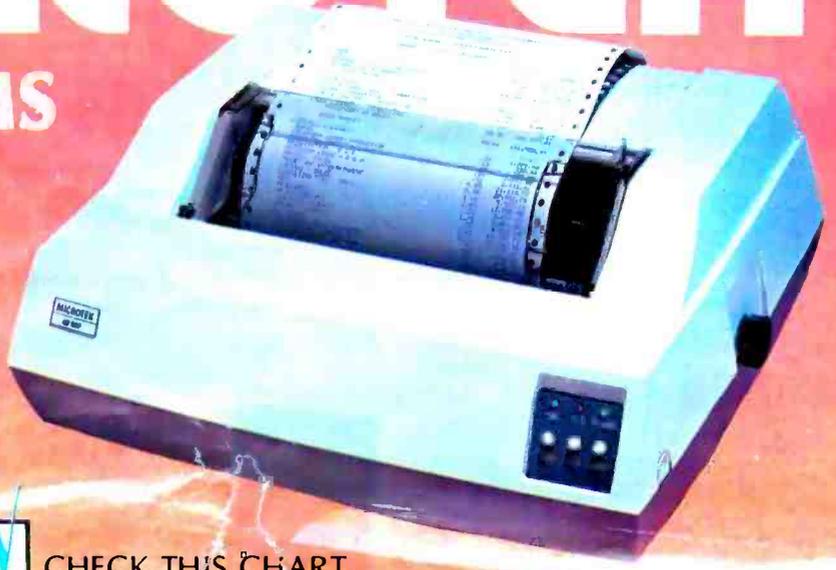
1 byte string variables rather than in multi-byte numerical variables. Alternatively, several board squares could be stored in one numerical variable, using the 1's position for the first square, the 10's position for the second square, etc. If the BASIC package has POKE and PEEK instructions, still another possibility is to store each square as 1 byte in memory with a POKE instruction and retrieve each square as needed with an appropriate PEEK instruction.

Program Structure

Having chosen the data structure, I next had to choose a program structure. Just as I chose a simple data structure so that it would be easily adaptable to many types of games, I selected what I hoped would be a very adaptable program structure. In designing the program structure, I drew upon

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the rich body of published descriptions of chess playing programs on the theory that a program structure capable of supporting a chess game should be adequate for most simpler board games. (See the computer chess material listed in the bibliography.)

The program structure consists of the following parts which will be analyzed in turn: the main game control routine and subroutines for initialization; board display; move input; legal move checking; legal move generating; computer move selection; and board evaluation. The following discussion will consider each of these, since each typifies a routine needed for almost any board program.

First I'll discuss the main game control procedure. This procedure must first call the subroutine that gives initial values to the board squares and to the board evaluation array. Then it must display the board on the video screen or print it on the Teletype and ask Black to make the first move. It must call the appropriate subroutine to check each move made for legality, and must terminate the game and declare the score if there are no legal moves. If the user wants the computer to make a play, it must call the subroutine that selects a move for the computer.

The board initialization routine is the simplest: Since the board is empty at the start of the game, it is filled with zeroes, except for the four center squares that must be covered in the first four moves. The out-of-bounds squares are filled with threes (see figure 3). If this were a game such as checkers, which starts with pieces on the board, they would have to be indicated by assigning appropriate initial values for the occupied squares. The strategic value of each square (high for corner squares, low for center squares, negative for next to corner squares, etc) is also entered by the initialization subroutine into the evaluation array (see figure 4).

Next comes the board display routine. Here a simple Teletype oriented printout of the 8 by 8 board was chosen. It would have been more elegant and little more trouble to use POKE commands to directly alter squares on a board displayed on the video monitor, and to represent the pieces with good-looking symbols from my character generator, but I decided to forego these luxury features in the interests of program portability. I also made an effort to limit each display frame to 15 lines so it would not disappear off the top of a 16 line video display monitor.

Before a player is asked to move, the computer must see if that player has any legal moves. This is done by a subroutine

that checks for the existence of a legal move. It first searches for an empty square; if it finds one, it checks to see if there is an adjacent square occupied by an opponent. The flattening of the two-dimensional board into one dimension causes adjacent squares to be in positions that are +1, +11, +10, +9, -1, -11, -10, or -9 squares away from the square in question (see figure 2). These adjacent squares are checked in turn. If a square is found that is occupied by an opponent, the search continues in the same direction as long as more opponent's pieces are found. When the first square that does not have an opponent's piece is found, it is examined. If it contains one of the player's pieces, the move is legal; if it is empty or out-of-bounds, the move is illegal. This search process is continued until a legal move is found, or it is established that there is no legal move. Modifications of this search routine will work for games anywhere in the range between tic-tac-toe and chess, inclusively.

The next routine used is the input routine. I decided to ask the user to input two numbers, giving the x and y coordinates of the square to which the player wishes to move. I avoided alphabetic input since I wanted the program to work for BASIC without string variables. I also provided that the input of the coordinates (0, 0) would be a signal that the user wants the computer to make the next move. Both approaches can be used for almost any board game.

Once a play is entered, the next step is to see if it is legal. If so, the computer must make the play and change the color of any pieces turned over by the play. If it is not legal, the computer must ask the player to try another play. The routine used to check and execute the move is very similar to that mentioned earlier for checking the legality of moves. However, unlike the legal move routine, the routine cannot stop after finding that a play allows turnovers in one direction, but must continue to make all turnovers in all directions the player is entitled to.

Some moves may affect the strategic value of board squares. For instance if a piece is placed in a corner, the squares next to that corner no longer are dangerous, so their values in the evaluation array must be changed from highly negative values to slightly positive. This is the only change in evaluation values made during the running of the present program. Undoubtedly it could be improved by introducing a number of other changes reflecting particular board configurations and the possibility that a square might have different values for

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Black and White in some circumstances. Chess playing programs often have entirely separate evaluation routines for beginning, middle and end game positions.

Finally come the most complicated and interesting subroutines, those for choosing a move for the computer. These use an approach suggested by Shannon in his classic article, an approach later refined by numerous other researchers (see the bibliography). This is the minimax algorithm. Assume that the computer is to make a play for White. It generates all legal moves for White (using the legal move checking procedure discussed above). As each legal move is generated, the computer considers all possible replies by Black. An evaluation routine is called to calculate the strategic value to Black of the board position after Black has played. The minimax strategy calls for the computer to select that legal play for White that *minimizes* the *maximum* value of the response Black can make.

For instance, suppose White has two legal plays, and that for the first play Black may make reply A with value to Black of 80, or reply B with value 90. For White's other possible move, Black may make reply C with value to Black of 100, or reply D with value 50 (see figure 5). Using the minimax strategy, White will choose the first move. This ensures that even if Black makes his best reply, he cannot achieve a board position worth more than 90 evaluation points.

This procedure can be extended to any depth. However, the number of moves to be evaluated, and consequently the computer time needed, rises at an astronomical rate. In the middle game in chess, each side may have 50 legal moves. This means that the complexity of search is of the order of 50^n , where n represents the depth of the search. This is a very large number even for a relatively shallow search, which may explain why world championship computer chess matches are usually won by very large and fast computers. In Reversi there is an average of approximately 8 possible legal plays per turn. This means that

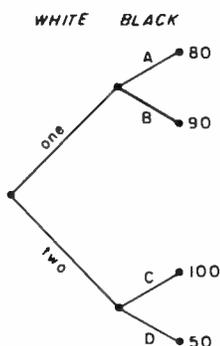


Figure 5: Minimax strategy tree, showing alpha-beta pruning. Minimax is a game theory strategy in which the object is to minimize the value of the opponent's maximum response. In this illustration, White has two moves to choose from: move one enables Black to counter with moves having strategic values of 80 or 90 (the higher the number, the better). Move two, on the other hand, enables Black to respond with moves having values of 50 or 100. Move one is the preferable move for White, since it minimizes Black's maximum response to 90, rather than 100. It is not necessary for the computer, playing the role of White, to analyze the move two branch any further, since it has already been eliminated by the minimax strategy. That branch can therefore be pruned to save computing time.

for a search of depth 2 (ie: to consider all possible moves by White and all possible replies by Black) 64 final board positions would have to be evaluated. A search of depth 4 would require 2796 evaluations.

Computer chess programmers have adopted a number of tricks to speed up the search process. Many of these tricks are adaptable to other types of board games; one of them is used here. This is what artificial intelligence specialists call alpha-beta pruning. A simple example may be given. Consider again the situation mentioned above, in which White has two legal plays. For play one, Black may make play A with value 90 or play B with value 80. For play two, Black may make play C with value 100 or play D with value 50 (see figure 5). Suppose the computer evaluates play one first. It discovers that the best that Black can do if White makes play one is to achieve a 90 point position. Now the computer starts to evaluate White's play two. It finds that Black has reply C which gives it a 100 point position. It need consider no further replies to play two, since it already knows enough to realize that play two is inferior to play one under the minimax approach, ie: Black has at least one reply to play two which is better for Black and hence worse for White than any of Black's replies to play one.

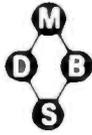
Another important method used for speeding the operation of chess programs, but not yet incorporated in my Reversi program, is that of saving particularly good moves (or particularly harmful replies by an opponent) and trying them in other situations. Thus Black may have a reply that is extremely damaging for almost any move White makes, plus a number of weaker replies. It pays to check Black's most powerful replies to previously checked White moves first, since a good reply to one move is often a good reply to other moves.

A sure way to speed up evaluations substantially and allow a deeper search is to use a compiled rather than interpreted language or to rewrite the program (or at least the move selection strategy) in assembler language. Again it is instructive to note that most championship chess programs are written in assembler language to obtain an extra edge in the depth of search possible under the time limits enforced in chess tournaments.

Once a game program is up and working, the most interesting point for further effort is to try to improve the program's strategy. It certainly helps to be a good player of the game, or at least to have read some background material on the theory of play. One ingenious method sometimes

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Listing 1: BASIC program for playing the game of Reversi.

```

1  REM **** REVERSI ****
2  REM ALL REMARKS MAY BE OMITTED TO SAVE MEMORY
50  REM VARIABLES
56  REM A(100) - FOR SAVING BOARD
60  REM B(100) - BOARD
62  REM C(100) - FOR SAVING BOARD
63  REM D(8) - DISTANCE TO NEXT SQUARE IN 8 DIRECTIONS
64  REM E(100) - VALUE OF BOARD SQUARES
66  REM F - VALUE OF OPPONENT'S BEST REPLY TO
66  REM COMPUTER'S BEST PLAY
67  REM G - VALUE OF OPPONENT'S BEST REPLY TO
68  REM COMPUTER'S CURRENT PLAY
69  REM H - VALUE OF OPPONENT'S CURRENT REPLY
70  REM I - NOT USED
71  REM J, K, L - COUNTERS
74  REM M - PLAY
75  REM N - COUNTER
76  REM O - NOT USED
77  REM P - PLAYER, BLACK=-1, WHITE=1
78  REM Q - TOTAL MOVES
79  REM R, S - NOT USED
80  REM T - LOGICAL VALUE, TRUE=1, FALSE=0
81  REM U - COUNTER
82  REM V, W - TO SAVE PLAY
84  REM Z - COUNTER
106 DIM A(100)
110 DIM B(100)
112 DIM C(100)
113 DIM D(8)
114 DIM E(100)
115 REM RANDOMIZE
118 REM IF YOUR COMPUTER HAS A RANDOMIZE COMMAND, SUBSTITUTE
119 REM IT FOR LINE 115 AND OMIT LINES 118 THROUGH 160
123 PRINT "TYPE A NUMBER BETWEEN 100 AND 1000":
126 INPUT N
130 IF N<100 THEN 123
135 IF N>1000 THEN 123
137 PRINT "RANDOMIZING"
140 FOR J=1 TO N
145   LET Z=RND(10)
150 NEXT J
171 LET D(1)=1
172 LET D(2)=11
173 LET D(3)=10
174 LET D(4)=9
175 LET D(5)=-1
176 LET D(6)=-11
177 LET D(7)=-10
178 LET D(8)=-9
182 REM INITIALIZE
186 GOSUB 9000
190 REM DISPLAY BOARD
200 GOSUB 9000
206 IF Q<5 THEN 295
210 REM CHECK FOR LEGAL PLAY
216 GOSUB 1300
220 IF T=1 THEN 296
226 LET T3=T3+1
226 IF T3<2 THEN 254
228 PRINT "THE GAME IS OVER"
229 LET N=0
230 LET J=0
231 FOR Z=1 TO 89
232   IF B(Z)=-1 THEN 230
234   IF B(Z)<>1 THEN 244
235   LET J=J+1
237   GOTO 244
239   LET N=N+1
244 NEXT Z
246 PRINT "BLACK HAS ".N." WHITE HAS ".J." PIECES"
248 PRINT "DO YOU WANT TO PLAY AGAIN (0=NO, 1=YES)":
250 INPUT T
251 RESTORE
252 IF T=1 THEN 185
253 GOTO 9998
254 PRINT
256 IF P=1 THEN 260
258 PRINT "BLACK HAS NO PLAY, LOSES TURN"
258 GOTO 960
260 PRINT "WHITE HAS NO PLAY, LOSES TURN"
270 GOTO 960
295 GOSUB 1100
380 IF M<>1 THEN 500
390 IF Q>4 THEN 430

```

```

395 REM COMPUTER PLAYS
400 REM FIRST 4 PLAYS
402 LET M=45
403 IF B(M)=2 THEN 540
404 LET M=M+1
405 GOTO 403
430 GOSUB 3000
460 REM CHECK PLAY
500 IF M<1 THEN 800
510 IF M>100 THEN 800
520 IF Q>4 THEN 600
530 IF B(M)<>2 THEN 800
540 LET B(M)=P
560 GOTO 830
600 GOSUB 1400
640 IF T<>0 THEN 960
800 PRINT "ILLEGAL PLAY"
820 GOTO 200
830 LET Q=Q+1
960 LET P=-P

```

Listing 1 continued on page 78

used in order to find better parameters for evaluation routines is to select a variety of values for use in these routines and to have the program run a tournament against itself using the different values. The winning values are then incorporated in the revised and improved program.

I hope this description and the listing of the Reversi program will inspire readers to make their own game playing programs. The books about board games mentioned in the bibliography list over 700 games, so there are plenty of games waiting to be programmed.

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Listing 1, continued:

```

966 IF E(M) <> 84 THEN 200
969 GOSUB 5000
970 GOTO 200
1089 REM * GET A PLAY *
1100 PRINT
1101 PRINT "IF YOU WANT THE COMPUTER TO PLAY, ENTER 0,"
1115 IF P=1 THEN 1140
1120 PRINT "BLACK";
1130 GOTO 1145
1140 PRINT "WHITE";
1145 PRINT "S TURN, ENTER X,Y";
1150 INPUT X,Y
1160 LET M=X+1+10*Y
1170 RETURN
1299 REM * CHECK FOR LEGAL PLAY *
1300 LET T=1
1301 PRINT "CHECKING";
1302 LET M=1
1310 IF U<4 THEN 1318
1316 LET U=0
1317 PRINT ".,.";
1318 LET U=U+1
1320 IF B(M) <> 0 THEN 1390
1330 LET N=1
1340 LET J=D(N)
1350 IF B(M+J) <> -P THEN 1385
1370 LET K=M+J+1
1380 IF B(K)=3 THEN 1385
1381 IF B(K)=0 THEN 1385
1382 IF B(K)=P THEN 1394
1383 LET K=K+J
1384 GOTO 1380
1385 LET N=N+1
1386 IF N<9 THEN 1340
1390 LET M=M+1
1391 IF M<90 THEN 1310
1392 LET T=T+1
1394 RETURN
1399 REM * MAKE A PLAY *
1400 LET T=0
1410 IF B(M)=0 THEN 1430
1420 RETURN
1430 LET N=1
1440 LET J=D(N)
1444 IF B(M+J) <> -P THEN 1700
1470 LET K=M+J+1
1480 IF B(K)=3 THEN 1700
1490 IF B(K)=0 THEN 1700
1500 IF B(K)=P THEN 1530
1510 LET K=K+J
1515 GOTO 1480
1530 LET T=1
1531 LET L=M
1532 IF L=M THEN 1700
1533 LET B(L)=P
1534 LET L=L+J
1535 GOTO 1532
1700 LET N=N+1
1706 IF N<9 THEN 1440
1710 RETURN
2999 REM CHECK COMPUTER'S PLAYS *
3000 PRINT "THINKING";
3990 LET F=9999
3999 FOR Z=12 TO 89
3700 LET C(Z)=B(Z)
3710 NEXT Z
3750 LET M=12
3752 IF U<4 THEN 3759
3753 LET U=0
3755 PRINT ".,.";
3759 LET U=U+1
3770 GOSUB 1400
3780 IF T=0 THEN 3850
3790 GOSUB 3900
3800 IF H>F THEN 3840
3802 IF H<F THEN 3810
3803 REM CHOOSE RANDOM OF EQUAL PLAYS
3804 LET Z=RND(10)
3805 IF Z>=7 THEN 3840
3810 LET F=H
3815 REM FOUND BETTER MOVE
3820 LET W=V
3840 FOR Z=12 TO 89
3850 LET B(Z)=C(Z)
3855 NEXT Z
3860 LET M=M+1
3865 IF M<90 THEN 3752
3870 LET M=W
3880 RETURN
3899 REM * CHECK OPPONENT'S REPLIES *
3900 LET H=-9999
3920 FOR Z=12 TO 89
3925 LET A(Z)=B(Z)
3930 NEXT Z
3935 LET P=-P
3940 LET V=M
3950 LET M=12
3970 GOSUB 1400
3980 IF T=0 THEN 4080
3990 GOSUB 4130
4000 IF G<F THEN 4030
4014 REM FORGET THIS PLAY
4016 LET H=G
4020 GOTO 4100
4030 IF G<H THEN 4050
4035 REM FOUND MORE HARMFUL REPLY
4040 LET H=G
4050 FOR Z=12 TO 89
4055 LET B(Z)=A(Z)
4070 NEXT Z
4080 LET M=M+1
4090 IF M<90 THEN 3970
4100 LET M=V
4105 LET P=-P
4110 RETURN
4129 REM * EVALUATE *
4130 LET G=0
4140 LET Z=12
4150 IF B(Z)=P THEN 4190
4160 IF B(Z)=0 THEN 4300
4170 LET G=G+E(Z)
4180 GOTO 4300
4190 LET G=G+E(Z)
4195 REM FORGET THIS PLAY
4200 IF G>F THEN 4500
4300 LET Z=Z+1
4400 IF Z<90 THEN 4150
4500 RETURN
4999 REM ADJUST CORNER VALUES
5000 IF M<12 THEN 5100
5010 LET E(13)=5
5020 LET E(22)=5
5030 LET E(23)=5
5100 IF M<> 19 THEN 5200
5110 LET E(18)=5
5120 LET E(28)=5
5130 LET E(29)=5
5200 IF M<> 82 THEN 5300
5210 LET E(72)=5
5220 LET E(73)=5
5230 LET E(83)=5
5300 IF M<> 89 THEN 5400
5310 LET E(77)=5
5320 LET E(78)=5
5330 LET E(88)=5
5400 RETURN
7999 REM DISPLAY THE BOARD
8000 PRINT " 1 2 3 4 5 6 7 8"
8200 FOR Y=6 TO 1 STEP -1
8300 PRINT Y; " ";
8400 FOR X=1 TO 8
8500 IF B(X+1+Y*10)=1 THEN 8700
8550 IF B(X+1+Y*10)=-1 THEN 8900
8600 PRINT " - ";
8650 GOTO 8990
8700 PRINT " W ";
8800 GOTO 8990
8900 PRINT " B ";
8990 NEXT X
8995 PRINT Y
8996 NEXT Y
8997 PRINT " 1 2 3 4 5 6 7 8"
8998 RETURN
8999 REM * INITIALIZE *
9000 FOR N=1 TO 90
9050 READ E(N)
9055 NEXT N
9065 FOR N=1 TO 100
9068 LET B(N)=0
9070 NEXT N
9074 FOR N=1 TO 10

```

```

9076 LET B(N)=3
9078 LET B(90+N)=3
9080 LET B(10*N-9)=3
9082 LET B(10*N)=3
9085 NEXT N
9087 LET B(45)=2
9088 LET B(46)=2
9089 LET B(55)=2
9090 LET B(56)=2
9172 LET U=5
9186 LET Q=1
9190 LET P=-1
9191 RETURN
9220 DATA 0,64,-30,10,5,5,10,-30,64,0
9222 DATA 0,-30,-40,2,2,2,2,-40,-30,0
9224 DATA 0,10,2,5,1,1,5,2,10,0
9226 DATA 0,5,2,1,1,1,1,2,5,0
9228 DATA 0,5,2,1,1,1,1,2,5,0
9230 DATA 0,10,2,5,1,1,5,2,10,0
9234 DATA 0,-30,-40,2,2,2,2,-40,-30,0
9236 DATA 0,64,-30,10,5,5,10,-30,64,0
9998 STOP
9999 END
    
```

Listing 2: Sample output of the program in listing 1.

```

IF YOU WANT THE COMPUTER TO PLAY,
ENTER 0,0
BLACK'S TURN, ENTER X, Y
73,4
    
```

	1	2	3	4	5	6	7	8	
8	-	-	-	-	-	-	-	-	8
7	-	-	-	-	-	-	-	-	7
6	-	-	-	-	-	-	-	-	6
5	-	-	-	W	B	-	-	-	5
4	-	-	B	B	B	-	-	-	4
3	-	-	-	-	-	-	-	-	3
2	-	-	-	-	-	-	-	-	2
1	-	-	-	-	-	-	-	-	1
	1	2	3	4	5	6	7	8	



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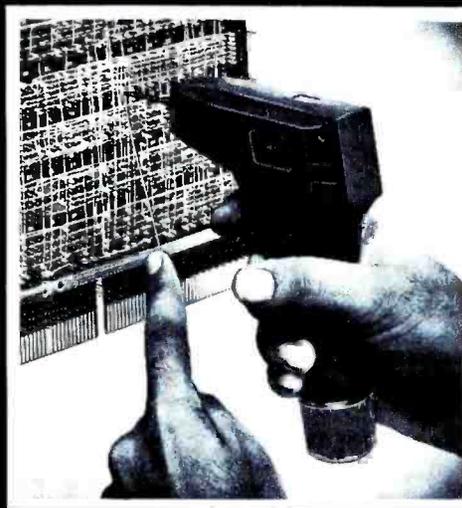
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BYTE News . . .

HOME BUS STANDARD BEING DEVELOPED: Stanford Research Institute, Menlo Park California, and the Home Bus Standard Association, Washington DC, are conducting a feasibility study to develop a home bus standard. It will allow home electronic appliances to interact with one another over regular home wiring.

TI MICROCOMPUTER PICTURE IN TRANSITION: Although Texas Instruments finally introduced its 99/4 personal computer system in June, it is expected to be an interim product. TI failed to get FCC approval for the original version and also ran into processor production difficulties which forced the introduction of a high-priced personal computer system (\$1150). TI is still pursuing a rule change request with the FCC and the development of its 9985 stripped down version of its 9940 16-bit processor. TI hopes to then introduce a personal computer system for under \$500 which connects to a standard color-television receiver.

TI has also expanded its small business computer (99/7) marketing efforts. The 99/7, which starts at \$5000, will be marketed by Moore Business Forms, through over 750 sales offices as well as through computer stores and TI's own retail outlets.

AT&T TESTING HOME INFORMATION SYSTEMS: American Telephone and Telegraph Co has undertaken customer acceptance tests of several home information systems similar to the Viewdata system. Among the systems AT&T will test are the Knight-Ridder system (reported in the August BYTE News), a system developed by McDonnell Douglas, and a Bell Labs developed system.

The Knight-Ridder system test will take two years and involve 150 to 200 families in Miami, Florida. The system will transmit news, sports results, weather, and public information. The McDonnell Douglas system will be tested in Kansas City, Michigan, and New York. It will allow users to call a special number, key a special code on a push button phone, and receive the requested information in audible form. No details are as yet available on the Bell system.

HEATH ACQUIRED BY ZENITH: Heath Co, a leader in the consumer electronic kit business, was sold by Schlumberger Ltd to Zenith Radio Corp for \$64.5 million. In 1977 Heath introduced two personal computer kit systems, the H-8 which is based on the 8080 processor, and the H-11 which is based on the Digital Equipment Corp (DEC) LSI-11. Heath entered into a three-year contract with DEC. Heath also entered the adult-education market. Heath sales for the last several years have declined at a 3 to 5% rate.

Zenith, a manufacturer of radio and television receivers, has been diversifying. They have been making video monitors for terminals and cable-television converters. Immediately after the acquisition was completed, Heath announced an aggressive marketing program to sell assembled computer systems through a network of distributors and original equipment manufacturers.

8-INCH WINCHESTER DISK MARKET STILL TRYING TO GET OFF THE GROUND: Despite the publicity and advertising, only one manufacturer is presently shipping production quantities of 8-inch hard-disk drives. The company is International Memories Inc (IMI), which is currently shipping limited quantities of their 11 M byte drive at \$1775. IMI will introduce a 20 M byte unit early next year, and expects to reduce the price on the 11 M byte unit 10 to 20% by midyear as production is increased.

Micropolis expects to start shipping limited quantities of its 27 and 45 M byte drives soon. The introductory price for the 45 M byte drive is \$2688 and should drop to under \$2000 by midyear.

Shugart has not yet revealed its marketing plans for its 8-inch rigid drive.

COMPUTERIZED PORTABLE HOME ENTERTAINMENT CENTER SHOWN: Sharp Electronics recently showed a portable unit, about the size of a typical portable stereo system, which included the following: a television receiver with a 4.5 inch screen, an AM/FM radio, a stereo cassette, a digital clock, a calculator, and a personal computer. The computer's 48-key keyboard slides into the unit for storage, when it becomes necessary to transport the unit. The video screen is used for display, and the audio cassette recorder is for data and program storage. It uses BASIC, has graphics capabilities, and is expandable. No immediate marketing plans have as yet been announced.

LOOK IT UP IN THE DATA DICTIONARY: Data base management (DBM) systems are growing in size, sophistication, and popularity. Users, therefore, need more advanced tools for defining and keeping track of their data resources. Data dictionaries have been developed to do this and to augment existing data base management systems. The data dictionary is integrated into the data base management system's nucleus and utilities as well as managing the data resources.

On large computer systems such as the large IBM mainframes, the problem of managing these systems is acute, and data dictionaries are popular here. However, data dictionaries are now being developed for microcomputer systems as they increase in complexity. Someday you can expect to see them on microcomputer systems.

IEEE-488 BUS INTERFACING SIMPLIFIED: Now you can interface your computer system to the IEEE-488 bus without a special bus interface. ICS Electronics Corp. San Jose, California, has come up with an easy way of doing it. They have developed a 488-to-RS-232C interface and controller. Just place this device in the line between your terminal and processor and plug your IEEE-488 cable into the device. Now you can program your computer to process data coming from all those instruments with 488 interfaces.

SILICON VALLEY-II DEVELOPING: "Silicon Valley" is the nickname given to the area in California just south of San Francisco that has the highest concentration of integrated circuit manufacturers. A regional shift now appears underway as more and more integrated circuit manufacturers are opening facilities in Texas. Long the stronghold of Texas Instruments, the Dallas and Austin areas have seen the opening of plants by Mostek and Hitachi. Now, Motorola and Advanced Micro Devices are following suit. The desertion of California appears to be due to high operating costs.

GTE TAKES ON VIEWDATA: General Telephone and Electronics Corp has been licensed to offer Viewdata information services in the USA and Canada. Viewdata was developed by the British Post Office, and is a data base information system allowing users to access data on their television receivers via telephone lines.

DUAL-SIDED FLOPPIES STILL IN SHORT SUPPLY: Shugart expects to finally get into quantity production on dual-sided floppy disks by the end of the first quarter of 1980. Presently they are shipping only limited quantities. Originally introduced in early 1977, Shugart did not start shipping until early 1979. Media wear problems caused these delays and has limited production to 100 drives per day at best. Shugart has designed a completely new double-sided head which they expect will cure these problems. However, Shugart has found it necessary to increase the price of the drives. The SA850, an 8-inch drive, in 500-lot quantities will be priced from \$485 to \$580.

FCC COMPLETES RADIO FREQUENCY RADIATION TESTS: The FCC has completed its test of six personal computer systems and will release its data soon. Reportedly, the FCC has found that all but one exceed the interference levels permitted for devices that connect to television receivers (eg. games). The test included the Atari, Apple, PET, Heath, Southwest Technical Products, and Radio Shack systems. Only the Atari system passed. The rest caused excessive radio frequency (RF) radiation interference on nearby television receivers. None of these systems are required to meet the existing regulations. In the meantime, the large numbers of personal computer systems in use are beginning to generate interference complaints.

8080 STILL GOING STRONG: The 8080 microprocessor, introduced by Intel in 1974 and the integrated circuit that started the microprocessor "revolution," is still going great. This is despite improved successors such as the Z80 and 8085. An estimated 500,000 8080As are being made each month, and many purchasers are finding them in short supply. The 8080A is currently being made by five manufacturers. Prices for large quantities have gone back up to the \$3 to 4 range, after they had dipped as low as \$2.75 each in late 1978. Demand for the 8080A is expected to continue strong through mid-1980, and it should continue in production for several more years.

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

by Sol Libes
ACGNJ
1776 Rowlton Rd
Scotch Plains NJ 07076

We're about to make a new name for ourselves.

Not that the old one was so bad. As Ithaca Audio, we've made quite a name for ourselves. As the source for CPU, memory, video display and disk controller boards to upgrade other makers' mainframes and peripherals. The company that makes those neat little RAM expansion kits. And the folks behind the world's only Z-80 Pascal compiler.

But as much as we've enjoyed improving other people's equipment, we've been quietly moving towards larger endeavors, with a lot of encouragement from our customers. Listening to people's problems, as well as their needs. And, as a prime mover behind the IEEE S-100 Bus Standard, answering some really knotty questions.

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You can watch this magazine for updates. Or contact us directly for straight, friendly answers and detailed information from key staff people. Just the way you always have. Because even though we're making a new name for ourselves, we'll never forget who made it possible.

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.....
Get your shears out, and
get ready to cut back your
game trees, thereby saving
both space and time
.....

Sooner or later, almost everyone with a small system gets the idea of programming it to play chess, checkers, or some other two-person board game. Most of us give up before we start because we have no idea how to determine the best move in any given situation. The other aspects of playing a game are generally no problem.

We can see how to represent 64 squares on a board by 64 bytes in memory, each of which contains a code number which might be 3 for Bishop, 6 for King, or 0 for a blank square, and so on. We can see how to write a program for each piece, determining where it can move in a given situation depending upon the rules of the game. For example, a Bishop can move as far as possible in any of four directions, so we have to write a program to search in one direction until it finds a square that is not blank (ie: the corresponding byte does not contain 0, the code for a blank square). If this square is n squares away from where the Bishop is currently positioned, then there are $n - 1$ possible moves that the Bishop can make in that direction. This loop is then repeated, once for each of the four directions.

Finally, we can see how to write a

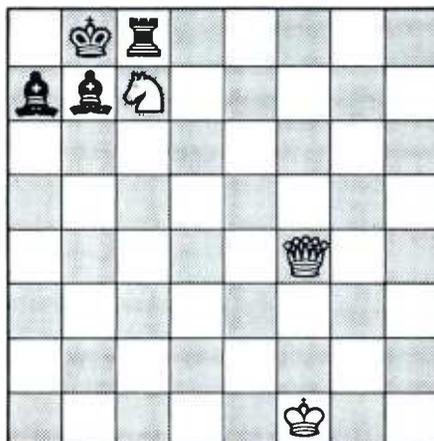
program that would find all of the pieces on the board, would determine the type of each piece, and would find all possible moves for each piece, according to its type. In this way we could get a list of all of the moves that could be made by one player in any given situation. But to find the best of these defies the low-level intuition that most of us rely upon.

In this article, I will describe a general procedure for programming board games, relying heavily on chess in my examples, but utilizing procedures that can be applied in any board game where you have to "look ahead." The logic is roughly as follows: if I make move X, then my

opponent will make move Y; if I make move Z, then my opponent can make move U, which is better for him than move Y, so I shouldn't make move Z; but if I make move W...and so on.

The first illustration will be from a famous dramatic finish to a chess game. This is illustrated in figure 1. White is already far ahead, having a Queen and a Knight, whereas Black has only a Rook and two pawns. To finish the game quickly, White lets Black capture his Queen, then gives checkmate with his Knight. For those who have forgotten their chess (and also to illustrate what the computer does when it sees this position), the entire finish of the game is illustrated in figure 2 (see page 88).

It is clear that the computer has to perform a complete analysis of the given position in a game; much more complete than that given in either figure 1 or figure 2. For example, look at White's first move: N-R6 double check. In chess terminology, as soon as White makes this move, Black's next move is "forced." There is nothing that Black can do except move K-R1. But what does this mean? Black actually has several moves, but all of the others are illegal because White would be able to capture his King. Specifically:



1. N-R6 dbl ch K-R1
2. Q-N7 ch R x Q
3. N-R6 mate

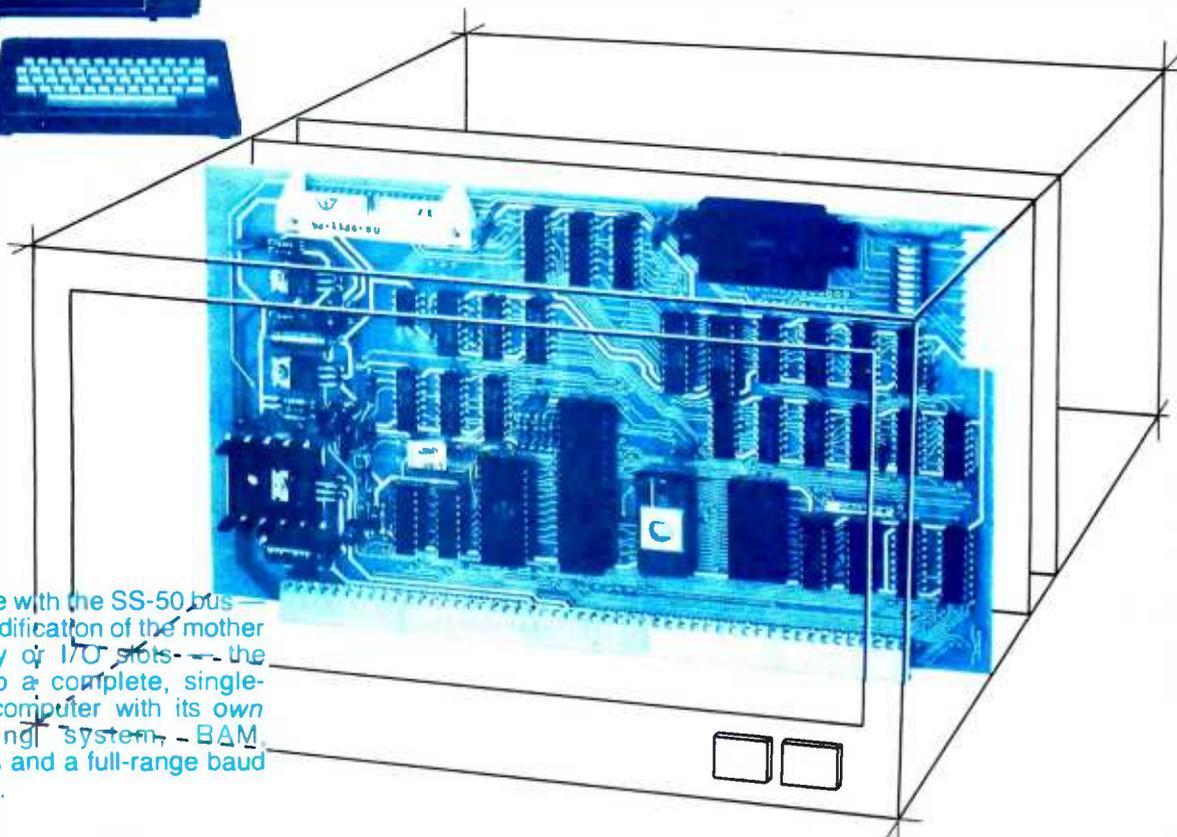
Figure 1: Chessboard layout just prior to the conclusion of a famous dramatic ending to a chess game.

- If Black plays R-B2 (interposing the Rook), then White plays NxK (capturing the King with his Knight).
- If Black plays PxN (capturing the Knight), then White plays QxK

Text continued on page 90

6809 PROCESSING POWER!

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And to complement the extraordinary 6809, the Percom design team has developed PSYMON™, an extraordinary 6809 operating system for the SBC/9™.

PSYMON™ — Percom SYstem MONitor

Although PSYMON™ includes a full complement of operating system commands and 15 externally callable [™]trademark of Percom Data Company, Inc.

utilities, what really sets PSYMON™ apart is its easy hardware adaptability and command extensibility.

For hardware interfacing, you merely use simple, specific device driver routines that reference a table of parameters called a Device Control Block (DCB). Using this technique, interfacing routines are independent of the operating system.

The basic PSYMON™ command repertoire may be readily enhanced or modified. When PSYMON™ first receives system control, it initializes its RAM area, configures its console and then 'looks ahead' for an optional second ROM which you install in a socket provided on the SBC/9™ card. This ROM contains your own routines that may alter PSYMON™ pointers and either subtly or radically modify the PSYMON™ command set. If a second ROM is not installed, control returns immediately to PSYMON™

- Provision for multi-address, 8-bit bidirectional parallel I/O data lines for interfacing to devices such as an encoded keyboard.
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- On-board devices which are fully decoded so that off-card devices may use adjoining memory space.
- Fully buffered address, control and data lines.

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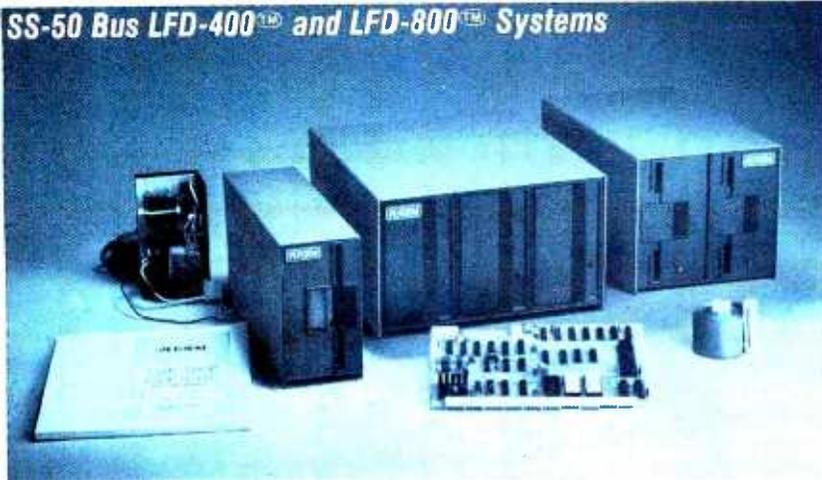
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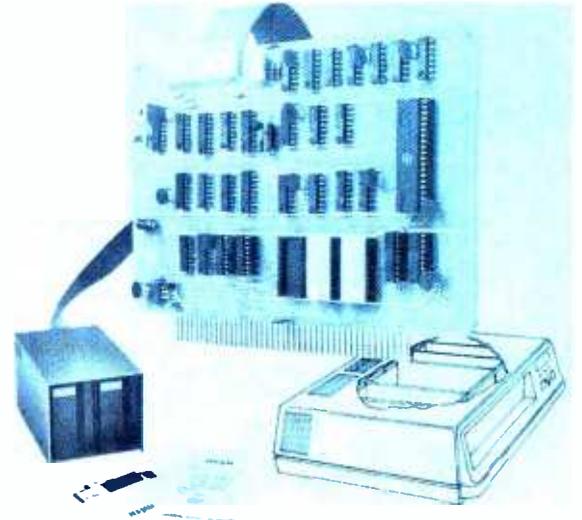
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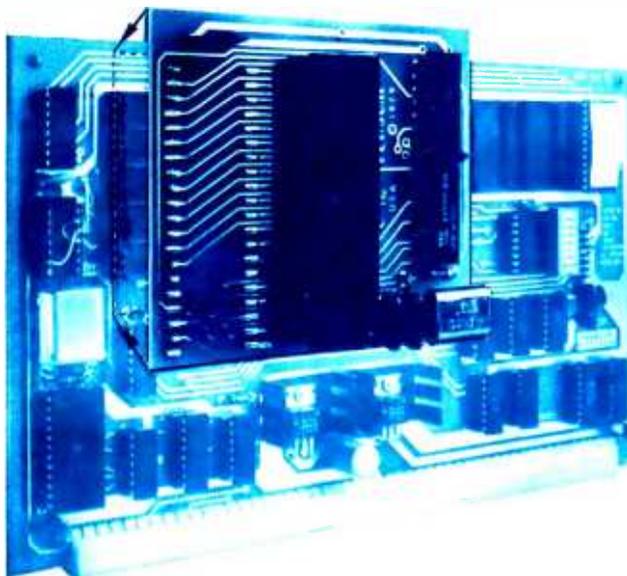
The LFD-1000™ systems (not pictured) have dual-drive units which store 800K bytes on-line. The LFD-1000™ controller accommodates two drive systems so that a user may have as much as 1.6M bytes on-line.



Mini-disk storage system prices:

MODEL	1-DRIVE SYSTEM	2-DRIVE SYSTEM	3-DRIVE SYSTEM
For the SS-50 Bus:			
LFD-400™	\$ 599.95	\$ 999.95	\$1399.95
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Although designed with the SWTP 6800 owner in mind, this upgrade adapter may also be used with most other 6800 and 6802 MPUs. The adapter is supplied assembled and tested, and includes the 6809 IC, a crystal, other essential components and user instructions. Restore your original system by merely unplugging the adapter and a wire-jumpered

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- Ordinary functions may be accomplished with 6800 Mikbug* monitor

Prices: Kit, \$79.95; Assembled, \$99.95. Prices include a comprehensive instruction manual. Also available: Test Cassette, Remote Control Kit (for program control of recorders), IC Socket Kit, MITS 680b mod documentation and Universal Adapter Kit (converts CIS-30+ for use with any computer).

of 6800 Microcomputing.

6800/6809 SOFTWARE

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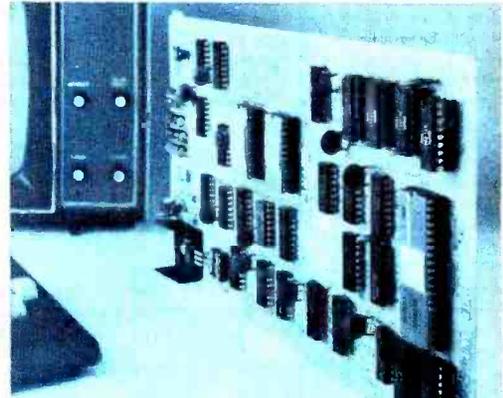
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(Single-Board-Computer/6809) — stands alone as a control computer, but also compatible with the SS-50 bus for use as an MPU card. Includes PSYMON™ (Percom System MONitor) in a 1K ROM and provides for additional 1K of ROM. Also includes 1K of RAM. Features: Super Port — provision for multi-address, 8-bit bidirectional data lines • an intelligent data bus for multi-level data bus decoding • an on-board 110-baud to 19.2 kbaud clock generator • extended address capability — to 16 megabytes — without disabling baud clock or adding hardware. And much more. Supplied with PSYMON™ and comprehensive users manual. Price \$199.95.

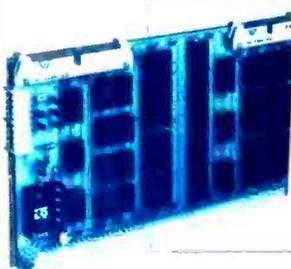
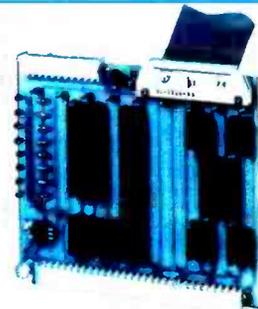
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- I/O card is 1-1/4 inches higher than SWTP I/O card • interdigitated power conductors • contacts for power regulators and distributed capacitance bypassing
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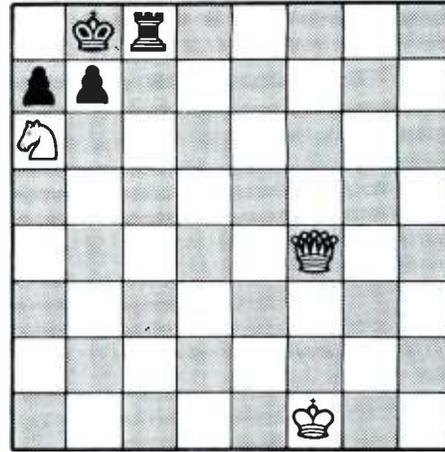
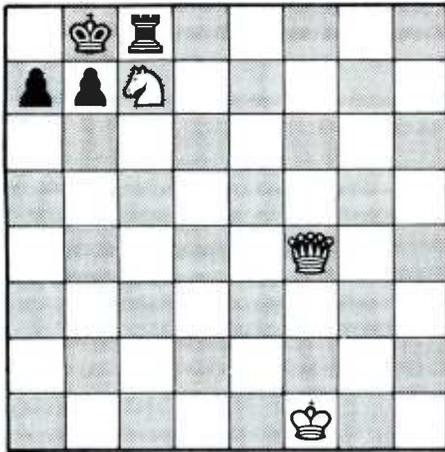
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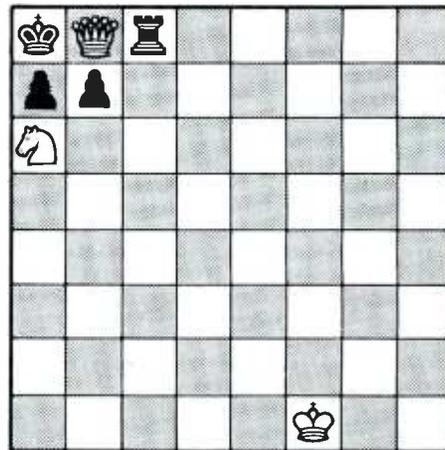
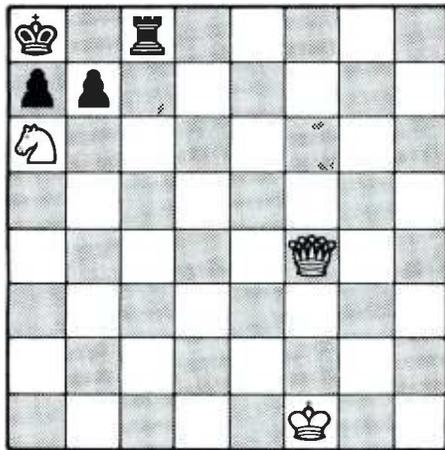
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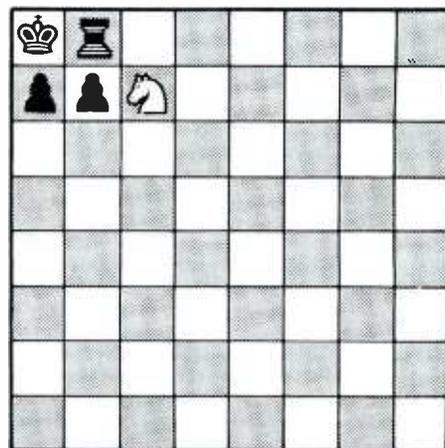
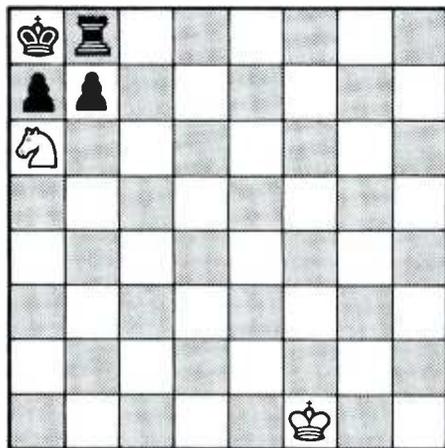
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IT IS WHITE'S TURN TO MOVE, AND.....WHITE CHECKS WITH BOTH QUEEN AND KNIGHT. BLACK IS FORCED.....



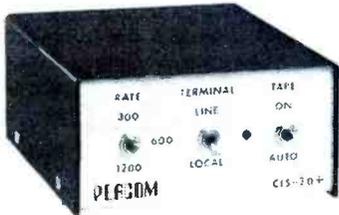
....TO MOVE INTO THE CORNER, AND.....NOW WHITE SACRIFICES THE QUEEN.



THERE IS NOTHING THAT BLACK CAN DO BUTWHEREUPON WHITE GIVES CHECKMATE. TO TAKE THE QUEEN.....

Figure 2: The sequence of moves that White makes to capture Black's King . . . CHECKMATE!

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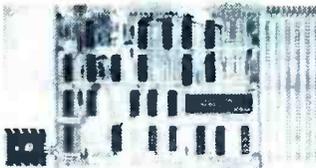
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Text continued:

(capturing the King with his Queen).

- If Black plays anything else, then White can play either $N \times K$ or $Q \times K$.

You might argue that the computer does not need to perform all of this analysis, because there is an old rule that states when you are in double check, you have to move your King—there is no other way out. This is perfectly true, but how do you know that you are in double check in the first place, without a similar analysis? It is easier to run through all of the moves, as described above, and verify that, in every case but one, Black's King would be captured. Additionally, look at the next position. Black does play $K-R1$, and now White plays $Q-N8$ check. This time Black is not in double check, but his next move is still forced, and Black's King can be captured in two different ways if he does not make the move he is forced to make. Specifically:

- If Black plays $K \times Q$ (capturing with

the King instead of with the Rook), then White plays $N \times K$.

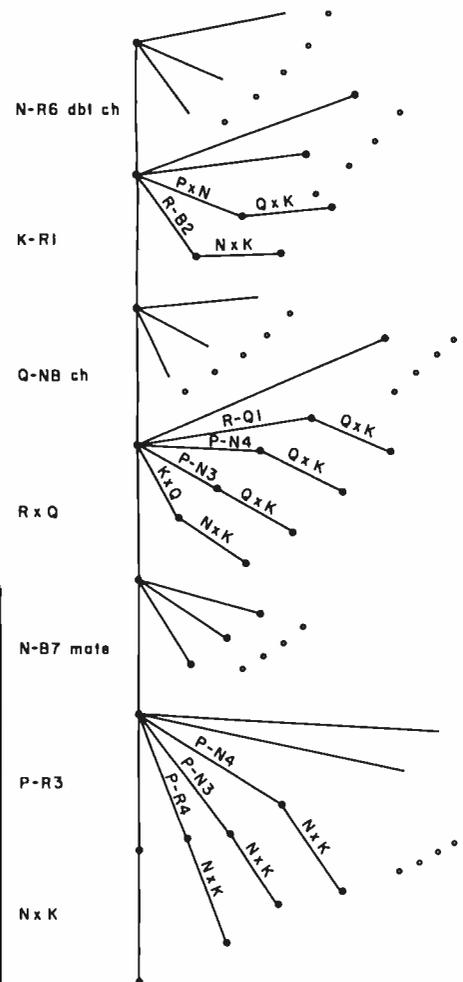
- If Black plays $P-N3$ (or any other move than $R \times Q$ or $K \times Q$), then White plays $Q \times K$.

When Black plays $R \times Q$, White plays $N-B7$, which is checkmate. But the computer's job is still not finished. How can you tell that this is checkmate? The only way to tell is to look at all of Black's possible moves and make sure that White can capture Black's King in each case. From the computer's point of view, the game is never over until the King is actually captured.

A diagram of the analyses that have been carried out so far would look like figure 3. Each point (dot) in this figure denotes a position of the board. The lines between board positions denote moves. The actual moves that have been made are at the left, but there are other moves which were not taken. In Black's case, each of these led to Black's King being captured. In White's case, they were simply other possible moves that

were not made because White has a way, as shown, of winning the game. This diagram is called a *game tree*.

Figure 3: An illustration of the game tree diagram. A complete game tree diagram would enumerate all possible moves so that the optimum move could be chosen.



The game tree of figure 3 is a bit hard to visualize because there are so many possible moves. Therefore, in order to illustrate the processing of game trees by computer, I have drawn a simplified game tree in figure 4. In this game tree there are only two possible moves for White at each point, and only two possible moves for Black. This will almost never be the case in a real game situation; here it allows the tree to fit easily on one piece of paper, so that it can be readily visualized. Like any tree, this tree has leaves, branches, and a root; in this case A, B, C...through P are the leaves, 5 is the root, and all of the other nodes are branches.

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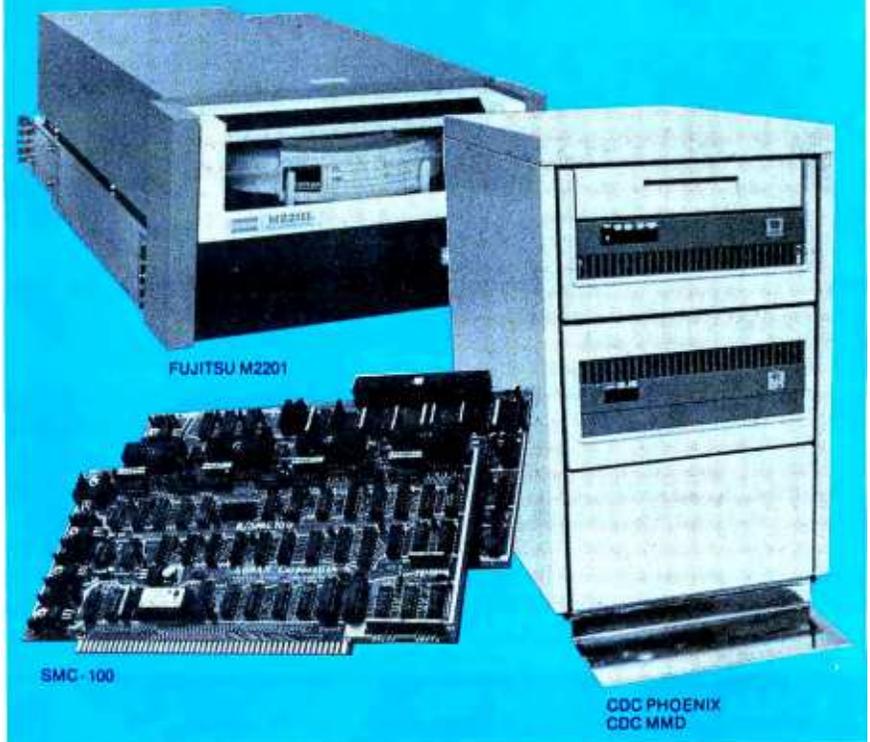
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In any game tree, the first question you must ask is whether or not it is complete. A game tree is complete if every one of its leaves corresponds to the end of the game. In figure 3, all leaves that are shown correspond to the end of the game (the King is captured), but there are some other leaves, not shown, that do not have this property. If a game tree is complete, it should be obvious that we can tell who ought to win, and the winning strategies. Suppose that the leaves B, L, A, C, and K represent a win for Black, and all other leaves represent a win for White. White (moving first) can win by moving to branch 4. Black will move to branch 1, and White now moves to branch U, winning regardless of Black's move (moving to leaf I or J).

Furthermore, this is the only winning strategy for White. If White's first move is to branch 3, then Black moves to branch Y, and Black now wins, no matter what White does (moving to branch Q or R). If White moves to branch V on his second move, then Black wins by moving to either K or L. This state of affairs will not always hold. There are positions in which White can win no matter what his first move is (suppose, for example, Black's winning positions were B, L, A, E, K...figure it out for yourself). There are also positions in which White cannot win, no matter what his first move is. If Black's winning positions are B, L, I, C, and K, and White starts by moving to 3, then Black moves to Y, whereas if White starts by moving to 4, Black moves to 1. In either case, Black can eventually win.

Now suppose that the game tree is not complete. This is presumably because it is so large that you would run out of memory if you tried to store the complete tree, so you would only store part of it. In this case it is still quite possible that there is a winning strategy for one player or the other. Suppose that Black's winning positions are B, L, I, C, and K, as in the last of the three examples above, but the other leaves of the tree are not winning positions for either White or Black. (In fact, these are not really leaves; if I had room to keep more of this game tree, I could consider further moves beyond each of these points.) It is clear that Black can still

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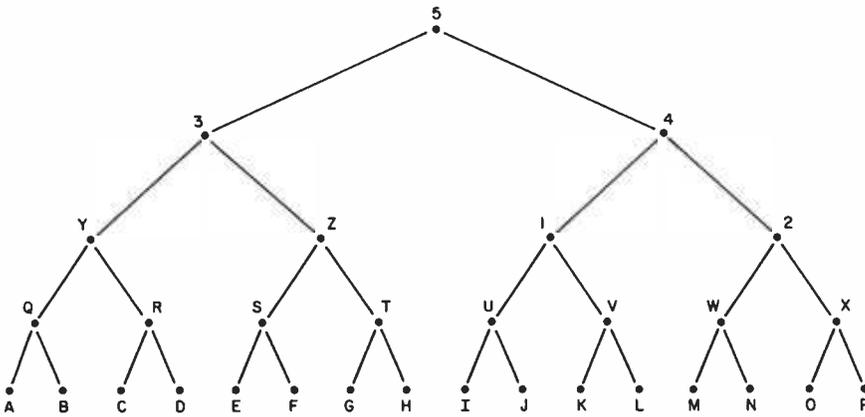


Figure 4: Simplified version of the game tree that assumes each player has only two possible moves.

win, no matter what White does, and for exactly the same reason as before.

In most cases, however, the game tree will be far from complete. In chess, for example, you might be in the middle of the game, and neither White nor Black can win the game in the next twenty-five moves. You can

still use game trees, but in a slightly different way. The first thing to do is code your knowledge as to when one position is better than another in terms of material gained and lost. For example, if White captures a pawn and loses a Bishop, or captures a Knight and loses a Rook, then Black

is obviously ahead. But what if White captures the Queen and loses both Rooks? Is that good or bad? What if White captures two pawns, but loses a Knight?

The usual pawn and piece values are: Queen = nine pawns, Rook = five pawns, Bishop and Knight are three pawns apiece. Greatly improved tables of values have been constructed; table 1 is a reprint of values (in abridged form) from R M Hyatt, the author of a chess program called BLITZ. Through the use of such a table, you can derive, for any position, a total numerical score that represents the value of that position. The function which computes this score is called the *evaluation function* corresponding to the given table.

You might think that with such an evaluation function there would be no further need for game trees. You could simply try all of the possible moves, and then choose the one with the largest value of the evaluation function. This, however, would lead to a very bad chess-playing program, rather like someone who had been playing for only a few months. The reason, of course, is that the evaluation function is only an approximation. It is very easy to lose a piece after you have made what seems to be the best move according to your evaluation function, because you have not looked far enough ahead. The best game programs use a combination of game trees and an evaluation function, together with the special technique of *alpha-beta pruning*, the subject of this article.

Once more I will set up an artificially small and simple game tree, in order to illustrate how this works. Consider the game tree of figure 5, which is exactly the same as the game tree of figure 4 except that a value of the evaluation function at each of the leaves of the tree has been specified. The evaluation function at the branches has *not* been specified, because this will be computed in a different way. Specifically, look at the leaves A and B. Since the value of the function is 26 at A, and 37 at B, you can conclude that, since it is Black's turn to play, at the branch Q Black will play to branch A. (This move assumes that the higher the value of the evaluation function, the better the position is for White, and the worse

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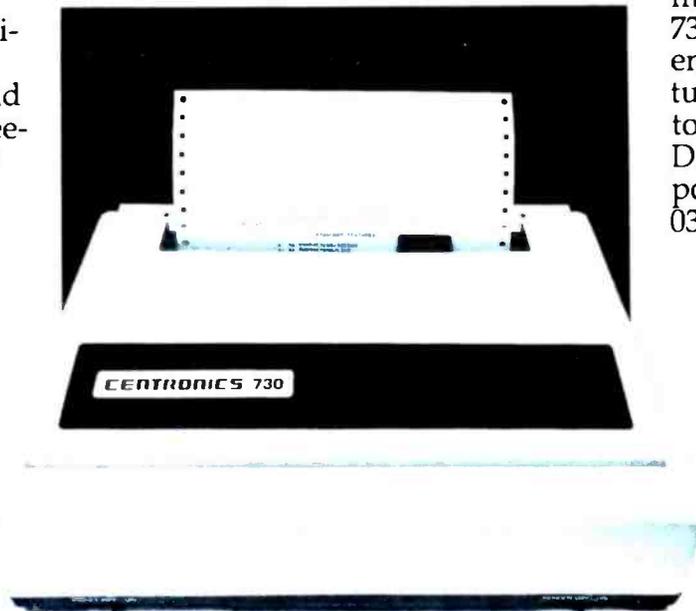
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the position is for Black. Black will make the move that gives the *lower* evaluation function value. Again, this is only an approximation, but it becomes a better one as the tree gets larger.)

In the same way you may conclude that, since it is Black's turn to move, at branch R Black will move to branch D, since 28 is less than 29. Let us go back to branch Y. Here it is White's turn to play, and White wants to make the move that results in the *highest* value of the evaluation function. Does this mean 37, the largest of the four values at A, B, C, and D? No, it does not. If White plays

to Q, Black will play to A. If White plays to R, Black will play to D. Therefore, you should compare only A and D. Since 28 is larger than 26, White should play from Y to R.

This potential source of confusion suggests that you should mark the nodes Q, R, S, T, and so on, with the *expected* evaluation function values (ie: the values that would ensue if Black makes the best play, in a highly approximate sense, on the next move). In this case Q would receive the value 26, R would receive the value 28, and in general each node would receive the *lowest* of the values of the nodes below it. This, of course,

is only because it is Black's turn to move. On the next level up, it is White's turn to play, and you can mark each of the nodes Y, Z, 1, and 2 with the *highest* of the values of the nodes below it, because White now wants to make the ultimate value of the evaluation function as large as possible. Continuing this all the way to the top of the tree, you get the situation illustrated in figure 6. The expected value for White at the top of the tree is 25. By following the figure 25 down through the tree, you will see that, at this point in the game, White is expected to move to node 4, Black to reply by moving to node 1, White to then move to U, and Black to play to J.

Capturing the Queen	9000
Capturing a Rook	5000
Capturing a Knight or Bishop	3000
Capturing a pawn	1000
Doubled pawns	-30
Tripled pawns	-100
Isolated pawns	-90
Two pawns next to each other	10
One pawn guarding another	36
Knight on opponent's side of the board	40
Same, with pawn guarding it	60
Bishop on strong diagonal	24
Rook on open file	60
Doubled Rooks on open file	170
Rook behind passed pawn	60
Rook on seventh rank, two unmoved opposing pawns	100
Rook on seventh rank, three unmoved opposing pawns	200
Rook on seventh rank, four unmoved opposing pawns	300
Rook moved before castling has occurred	-200
King moved before castling has occurred	-200
Castled King	300
Piece or pawn moved twice in the opening	-30
Taking two moves instead of one to get to a square	-30
Knight never moved	-36
Knight in front of King's pawn or Queen's pawn	-120
Bishop never moved	-20
Bishop in front of King's pawn or Queen's pawn	-120

Table 1: An abbreviated table of the approximate numerical values assigned to a variety of possible moves.

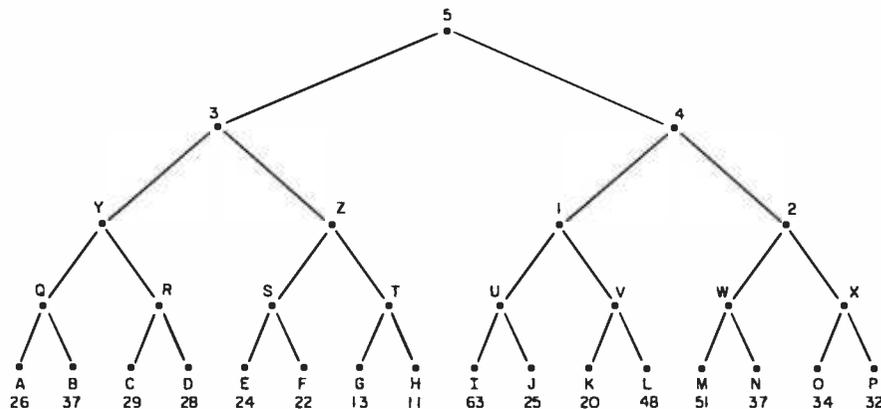


Figure 5: Same game tree as that shown in figure 4, along with a specification of the evaluation function at each leaf of the tree.

This does not, of course, have to be what actually happens in the game. Black might be a poor player, and play to node 2 instead of node 1, or Black might discover, upon looking more moves ahead, that node 2 is actually a better play than node 1. This tends to happen in actual games. As you look further ahead (ie: as you consider trees with greater and greater numbers of levels), expected moves at all levels, even the top level, can change.

At this point a very important question is raised: is it really necessary to generate this whole tree? It would be nice to find certain nodes that do not have to be constructed.

Consider the situation at node Z. White has two possible moves: one to node S and one to node T. At node S, White gets a score of at least twenty-two on the next move. Is this a better move for White than the move to node T? To determine the answer, look at node T. The first thing you will see is that if White moves to node T, then Black can move to node G. If Black does that, White ends up with a score of only thirteen. By this point you already know what White should not move to node T because he can do better by moving to node S.

Now look at node H. If White moves to node T, then Black could also move to node H, leaving White with a score of eleven. This is a better move for Black than the move to node G. The point is that *this does not matter*. As soon as you look at node G, you know that White should not move to node T. When you are aware of this it does not matter what

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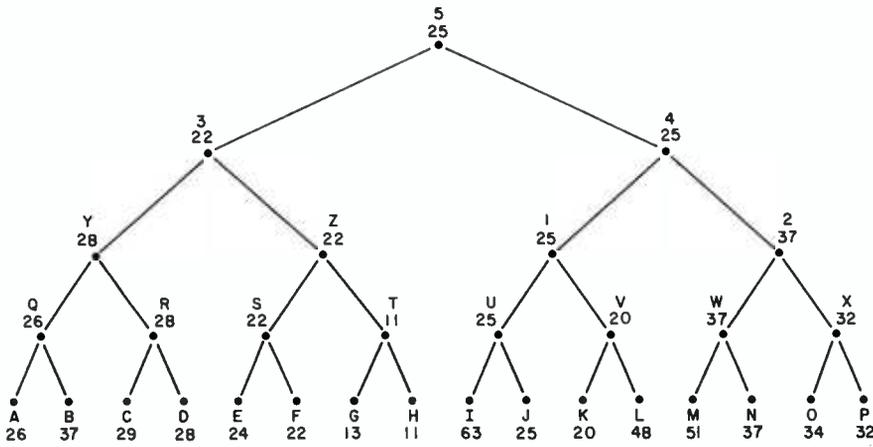


Figure 6: A more informative version of the game tree shown in figures 4 and 5. Here the expected evaluation function values are shown at each of the nodes.

score node H has—in fact, you do not have to generate node H at all. This kind of logic can be applied to either

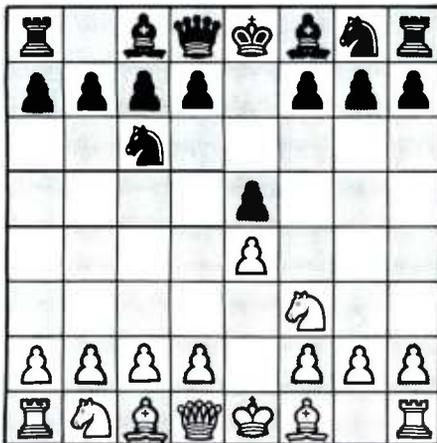


Figure 7: A simple example to illustrate the principle of alpha-beta pruning. It is now White's turn to move. An obvious bad move would be NxP. Black's reply would be NxN, and White would have captured a pawn but lost a Knight.

player; it is called *alpha cutoff* in a case like this, where it is White's original move that is being considered (as at node Z here). It is called *beta cutoff* when it is Black's original move that is being considered. *Alpha-beta pruning* is the combination of alpha cutoff and beta cutoff within the general framework described here.

For an example of beta cutoff, look at node 4. It is Black's turn to move. By considering node 1 and all the nodes beneath it (that is, nodes U, V, I, J, K, and L), you will note that Black can eventually expect a score of twenty-five if he moves to node 1. The next question is whether or not a move to node 2 would be any better for Black. Suppose Black moves to node 2, and that White moves to node W. By analyzing the nodes (M and N) beneath node W, you will find that Black can achieve a score of either fifty-one or thirty-seven. Black would naturally choose thirty-seven, that is, node N. But if that is the best

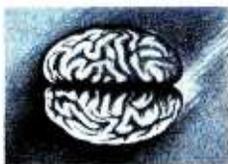
that Black can do, then the answer to the original question must be no; that is, a move from node 4 to node 2 would *not* be any better for Black than a move to node 1. Once you know this, it is not necessary to consider node X at all and, more important, you do not have to consider nodes O or P either. In other words, you have pruned not just a single leaf, but a branch with leaves below it.

An informal example of alpha-beta pruning is given in figure 7. Here it is White's turn to move. White has many possible moves, but an obvious bad move for White is NxP. In order to determine that this move is bad, it is not necessary to figure out Black's best move; it is only necessary to note that Black can move NxN. Any other possible moves need not be considered as long as White has any move that does not result in the loss of a piece, and as long as NxP is not really a viable sacrifice. ■

Glossary

alpha-beta pruning: In order to guarantee a winning strategy an entire tree search of a complete game tree would be necessary. Alpha-beta pruning is an algorithm devised to optimize the use of game trees by reducing the number of branches needed to be searched.

game tree: A graphic representation of the decision making process involved in a sequence of moves between two opponents. A complete game tree is a representation in which all the terminal nodes correspond to the end of the game.



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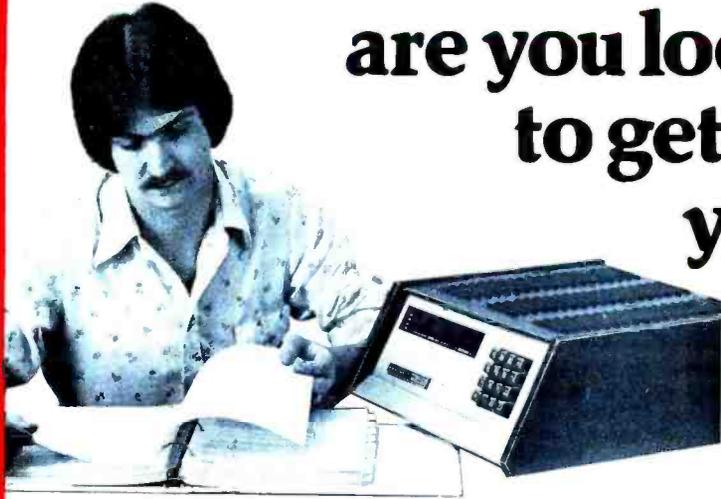
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Interfacing the PET to a Line Printer

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Introduction

From both software and hardware points of view, this article presents a design example for interfacing the 8-bit user port on the Commodore PET 2001 personal computer to an external device. The design example will show how the user port may be used to develop a handshake interface to a line printer. We shall begin with a brief discussion of the programmable features of the user port.

Peripheral Interface Port

The 8-bit port, described in the PET user manual, is actually a part of the MCS6522 peripheral interface adapter (PIA), manufactured by MOS Technology. The 6522 is a general purpose I/O (input/output) device, configured as two 8-bit I/O ports A and B. It provides handshaking logic associated with parallel data transfers occurring through I/O port A. Counter and timer, and elementary serial I/O logic are associated with the MCS6522 port B. In the PET 2001, most features of port B are reserved for internal use, leaving port A as the only peripheral interface port available to the user.

To the user, the MCS6522 peripheral interface adapter appears as sixteen contiguous memory locations. Table 1 identifies the sixteen ad-

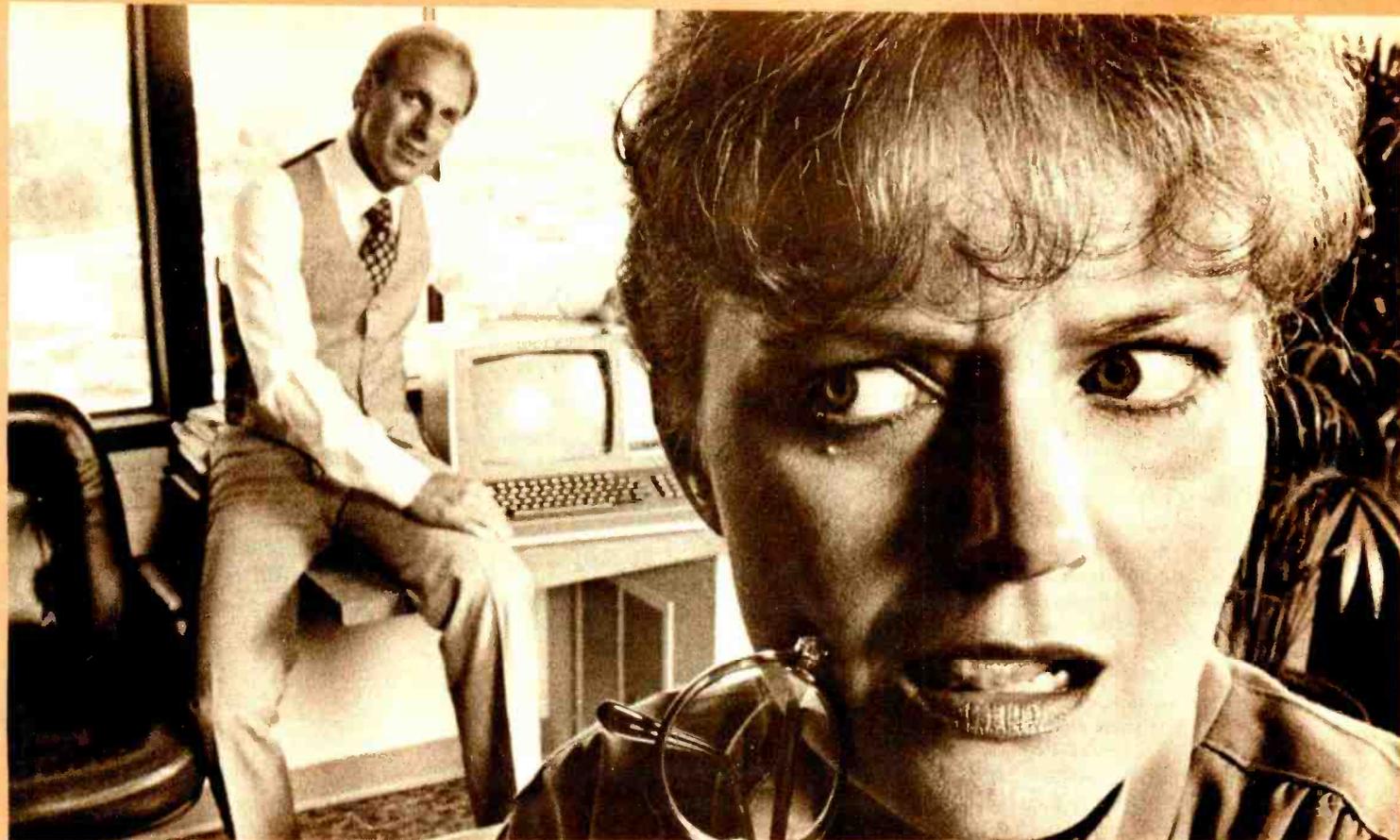
PET Memory Location	Function Provided by the 6522
59456	Output register for I/O port B.
59457	Data register for port A with handshake.
59458	I/O port B data direction register
59459	I/O port A data direction register.
59460	Read timer 1 counter (low-order byte). Write to timer 1 latch (low-order byte).
59461	Read timer 1 counter (high-order byte). Write to timer 1 latch (high-order byte).
59462	Access timer 1 latch (low-order byte).
59463	Access timer 1 latch (high-order byte).
59464	Read low-order byte of timer 2 and reset counter interrupt. Write to low-order byte of timer 2 but do not reset interrupt.
59465	Access high-order byte of timer 2; reset counter interrupt on write.
59466	Serial I/O shift register.
59467	Auxiliary control register.
59468	Peripheral control register.
59469	Interrupt flag register.
59470	Interrupt enable register.
59471	Data register for I/O port A without handshake.

Table 1: Internal registers of the 6522 peripheral interface adapter given in terms of addresses in the PET memory address space. Addresses that are of direct concern to the PET user (for interfacing to port A) are shown in *italic* characters.

dressable locations of the 6522. Locations of direct concern to the PET user (for interfacing to port A) are in *italic* characters.

The characteristics and functions of the interface lines on the peripheral interface port A are determined by the operating mode selected under program control. Two modes of operation may be selected under program control: *basic input/output*

without handshake, *strobed input/output* with handshake. By selecting the correct operating mode for the data direction register (this may be done using the BASIC statement POKE 59459,X where X=0 for input and 1 for output), interface lines may be configured to fulfill specific interface requirements. Device strobes may be easily generated by software without utilizing external logic by



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Listing 1: PRINTSCREEN, a program in BASIC which provides a hard copy of any characters displayed on the PET's video display. An image of the text appearing on the screen is sent to the printer. Note that here the program was used to create its own listing. The data transfer rate is about 6 characters per second.

```
5 REM FILENAME "PRINTSCREEN"
10 REM OUTPUT DATA TO EXTERNAL DEVICE
15 REM HANDSHAKE WITH LINE PRINTER
16 REM CB2 FOR DATA STROBE; TO DEVICE
18 REM CA1 FOR ACKNOWLEDGE; FROM DEVICE
20 POKE 59459,255:REM DIRECTION OUT
25 GOSUB 100:REM HANDSHAKE NOT READY
34 FOR I=1 TO 25 :REM SCAN ROWS
35 FOR J=1 TO 40 :REM SCAN COLUMNS
36 V=PEEK(32767+J-1+40*(I-1))
37 IF V>64 THEN V=V+32 :REM LOWER CASE
38 IF V<=26 THEN V=V+64:REM UPPER CASE
39 IF V=128 THEN V=V-96:REM SPACE
40 IF J=1 THEN 180 :REM PRINT SPACE
50 POKE 59457,V AND 127:REM SEND VALUE
51 GOSUB 150:REM READY TO OUTPUT
52 GOSUB 100:REM NOT READY
56 ACK=PEEK(59469)AND2:REM INT FLG REG
58 IF ACK <> 2 THEN 56:REM ACKNOWLEDGE
70 NEXT J
```

READY.

RUN

READY.

LIST 71-97

```
72 POKE 59457,13:REM CR
73 GOSUB 150:REM READY
74 GOSUB 100:REM NOT READY
76 POKE 59457,10:REM LF
78 GOSUB 150:REM READY
80 NEXT I
82 GOSUB 100
84 POKE 59457,128 :REM STOP PRINT
85 PRINTCHR$(147) :REM CLEAR SCREEN
86 END
```

READY.

RUN

changing the contents of decimal location 59468 (the peripheral control register).

Interfacing to a Line Printer

This example demonstrates how the PET parallel port can be interfaced to a line printer. The first step in the design is to examine the specification for the printer, and to identify the control and data signals which must be supported by the inter-

READY.
LIST 98-199

```
98 REM SUBROUTINES
100 REM SET CB2 TO LOGIC 1:NOT READY
110 POKE(59468),PEEK(59468) OR 224
120 RETURN
150 REM SET CB2 TO LOGIC 0 :REM READY
160 POKE (59468),PEEK(59468)AND31OR192
170 RETURN
180 V=32 AND 127 :REM SPACE
182 GOSUB 150:REM READY
184 GOSUB 100:REM NOT READY
186 GOTO 50
```

READY.

RUN

READY.

POKE 59468,14

READY.

LIST 200-

```
200 PRINT" Upper and Lower Case "
240 PRINT"ABCDEFGHIJKLMNPOQRSTUVWXYZ"
250 PRINT"abcdefghijklmnopqrstuvwxyz"
300 PRINT" These listings were made on
310 PRINT" TI Model 810 printer"
```

READY.

RUN 200

Upper and Lower Case
ABCDEFGHIJKLMNPOQRSTUVWXYZ
abcdefghijklmnopqrstuvwxyz
These listings were made on
TI Model 810 printer

READY.

RUN 5

face. Figure 1 is a block diagram of the interface design. A data strobe/acknowledge interface is supported. The ACKNLG signal notifies the PET that a character transferred to the printer by a data strobe has been accepted. After ACKNLG is issued, the printer is considered idle.

Software Driver

The software driver implemented for the example was specifically

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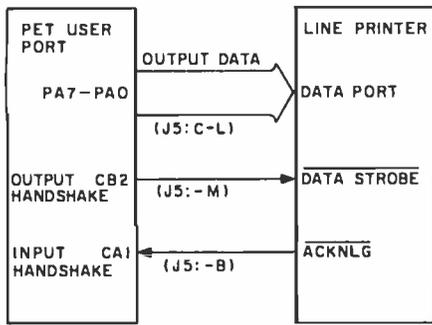


Figure 1: Block diagram of printer interface using the PET user port (MCS6522 port A). J5 is the PET user port connector; pins are labeled alphabetically. Pin assignments at the line printer are not given since they vary between different manufacturers.

figure 2, and a program listing is included in listing 1. The program is called PRINTSCREEN. It scans the twenty-five lines on the PET screen and transmits the data displayed there to the user port, one character at a time. You will observe that transferring data to the parallel port using BASIC is relatively slow. In this example, the data transfer rate is about six characters per second. ■

- PA7-PA0: Output data used to support printer data port.
- DATA STROBE: Signals to printer that data is available at the printer data port.
- ACKNLG: Signals to the PET that the printer has accepted the data.
- J5: -A PET user port connector J5-Pin A.

designed to generate a hard copy listing of the image displayed on the PET screen.

The PET video display presents 1000 characters arranged in twenty-five lines of forty characters each. The display is continuously refreshed from a section of memory called *display memory*. By direct access to these 1000 locations, and using the programmable I/O port connected to a line printer, you can generate a hard copy of the screen image. The flowchart of the procedure is shown in

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3. *An Introduction to Microcomputers, Volume II: Some Real Products* Adam Osborne and Associates, POB 2036, Berkeley CA 94702.

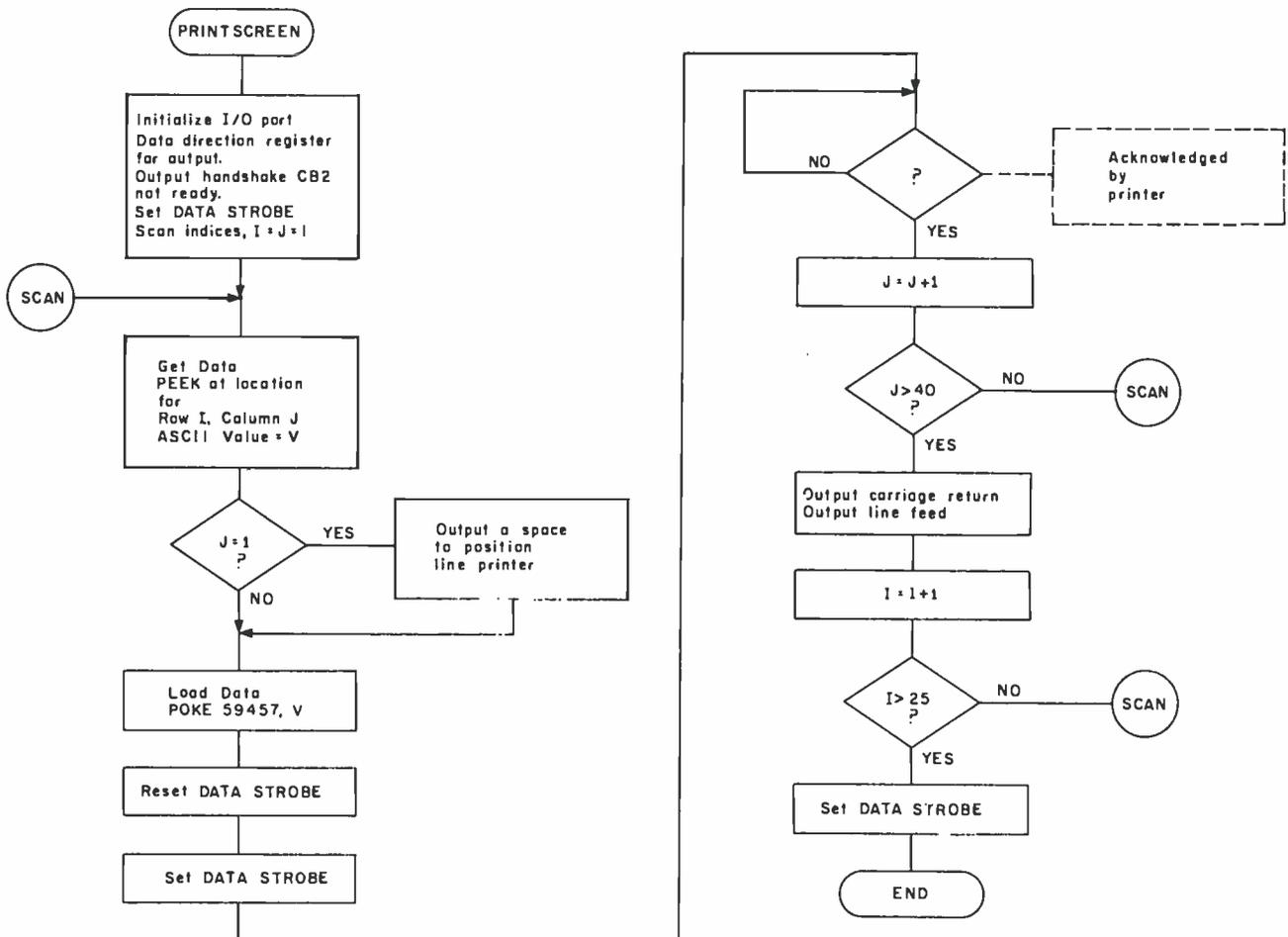


Figure 2: Flowchart of the BASIC program PRINTSCREEN. This program transmits images of text on the PET video display screen to the line printer.

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This article describes a BASIC program that enables the user to design and put into orbit a multistage spacecraft launched from Earth-based conditions. By asking for engine throttle settings, thrust angles, and firing times, your computer puts you at the controls of a multistage spacecraft of your own design as you pilot it from the Earth's surface into orbit. Continuous data displays of the user's status after each maneuver are presented, as well as arrays of altitude and range information for possible plotting at the end of the mission. The following is a description of the program operation.

The program first asks for and verifies all ship design parameters, the first being the number of stages. Then the iteration time (dt) in seconds and the height in miles of the desired orbit are required. During each iteration, the computer calculates formulas of the form:

$$V_{\text{final}} = V_{\text{initial}} + \text{acceleration} \times \text{dt} (1)$$

The final values are then taken as the initial ones for the next iteration. An iteration time evenly divisible into one second is recommended; 0.1 seconds is suggested for faster than real-time computation. A figure of 0.01 seconds, for example, will give a slightly better mathematical accuracy but at the expense of ten times more processing time.

The craft is assembled from top down, the weight of the payload in
Text continued on page 108

Listing 1: BASIC listing of the rocket launcher program.

ROCKET LAUNCHER PROGRAM

```
10 DIM A(100),AD(100),A1(7),A2(7),A3(6),A4(6)
20 PRINT "DESIGN AND ORBIT A SPACE SHIP. TYPE NO. STAGES UP TO 6. "
30 INPUT A5
40 PRINT "VERIFICATION. ";A5;" STAGES."
50 A6 = A5 + 1
60 PRINT "ENTER ITERATION TIME IN SEC., AND ORBIT HEIGHT IN MI. "
70 PRINT ".1 SEC. IS OK AND .01 BETTER, BUT WITH MORE CPU TIME. "
80 INPUT A7,A8
90 PRINT "VERIFICATION. ITERATION TIME ";A7;" , ORBIT HEIGHT ";A8
100 PRINT "ENTER PAYLOAD WEIGHT IN POUNDS. "
110 INPUT A2(A6)
120 A1(A6) = 0.0
130 PRINT "VERIFICATION. PAYLOAD WEIGHT. ";A2(A6)
140 FOR A9 = 1 TO A5
150 B = A6 - A9
160 B0 = 3 + 1
170 PRINT "ENTER STAGE ";B;" FUEL AND HULL WEIGHTS IN LBS. "
180 INPUT A1(B), A2(B)
190 PRINT "STAGE ";B;" FUEL ";A1(B);" LBS., HULL ";A2(B);" LBS. "
200 A2(B) = A2(B) + A2(B0) + A1(B0)
210 B1 = A2(B) + A1(B)
220 PRINT "ENTER STAGE ";B;" THRUST AT LEAST ";B1;" LBS. "
230 INPUT A3(B)
240 PRINT "STAGE ";B;" THRUST. ";A3(B);" LBS. "
250 PRINT "ENTER SPECIFIC IMPULSE OF STAGE ";B;" FUEL/OXIDIZER. "
260 PRINT "THIS IS THE THRUST-TO-BURN RATE RATIO. "
270 PRINT "FOR GASOLINE =250, PEROXIDE =300, LIQUID HYDROGEN =500. "
280 INPUT A4(B)
290 PRINT "VERIFICATION, STAGE ";B;" SPECIFIC IMPULSE ";A4(B)
300 NEXT A9
310 B2 = 10
320 B3 = B2 * A7
330 B4 = 360
340 B5 = 33 / 100.0
350 B6 = 5280. * .3048
360 B7 = 6.67E-11 * 5.983E24
370 B8 = ATN(1.) / 45.
380 B9 = 90.
390 C = 1.0
400 C0 = 9QR(B7/9.80665)
410 C1 = C0
420 C2 = 3QR(B7/(C0+36*48)) / .3048
430 C3 = 0.0
440 C4 = 0.0
450 C5 = 0.0
460 C6 = 0.0
470 C7 = 0.0
480 C8 = 0.0
```

Listing 1 continued on page 108

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* CP/M is a trade name of Digital Research

† Z80 is a trademark of Zilog, Inc.

** UNIX is a trademark of Bell Laboratories.

*** WHATSIT? is a trademark of Computer Headware.

†† Microsoft TRS-80 Model I and PolyMorphic 8013 are included and must use especially compiled versions of System and applications software.

††† PolyMorphic 8013 CP/M scheduled for September 15 release.

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SOFTWARE SYSTEMS

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- BDS C Compiler** — Supports most major features of language, including Structures, Arrays, Pointers, recursive function evaluation, linkable with library to 8080 binary output. Lacks data initialization, long & float type and static & register class specifiers. Documentation includes "C" Programming Language book by Kernighan & Ritchie. **\$110/\$15**

- Whitesmith's C Compiler** — The ultimate in systems software tools. Produces faster code than Pascal with more extensive facilities. Conforms to the full UNIX™ Version 7 C language described by Kernighan and Ritchie, and makes available over 75 functions for performing I/O, string manipulation and storage allocation. Compiler output in A-Natural source. Supplied with A-Natural (see below) requires 60K CP/M. **\$630/\$30**

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- SMAL/80 Structured Macro Assembled Language** — Package of powerful general purpose text macro processor and SMAL structured language compiler. SMAL is an assembler language with IF, THEN-ELSE, LOOP, REPEAT-WHILE, DO-END, BEGIN-END. **\$75/\$15**

- SELECTOR II** — Data Base Processor to create and maintain single key data bases. Prints formatted, sorted reports with numerical summaries. Available for Microsoft and CBASIC (state which). Supplied in source code. **\$195/\$20**

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Software for most popular 8080/Z80 computer disk systems including NORTH STAR, iCOM, MICROPOLIS, DYNABYTE DB8/2, EXIDY SORCERER, SD SYSTEMS, ALTAIR, VECTOR MZ, 8" IBM, HEATH H17 & H89, HELIOS, IMSA VDP42 & 44, REX, POLYMORPHIC 8813; OHIO SCIENTIFIC and IMS 5000 formats.

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Manual cost applicable against price of subsequent software purchase.

The sale of each package includes a license for use on one system only.

Listing 1 continued:

```
490 C9 = 0.0
500 D = 0.0
510 D0 = 0.0
520 D1 = 0.0
530 D2 = 0.0
540 D3 = 0.0
550 PRINT "THE SHIP CAN SWIVEL ";32;" DEG/SEC. "
560 PRINT "EARTH'S GRAVITY IS 32.174 FT/SEC/SEC. "
570 PRINT "FORWARD VELOCITY NEEDED FOR ORBIT ";C2;" FT/SEC. "
580 D = D + 1
590 D4 = A2(D) / 2.2046
600 D5 = A3(D) / A4(D) / 2.2046
610 D6 = A1(D) / 2.2046
620 D7 = D6
630 D8 = A3(D)/2.2046*9.80665
640 PRINT "IGNITION OF STAGE ";D;" , ENTER THE STAGE NUMBER. "
645 INPUT X1
650 GO TO 1090
660 PRINT "ENTER THROTTLE SETTING IN %, FROM 0 TO 100, "
670 PRINT "THRUST ANGLE IN DEG. FROM -";34;" TO ";84
680 PRINT "AND BURN TIME IN SECONDS. "
690 INPUT D9, E, E0
700 D9 = ABS(D9 / 100.0)
710 E1 = D9 * D8
720 E2 = D9 * D5 * A7
730 E3 = E2 / 100.
740 E4 = E0 - (A7 / 100.0 )
750 E5 = C5 * C1
760 E6 = 0.0
770 IF E0 = 0.0 THEN 1080
780 IF C1 < C0 THEN 1080
790 E6 = E6 + A7
800 E7 = D7 - E2
810 E8 = E1 / (D4 + (D7 + E7) / 2.0 )
820 IF E7 >= E3 THEN 850
830 E7 = 0.0
840 E8 = 0.0
850 IF ABS( E - 89 ) < 85 THEN 930
860 IF E < 89 THEN 890
```

Listing 1 continued on page 110

Text continued:

pounds being required first. For each stage, the computer then asks for the weights of the fuel and hull (or tanks), the maximum thrust desired, and the specific impulse of the fuel. To insure the possibility of achieving orbit, a fuel to hull weight ratio of 4 or 5 to 1 is suggested. A thrust of about 20 percent more than the minimum amount required to lift the ship is suggested, so that the ship has sufficient acceleration, even when heavily laden with fuel.

Specific impulse is a figure of merit for fuel performance, the thrust to burn-rate ratio. Suggested values for different fuels are given in the program. Knowing the thrust and specific impulse defines the burn rate, and knowing the amount of fuel on board designates how long it will last at full throttle expenditure. Next, a printout chart, to be described shortly, displays initial fuel, altitude, and the velocity status of the ship.

At this point, the flight begins; the user is in control, and must specify the throttle setting, firing angle, and burn time for each maneuver. The force on the ship (in newtons) is first computed from the throttle setting

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REnumber any section of a program, MOve program segments, DElete program lines.
Combine programs with renumber and merge. Load or save any portion of program from tape.

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The business programmer will appreciate the versatile PRINT-USING capabilities which include dollar and asterisk fill, trailing minus sign, imbedded commas, and scientific notation. New string functions have been added for string searching (INSTR) and for creating a string which is the date (DATE\$). DPEEK and DPOKE are 16-bit peek and poke type functions. The SCALE command has been included to eliminate the round-off errors typically encountered in binary math packages. The INCH\$ function allows single-character input from the terminal. Programmer control of control C breaks is also included.

Overall, the Extended BASIC is the most complete BASIC offered for micro users and is only available on FLEX™ disk. A system with at least 32K of user space is recommended. Specify 8" or 5" media (5" 6800 is FLEX™ 2.0) and either the 6800 or 6809 version when ordering.

AP68-12	6800 Extended BASIC	\$100
SP09-6	6809 Extended BASIC	\$100

BASIC Precompiler

This program allows the creation of BASIC programs without the use of line numbers or restrictive two-character variable names. Alphanumeric line and subroutine labels may be used, as well as variable names of any length. Comment lines are marked with non-alphanumerics for easy readability. The output of the precompiler is in the standard BASIC compiled form. This allows applications programs to be written, precompiled, and then distributed in a non-source form. The precompiler can only be used with one of Technical Systems Consultants' BASICs. Specify 8" or 5" (5" 6800 is FLEX™ 2.0) when ordering.

AP68-13	Single Precision 6800 Precompiler	\$40
AP68-14	Double Precision 6800 Precompiler	\$50
SP09-7	Single Precision 6809 Precompiler	\$40
SP09-8	Double Precision 6809 Precompiler	\$50

FLEX is a registered trademark of Technical Systems Consultants, Inc.



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Listing 1 continued

```

870 B9 = 39 * B3
880 GO TO 900
890 B9 = 39 - 33
900 E9 = 39 * B8
910 C4 = COS(E9)
920 C = SIN(E9)
930 F = B8 * C4
940 F0 = E8 * C
950 F1 = C5 * F * A7
960 C6 = (C5 * F1) / 2.0
970 C7 = C7 + C6 * A7
980 F2 = F0 + C6**2 / C1 - B7 / C1**2
990 F3 = C8 + F2 * A7
1000 F4 = C1 * (C8 + F3) / 2.0 * A7
1010 IF DP <> 0.0 THEN 1030
1020 F1 = E5 / F4
1030 O7 = E7
1040 C5 = F1
1050 C8 = F3
1060 C1 = F4
1070 IF E6 < B4 THEN 770
1080 C3 = C3 * 86
1090 D2 = D2 * 1
1100 A(D2) = (C1 - C0) / .3048
1110 IF C9 >= A(D2) THEN 1130
1120 C9 = A(D2)
1130 IF A(D2) >= 0.0 THEN 1150
1140 A(D2) = 0.0
1150 IF A(D2) < 400000.0 THEN 1170
1160 D3 = D3 * 1
1170 F5 = A(D2) / 5280.
1180 F6 = C8 / .3048
1190 F7 = F6 * 15./22.
1200 F8 = C5 / .3048
1210 F9 = F8 * 15./22.
1220 A0(D2) = C7 / 86
1230 G = 100. * D7 / D6
1240 G0 = D7 / D5
1250 G1 = B7 / C1**2 - C6**2 / C1
1260 G2 = D8 / (D4 + D7) / .3048
1270 J3 = J2 * 15. / 22.
1280 J4 = J2 - (G1 / .3048)
1290 G5 = J4 * 15. / 22.
1300 G6 = G1 / .3048 / G2
1310 G7 = 100. * G6
1320 J8 = 90.0
1330 IF G6 >= 1.0 THEN 1350
1340 J8 = ATN( G6 / SQRT( 1.0 - 26**2 ) ) / 88
1350 G9 = SQRT( B7 / C1 ) / .3048
1360 H = 100. * F8 / C2
1370 H0 = 100. * A(D2) / (A8 * 5280. )
1380 H1 = 100. * F8 / G9
1390 H2 = (C2 - F8) / J2
1400 H3 = (G9 - F8) / G2
1410 IF F6 = 0.0 THEN 1440
1420 H4 = (A8*5280. - A(D2)) / F6
1430 IF H4 <= 9999.99 THEN 1460
1440 H4 = 9999.99
1450 REM-TIMES OVER 9999.99 SET TO 9999.99 TO NOT EXCEED DISPLAY.
1460 IF D3 < 1.0 THEN 1480
1470 PRINT "4000 FT. ACHIEVED, YOU ARE IN VACUUM. "
1480 PRINT "FLIGHT TIME", "FUEL LEFT", "AT FULL THROT.", "SHIP ANGLE"
1490 PRINT C3;"SEC.",G;"°",G0;"SEC.",89;"DEG."
1500 PRINT
1510 PRINT "ALTITUDE", "ASCENT RATE", "FORWARD V.", "RANGE"
1520 PRINT A(D2) ;"FT.", F6;"FT/SEC.",F8;"FT/SEC.",A0(D2) ;"MI."
1530 PRINT F5;"MI.",F7;"MI/HR.",F9;"MI/HR."
1540 PRINT " "
1550 PRINT "MAX ACCEL.", "MAX VERT ACCEL.", "ANGLE(C.A.)", "THROT(C.A.)"
1560 REM-ANGLE(C.A.), CRITICAL ANGLE FOR CONST. ASCENT AT FULL THROT.
1570 REM-THROT(C.A.), CRITICAL THROT. OF CONST. ASCENT AT 90DEG.
1580 PRINT G2;"FT/S/S",J4;"FT/S/S", "FULL THROT.", "VERT. POS."
1590 PRINT G3;"MI/H/S",G5;"MI/H/S",G8;"DEG.",G7;"°"
1600 PRINT " "
1610 PRINT H1;"% ORBITAL VELOCITY",H0;"% ORBITAL HEIGHT."
1620 PRINT H1;"% VELOCITY NEEDED FOR ORBIT AT CURRENT ALTITUDE."
1630 PRINT " "
1640 PRINT " ", " ", "TIME TO ARRIVE"
1650 PRINT "OR9. ALT.", "OR3. VEL.", "CUR. ALT. OR3. VEL."
1660 PRINT "AT CUR. RATS", "AT FULL THROT.", "AT FULL THROT."
1670 PRINT d4;"SEC.",H2;"SEC.",H3;"SEC."
1680 PRINT " "

```

and maximum specified thrust. Also, note that a firing angle of ninety degrees is vertically upward, and angles less than ninety degrees are to the right, or east, etc. A one hundred percent throttle setting at ninety degrees for fifteen or twenty seconds is suggested to gain altitude before beginning to swivel the ship to achieve horizontal orbital velocity.

The amount of fuel used during an iteration is simply the throttle setting, times the maximum burn rate, times dt. This amount, subtracted from the weight of the fuel at the beginning of an iteration, gives the amount remaining at the end. The amount of fuel available during an iteration is taken as the average of the amounts before and after. This is added to the weight of the tanks and the upper stages that the engines must lift, and is the instantaneous weight (in kilograms) of the craft. Dividing into the thrust force yields the current engine thrust acceleration A, during the iteration, in meters per second per second (m/s²).

For a given firing angle, the horizontal and vertical components of this acceleration, a_h and a_v , are taken. Horizontal velocities and the range are computed by

$$V_h = V_{h0} + a_h \times dt \quad (2)$$

$$V_{av} = (V_{h0} + V_h) / 2 \quad (3)$$

$$\text{range} = \text{range} + V_{av} \times dt \quad (4)$$

where, for a particular iteration, V_{h0} is the initial horizontal velocity, V_h is the final horizontal velocity, and V_{av} is the average of the two.

The total outward vertical acceleration a_v is computed by adding centrifugal acceleration to the engine acceleration and subtracting gravity's downward contribution as follows:

$$a_v = a_{en} + (V_{h0}^2 / r_{en}) - GM / r_{en}^2 \quad (5)$$

where, r_{en} is the initial value of the vertical distance of the ship from the Earth's center, G is the gravitational constant, and M is the mass of the Earth. From the vertical acceleration, the velocities and altitude are computed just as the horizontal components were computed in equations 2 thru 4.

From physics, it will be noted that if no external force is applied by the engines, the rocket's angular momentum is a constant. For each maneuver, therefore, the computer retains

The following constants were used in listing 1:

G: Gravitational constant,
 $6.67 \times 10^{-11} \text{ Nm}^2/\text{kg}^2$
M: Mass of the earth,
 $5.983 \times 10^{24} \text{ kg}$
g: Gravitational acceleration,
 9.80665 N/kg ,
 $\text{m/sec}^2 = 32.174 \text{ ft/sec}^2$

0.3048 meters/foot
2.2046 pounds/kg

the product of horizontal velocity and distance from the Earth's center. If the engines are off during an iteration, the new horizontal velocity is set equal to this product divided by the new vertical distance value at the end of the iteration. Thus, angular momentum is conserved. As the ship coasts towards Earth, its horizontal velocity increases slightly, and would decrease slightly if the ship were receding. Quantities are then reinitialized and the next iteration begins.

When a firing sequence is completed, an important quantity Q is computed. It is the ratio of the net downward acceleration (gravitational minus centrifugal) to the total acceleration. The engines can currently deliver:

$$Q = \left(\frac{GM}{r_{iv}^2} - \frac{V_{avh}^2}{r_{iv}} \right) / a_r \quad (6)$$

Multiplied by 100, this is the critical throttle setting which will cause the ship to hover if stationary, or move vertically at a constant speed without accelerating. It is also the sine of the critical angle of ascent at which the vertical component of thrust equals the current weight of the ship. The angle, equal to the inverse sine of Q is alternatively computed from:

Listing 1 continued:

```

1690 IF H < 100.0 THEN 1760
1700 IF H0 < 100.0 THEN 1760
1710 D0 = D0 + 1
1720 IF D0 > 1 THEN 1760
1730 PRINT "IN DESIRED ORBIT. TO CONTINUE ENTER 1, TO PLOT ENTER 2. "
1740 INPUT H5
1750 IF H5 = 2 THEN 1920
1760 IF C3 = 0.0 THEN 660
1770 IF D7 <= E3 THEN 1800
1780 IF A(D2) <= 0.0 THEN 1800
1790 GO TO 660
1800 IF A(D2) = 0.0 THEN 1890
1810 IF D < A5 THEN 580
1820 D1 = D1 + 1
1830 IF D1 <> 1 THEN 1850
1840 PRINT "LAST STAGE SHUTDOWN."
1850 IF D0 <> 0.0 THEN 1880
1860 IF A(D2) <= 0.0 THEN 1880
1870 GO TO 660
1880 IF A(D2) > 0.0 THEN 1920
1890 H6 = INT( SQR( F6**2 + F8**2 ) + .5)
1900 H7 = INT( SQR( F7**2 + F9**2 ) + .5)
1910 PRINT "YOU CRASHED AT ";H6;" FT/SEC. ";H7;" MI/HR. "
1920 PRINT "AFTER ";D2;" PLOT POINTS: "
1930 FOR H8 = 1 TO D2
1940 REM-PLOT A(H8) Y-AXIS, VS. A0(H8) X-AXIS, ALTITUDE VS. RANGE.
1950 NEXT H8
1960 H9 = 25.0
1970 REM-LOWER 25% CUTOFF OF ALTITUDE FOR A BLOWUP PLOT.
1980 I = C9 * H9 / 100.0 * 1.0001
1990 I0 = D2 + 1
2000 I0 = I0 - 1
2010 IF A(I0) > I THEN 2000
2020 I1 = 100.0 * A0(I0) / A0(D2)
2030 PRINT "LOWER ";H9;"% OR ";I;" MI. OF MAX ALT. ATTAINED."
2040 PRINT "FIRST ";I1;"% OR ";A0(I0);" MI. OF TOTAL RANGE."
2050 PRINT "WITH ";I0;" STEPS:"
2060 FOR I2 = 1 TO I0
2070 REM-PLOT A(I2) Y-AXIS, VS. A0(I2) X-AXIS, LOWER ALT. VS. RANGE."
2080 NEXT I2
2090 END

```

$$\text{angle} = \tan^{-1}(Q/\sqrt{1.0 - Q^2})$$

At this time, distance and velocity values are converted from metric to English units for display purposes.

The first information printed consists of the elapsed flight time, the current ship angle, and the fuel left, both as a percentage of the original amount, and the number of seconds left at full throttle. Next, the program prints the altitude in miles and feet, the ascent rate and forward velocity in miles per hour and feet per second, and the number of miles down range.

The next printed information consists of the critical angle and throttle values of constant ascent, the maximum acceleration the engines can deliver, and the maximum vertical acceleration against gravity in both miles per hour per second and feet per second². For example, if the engine can deliver about 40ft/s² the

ship can accelerate at 8ft/s² against gravity.

Next the percentages of the orbital velocity and altitude are presented. The final items displayed are the time to achieve orbital altitude at the current ascent rate, and the time to achieve orbital velocity at the current full throttle rate of horizontal acceleration.

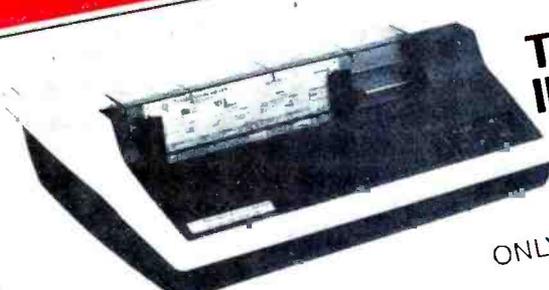
At this point the user is ready for the next move, and must again specify a new throttle setting, firing angle, and burn time. Finally, at the end of the mission (either when you achieve orbit, or run out of fuel), you can plot a picture of your trajectory, altitude versus range, and an expanded plot of the start of your mission, the lower 25 percent of your total attained altitude.

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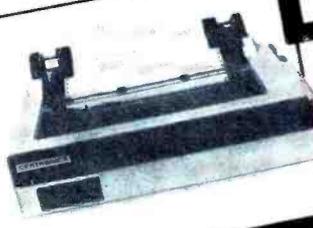


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Listing 2: A program, Roster, which reads data from a disk file concerning composition of a given baseball team and displays it on the terminal for inspection by the user. Figure 2 shows an example of its use.

```

10 DIMB(6),N$(10)
12 N$=""
15 INPUT"TEAM FILE ? ",F$
17 ""
20 OPEN#0,F$
25 !"ID ",
30 !"HITTERS      BATS HITS  2B  3B  HR  BB  KO"
40 FORA=0TO16
50 READ#0,N$FORB=0TO6\READ#0,B(B)\NEXT
55 !%21,A," ",
60 !N$,TAB(16),B(0),
65 !%5F3,B(1),B(2),B(3),B(4),B(5),B(6)
70 NEXT
75 !" \!" "\!ID ",
80 !"PITCHERS     R-L HITS  BB  KO"
90 FORA=0TO9
100 READ#0,N$,B(0),B(1),B(2),B(3)
105!%21,A," ",
110 !N$,TAB(16),B(0),
120 !%5F3,B(1),B(2),B(3)
130 NEXT\END

```

TEAM FILE ? 75-BOSTON

ID	HITTERS	BATS	HITS	2B	3B	HR	BB	KO
0	YASTREMSKI	1	.232	.205	.212	.308	.370	.169
1	DOYLE	1	.276	.219	.240	.281	.340	.051
2	BURLESON	0	.234	.171	.178	.219	.306	.101
3	PETROCELLI	0	.217	.156	.167	.240	.309	.199
4	EVANS	0	.246	.212	.265	.381	.349	.201
5	LYNN	1	.297	.269	.309	.429	.402	.255
6	RICE	0	.290	.167	.190	.316	.350	.313
7	FISK	0	.300	.161	.207	.322	.393	.182
8	COOPER	1	.293	.179	.242	.389	.352	.157
9	CARBO	1	.204	.256	.293	.476	.410	.291
10	GRIGGIN	0	.226	.087	.087	.101	.285	.133
11	BENIQUEZ	0	.262	.192	.247	.274	.351	.144
12	MILLER	1	.163	.095	.143	.143	.326	.230
13	HEISE	0	.208	.111	.111	.111	.238	.061
14	MONTGOMERY	0	.221	.227	.250	.295	.241	.245
15	BLACKWELL	2	.172	.115	.192	.192	.298	.123
16	CONEGLIARO	0	.108	.143	.143	.429	.231	.180

ID	PITCHERS	R-L	HITS	BB	KO
0	WISE	0	.253	.323	.156
1	TIANT	0	.250	.318	.135
2	LEE	1	.259	.324	.074
3	MORET	1	.218	.343	.132
4	CLEVELAND	0	.249	.324	.112
5	WILLOUGHREL	0	.237	.320	.149
6	FOLE	0	.267	.351	.110
7	DRAGO	0	.229	.333	.143
8	SEGUI	0	.230	.369	.146
9	BURTON	1	.260	.346	.175

Figure 2: Execution of the program Roster of listing 2. The file name is the same as that used for program Input.

everything is all right. Any other input allows for the reentry of the data.

Figure 1 omits the other sixteen entries and shows the first of ten pitcher entries. Here, the player's name Wise is entered along with his throwing arm designation of 0 (0=right, 1=left), innings pitched (255), hits (262), bases on balls (72), and strikeouts (67).

The next step is to see what information was entered and how the computer translates this data. In order to accomplish this program Roster (listing 2) is run. Figure 2 shows that the execution of this program asks for a file name, and 75-BOSTON is entered to correspond to the information just fed into the computer. The computer assigned identification numbers to the seven-

teen nonpitchers and ten pitchers, and translated all of the historical statistics into percentages.

That was a lot of data entry. Since I would not want to redo the entire input job again to change one player, program Fix (listing 3) was written; its execution is shown in figure 3. All that must be done to change an entry is to enter a file name and a hitter's identification number (from 0 thru 16), or a number greater than 16 as the identification number to change a

pitcher. Once the pitcher correction section is entered, an identification number greater than 9 ends the program execution.

Hypothetical Matchup

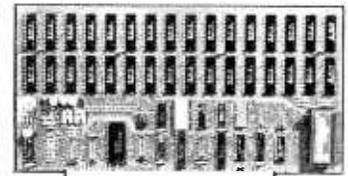
With this data I am ready to play a fictitious World Series between the 1961 New York Yankees (led by Roger Maris, who hit 61 home runs that year, along with Mickey Mantle and Whitey Ford) and the 1963 Los Angeles Dodgers (who beat the 1963

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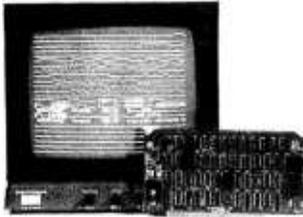
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Listing 3: A program, Fix, which allows the user to selectively correct data for a single player that has been stored on the disk by the Input program.

```

10 DIM B(7), N$(10)
12 J$="-----"
15 INPUT "TEAM FILE ? ", F$
20 OPEN #0, F$
90 "HITTERS"
100 INPUT "# ? ", A; IF A > 15 THEN 190 \ A = A * 47
110 INPUT "NAME ? ", N$
120 "BATS, AB, H, D, T, HR, BB, KO"
130 INPUT 1 " ? ", B(7), C, B(1), B(2), B(3), B(4), B(5), B(6)
132 IFC = 0 THEN C = 1
135 INPUT " OK ? ", Z$; IF Z$ <> " " THEN 110
137 B(7) = B(1) \ H = C - B(1)
140 C = C + B(5) \ B(1) = B(1) / C
142 FOR F = 2 TO 4 \ B(F) = B(F) / B(7) \ IFF = 2 THEN 146
144 B(F) = B(F) * B(F - 1)
146 NEXT \ B(5) = (B(7) + B(5)) / C \ B(6) = B(6) / H
155 N$ = N$ + J$
160 WRITE #0, A, N$, B(7), B(1), B(2), B(3), B(4), B(5), B(6), NOENDMARK
170 GOTO 100
190 "PITCHERS"
200 INPUT "# ? ", A; IF A > 9 THEN 310 \ A = 7 * 9 + (A * 32)
210 INPUT "NAME ? ", N$
220 "THROWS, IP, H, BB, KO"
230 INPUT 1 " ? ", B(0), C, B(1), B(2), B(3)
232 IFC = 0 THEN C = 1
235 INPUT " OK ? ", Z$; IF Z$ <> " " THEN 210
237 I = C * 2.75
240 C = (C * 2.75) + B(1) * B(2)
250 B(1) = B(1) / C
260 B(2) = (B(2) / C) + B(1)
270 B(3) = B(3) / C
275 N$ = N$ + J$
280 WRITE #0, A, N$, B(0), B(1), B(2), B(3), NOENDMARK
300 GOTO 200
310 CLOSE #0 \ END
    
```

```

TEAM FILE ? 75-BOSTO
HITTERS
# ? 0
NAME ? YASTREMSKI
BATS, AB, H, D, T, HR, BB, KO
? 1,543,146,30,1,14,87,67 OK ?
# ? 99
PITCHERS
# ? 0
NAME ? WISE
THROWS, IP, H, BB, KO ? 0,255,262,72,141 OK ?
# ? 99
    
```

Figure 3: Sample execution of the program Fix of listing 3. This program allows selective correction of the input data.

Yankees in four straight games in the 1963 World Series on the strong pitching of Sandy Koufax and Don Drysdale). To play this hypothetical series, all that is necessary is to load the program called Game and enter the file names 61-YANKS and 63-LA (assuming these files have been created in the manner just described).

Simulation of the first five games of this hypothetical World Series obtains the following results:

- Game 1: Dodgers 6, Yankees 2.
- Game 2: Yankees 3, Dodgers 1.
- Game 3: Dodgers 6, Yankees 3.
- Game 4: Yankees 11, Dodgers 4.
- Game 5: Yankees 2, Dodgers 1.

Detailed Play of Game 6

The series now stands with the Yankees having won 3 and the Dodgers 2 games. A win by the Yankees ends the series, so I will show the details of the sixth game. Program Game is loaded and executed as shown in figure 4. The computer asks for a random number; 41 is input. Next, the file name of the visiting team is entered, followed by that of the home team. It is now time to enter the Dodger batting order.

This is done by entering the identification number (taken from the computer roster, a sample was shown in figure 2) and position number of

Text continued on page 122

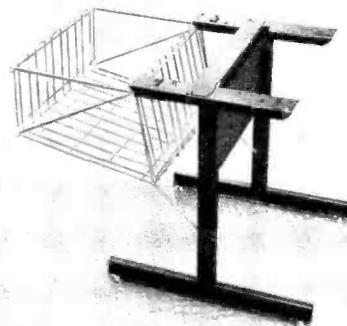


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Figure 4: Predicted play of a hypothetical baseball game between the 1961 New York Yankees and the 1963 Los Angeles Dodgers, using the Game program described in this article. The entry for NUM? is a seed for generating random numbers; the entries for the TEAM? inquiries are file names to reference data stored on disk by the Input program. The user enters the batting order and pitching staffs, and play of the game proceeds according to statistical probabilities.

```

NUM? 41
TEAM ? 63-LA
TEAM ? 61-YANKS
GIVE THE LINE-UP
BATTING 1 ID, FOS # ?2,6
BATTING 2 ID, FOS # ?1,4
BATTING 3 ID, FOS # ?5,8
BATTING 4 ID, FOS # ?6,7
BATTING 5 ID, FOS # ?4,3
BATTING 6 ID, FOS # ?3,5
BATTING 7 ID, FOS # ?7,2
BATTING 8 ID, FOS # ?0,9
BATTING 9 ID, FOS # ?10,10
ID# OF PITCHER ? 3
GIVE THE LINE-UP
BATTING 1 ID, FOS # ?15,1
ID, FOS # ?1,4
BATTING 2 ID, FOS # ?2,6
BATTING 3 ID, FOS # ?4,9
BATTING 4 ID, FOS # ?5,8
BATTING 5 ID, FOS # ?7,2
BATTING 6 ID, FOS # ?0,3
BATTING 7 ID, FOS # ?10,7
BATTING 8 ID, FOS # ?8,10
BATTING 9 ID, FOS # ?3,5
ID# OF PITCHER ? 6

WILLS----- SS OK ?
GILLIAM---- 2B OK ?
DAVIS W--- CF OK ?
DAVIS T--- LF OK ?
HOWARD---- 1B OK ?
MCMULLEN-- 3B OK ?
ROSEBRO-- C OK ?
FAIRLY---- RF OK ?
OLIVER---- DH OK ?
FOODRES--- OK ?

GONDER---- P OK ? NO
RICHARDSON 2B OK ?
KUBEK----- 1SS OK ?
MARIS----- RF OK ?
MANTLE---- CF OK ?
HOWARD---- C OK ?
SKOWRON---- 1B OK ?
CERV----- LF OK ?
LOPEZ----- DH OK ?
BOYER----- 3B OK ?
DALEY----- OK ?

INNING # 1
WILLS----- IS OUT
GILLIAM---- SINGLE
RUNNER ON FIRST
DAVIS W--- DOUBLE PLAY

RICHARDSON SINGLE
RUNNER ON FIRST
KUBEK----- SINGLE
RUNNER ON FIRST RUNNER ON THIRD
MARIS----- IS OUT
1 RUNS SCORE 63-LA 0 61-YANKS 1
RUNNER ON SECOND
P,H, OR B ?
MANTLE---- H. R.
2 RUNS SCORE 63-LA 0 61-YANKS 3
P,H, OR B ? P
F# ? 9
HOWARD---- IS OUT
SKOWRON---- SINGLE
RUNNER ON FIRST
CERV----- STRIKES OUT

INNING # 2
DAVIS T--- STRIKES OUT
HOWARD---- H. R.
1 RUNS SCORE 63-LA 1 61-YANKS 3
P,H, OR B ?
MCMULLEN-- STRIKES OUT
ROSEBRO-- IS OUT

LOPEZ----- SINGLE
RUNNER ON FIRST
BOYER----- IS OUT
RUNNER ON SECOND
RICHARDSON IS OUT
KUBEK----- WALK
RUNNER ON FIRST RUNNER ON SECOND
MARIS----- IS OUT

INNING # 3
FAIRLY---- IS OUT
OLIVER---- IS OUT
WILLS----- IS OUT

MANTLE---- SINGLE
RUNNER ON FIRST
HOWARD---- SINGLE
    
```

Figure 4 continued on page 120



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Figure 4 continued:

```

RUNNER ON FIRST  RUNNER ON THIRD
SKOWRON---- DOUBLE PLAY
  1 RUNS SCORE  63-LA      1  61-YANKS  4
P,H, OR B ?
CERV----- SINGLE
RUNNER ON FIRST
LOPEZ----- SINGLE
RUNNER ON FIRST  RUNNER ON SECOND
BOYER----- STRIKES OUT
    
```

```

INNING # 4
GILLIAM---- SINGLE
RUNNER ON FIRST
DAVIS W---- IS OUT
DAVIS T---- SINGLE
RUNNER ON FIRST  RUNNER ON SECOND
HOWARD----- STRIKES OUT
MCMULLEN--- IS OUT
    
```

```

RICHARDSON WALK
RUNNER ON FIRST
KUBEK----- DOUBLE
RUNNER ON SECOND  RUNNER ON THIRD
MARIS----- IS OUT
MANTLE----- H. R.
  2 RUNS SCORE  63-LA      1  61-YANKS  6
P,H, OR B ? P
P ? 220
  2
    
```

```

HOWARD----- SINGLE
RUNNER ON FIRST
SKOWRON--- IS OUT
RUNNER ON SECOND
CERV----- IS OUT
    
```

```

INNING # 5
ROSEBORO-- STRIKES OUT
FAIRLY---- IS OUT
OLIVER---- WALK
RUNNER ON FIRST
WILLS---- WALK
RUNNER ON FIRST  RUNNER ON SECOND
GILLIAM---- SINGLE
  1 RUNS SCORE  63-LA      2  61-YANKS  6
RUNNER ON FIRST  RUNNER ON THIRD
P,H, OR B ?
DAVIS W---- IS OUT
    
```

```

LOPEZ----- IS OUT
BOYER----- WALK
RUNNER ON FIRST
RICHARDSON DOUBLE PLAY
    
```

```

INNING # 6
DAVIS T---- IS OUT
HOWARD----- STRIKES OUT
MCMULLEN--- IS OUT
    
```

```

KUBEK----- SINGLE
RUNNER ON FIRST
MARIS----- SINGLE
RUNNER ON FIRST  RUNNER ON THIRD
MANTLE----- DOUBLE PLAY
  1 RUNS SCORE  63-LA      2  61-YANKS  7
P,H, OR B ?
HOWARD----- IS OUT
    
```

```

INNING # 7
ROSEBORO-- IS OUT
FAIRLY---- IS OUT
OLIVER---- SINGLE
RUNNER ON FIRST
WILLS---- SINGLE
RUNNER ON FIRST  RUNNER ON SECOND
GILLIAM---- IS OUT
    
```

```

SKOWRON--- SINGLE
RUNNER ON FIRST
CERV----- IS OUT
LOPEZ----- IS OUT
BOYER----- IS OUT
    
```

Figure 4 continued on page 122

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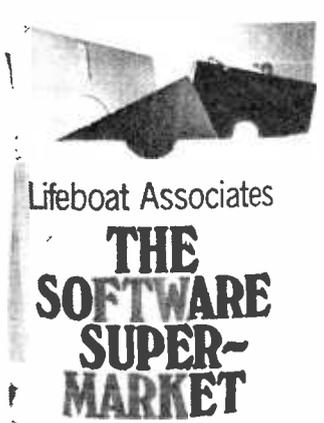
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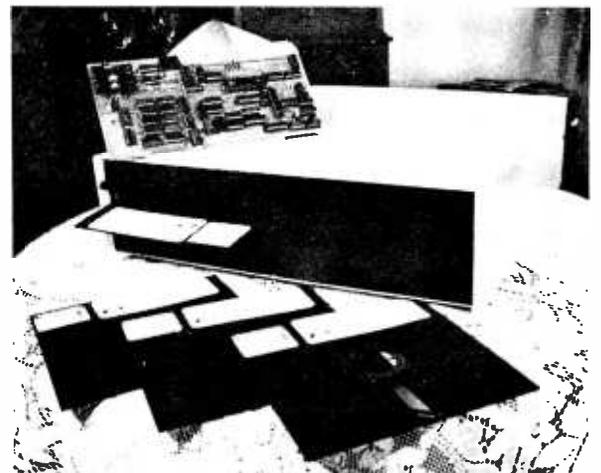
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BOX SCORE

63-LA						61-YANKS					
NAME	POS	AB	H	HR	RBI	NAME	POS	AB	H	HR	RBI
WILLS-----	SS	3	1	0	0	RICHARDSON	2B	4	1	0	0
GILLIAM----	2B	4	3	0	1	KUBEK-----	SS	4	3	0	0
DAVIS W----	CF	4	0	0	0	MARIS-----	RF	5	2	1	2
DAVIS T----	LF	4	1	0	0	MANTLE-----	CF	5	4	2	5
HOWARD-----	1B	4	2	2	2	HOWARD-----	C	5	2	0	0
MCMULLEN---	3B	3	0	0	0	SKOWRON----	1B	4	2	0	1
ZIMMER-----	3B	1	0	0	0	CERV-----	LF	4	1	0	0
ROSEBORO---	C	4	0	0	0	LOPEZ-----	DH	4	2	0	0
FAIRLY-----	RF	4	0	0	0	BOYER-----	3B	3	0	0	0
OLIVEK-----	DH	3	1	0	0						

PITCHERS		IP	H	R	ER	K	BB
PERRANOSKI	4.7	6	2	1	0	1	
PODRES-----	.3	3	3	3	0	0	LOSSER
SHERFY-----	3.0	8	3	3	2	2	
DALEY-----	7.7	8	3	2	5	2	WINNER
DUREN-----	1.3	0	0	0	0	0	

	1	2	3	4	5	6	7	8	9	-	T
VISITORS	0	1	0	0	1	0	0	1	0	0	3
HOME	3	0	1	2	0	1	0	1	0	0	8

8324
READY

Figure 5: Box score from the game played in figure 4.

this reason, a pinch hitter and a new pitcher are entered in order to illustrate all of the possible input situations occurring in this simulation.

In answer to the question "P, H or

B" in the Dodgers' half of the eighth inning, a B is input. A pitcher's identification number is solicited and 9 is entered, corresponding to Yankee Ryne Duren. Next, the computer asks

for the batting (Dodgers) team's substitutes with the question "Bats, P#". Here it is necessary to input what place in the nine batting positions (1 thru 9) the substitute will bat in and the player's identification number. The numbers 6 and 13 are typed in. Six is the sixth batting position; 13 represents Don Zimmer's identification number.

The "Bats, P#" question is again asked, and the user can continue to make substitutes or you can enter a 0 for the batting position in order to end the substituting. In the example, 0,0 is input and the game continues.

The Yankees go on to win the sixth game 8 to 3 and the series 4 games to 2 games. Figure 5 shows the box score for the final game of the series. Typing a carriage return ends the game at this point; typing any other character plays another game between the same two teams.

If the option to play another contest is selected, the computer asks "Line-ups OK"; and typing a carriage return lets the programmer play another game just by entering the identification numbers of two new

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- 03 = *ENTER PURCHASES
- 04 = *ENTER A/C RECEIVABLES
- 05 = *ENTER A/C PAYABLES
- 06 = ENTER/UPDATE INVENTORY
- 07 = ENTER/UPDATE ORDERS
- 08 = ENTER/UPDATE BANKS
- 09 = EXAMINE/MONITOR SALES LEDGER
- 10 = EXAMINE/MONITOR PURCHASE LEDGER
- 11 = EXAMINE/PRINT INCOMPLETE RECORDS
- 12 = EXAMINE PRODUCT SALES

SELECT FUNCTION BY NUMBER—

- 13 = PRINT CUSTOMER STATEMENT
- 14 = PRINT SUPPLIER STATEMENTS
- 15 = PRINT AGENT STATEMENTS
- 16 = PRINT TAX STATEMENTS
- 17 = PRINT WEEK/MONTH SALES
- 18 = PRINT WEEK/MONTH PURCHASES
- 19 = PRINT YEAR AUDIT
- 20 = PRINT PROFIT/LOSS ACCOUNT
- 21 = UPDATE END MONTH FILES
- 22 = PRINT CASH FLOW FORECAST
- 23 = ENTER/UPDATE PAYROLL (NOT YET AVAILABLE)
- 24 = RETURN TO BASIC

WHICH ONE? (ENTER 1-24) Each program goes to sub menu, e.g.: (9) allows A. LIST ALL SALES; B. MONITOR SALES BY STOCK CODES; C. RETRIEVE INVOICE DETAILS; D. AMEND LEDGER FILES; E. LIST TOTAL ALL SALES.

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Circle 331 on inquiry card.

BYTE November 1979 125

pitchers. If anything other than a carriage return is entered, the computer branches to the lineup entry section of the program and the user will be required to enter new lineups.

You can keep track of batting averages, earned run averages, and other statistics by loading the program Stats (listing 4) and entering the appropriate file name. This will give you a complete printout of all the statistics as shown in figure 6. The statistics shown are for all six games of the "World Series" that was just played.

The statistics keep accumulating each time the program is run. Therefore, I have provided program Erase (shown in listing 5). Figure 7 shows this program being used; the user merely supplies the file name. This program erases statistics extracted only from the games played, not the ratings information shown on the roster (figure 2) for each player. That

Listing 4: *The Stats program, which computes and displays statistics from box scores of simulated baseball games. An example of its use is shown in figure 6.*

```

1 DIMM$(270)
5 LINE 80
10 INPUT "FILE NAME ? ",F$;OPEN#0,F#
12 FORA=0TO16\N=(A*10)+1\READ#0,N$(N,N+9),Z,Z,Z,Z,Z,Z,Z\NEXT
14 FORA=0TO9\N=170+(A*10)+1\READ#0,N$(N,N+9),Z,Z,Z,Z\NEXT
20 "NAME AB H HR RBI AVE NAME IP H R ER KO BB W L ERA"
30 " KO BB W L ERA\FORA=1TO79\I=",\NEXT\I""
40 FORA=0TO16\B=1119+(A*20)\READ#0,Z,C,D,E,F\G#0
50 IFC>0THENG=D/C\T1=1+D\T2=T2+D\T3=T3+E\T4=T4+F
60 N=(A*10)+1\N$(N,N+9),Z4I,C,D,Z3I,E,Z4I,F,Z5F3,G," ",
70 IFA>9THEN90\B=14594(A*35)\N=171+(A*10)
72 READ#0ZB,C,D,E,F,G,H,I\J=INT(I/100)\K=I-(100*J)
74 F1=F1+C\F2=F2+D\F3=F3+E\F4=F4+F\F5=F5+G\F6=F6+H\F7=F7+I\F8=F8+K
76 F9=0\IFC=0THENE9=(F*27)/C\C=INT(C/3)
78 "N$(N,N+9),Z4I,C,D,E,F,G,H,Z3I,J,K,Z6F2,E9,
90 "!\NEXT
100 FORA=1TO79\I=",\NEXT\I""
110 IF I1:9THENTS=T2/I\IF I1>0THENF9=(F4*27)/F1\F1=INT(F1/3)
120 " ",Z4I,T1,T2,Z3I,T3,Z4I,T4,Z5F3,I5,
130 " ",Z4I,F1,F2,F3,F4,F5,F6,Z3I,F7,F8,Z6F2,F9

```

is how I run my complete computerized baseball simulation.

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What do you need to run these programs? An 8080-based micropro-

cessor system that can be linked to a North Star floppy-disk system, a North Star disk-operating system including BASIC, 24 K bytes of memory, and a terminal. The memory requirement is large because of the size

6a FILE NAME ? 61-YANKS															
NAME	AB	H	HR	RBI	AVE	NAME	IP	H	R	ER	KO	BB	W	L	ERA
SKOWRON---	20	4	0	1	.200	FORD-----	8	12	10	3	5	7	0	1	3.12
RICHARDSON	24	4	0	2	.167	TERRY-----	13	9	2	1	8	6	2	0	.68
KUBEK-----	23	7	0	0	.304	ARROYO-----	8	3	0	0	5	3	0	0	.00
BOYER-----	19	3	0	0	.158	STAFFORD-----	0	0	0	0	0	0	0	0	.00
MARIS-----	23	9	4	8	.391	COATES-----	0	0	0	0	0	0	0	0	.00
MANTLE-----	23	6	2	5	.261	SHELDON-----	0	0	0	0	0	0	0	0	.00
BERRA-----	7	0	0	0	.000	DALEY-----	11	14	7	5	8	3	1	0	3.86
HOWARD-----	23	8	2	5	.348	TURLEY-----	0	0	0	0	0	0	0	0	.00
LOPEZ-----	16	5	0	4	.313	RENIFF-----	4	6	2	2	0	2	1	0	4.15
BLANCHARD---	7	3	0	1	.429	DUREN-----	6	6	3	2	5	0	0	1	2.84
CERV-----	16	8	2	3	.500										
GARDNER---	0	0	0	0	.000										
DEMASTRI---	0	0	0	0	.000										
REED-----	0	0	0	0	.000										
TORGESSON---	0	0	0	0	.000										
GONIER-----	0	0	0	0	.000										
JOHNSON---	0	0	0	0	.000										

	201	57	10	29	.284		53	50	24	13	31	21	4	2	2.21

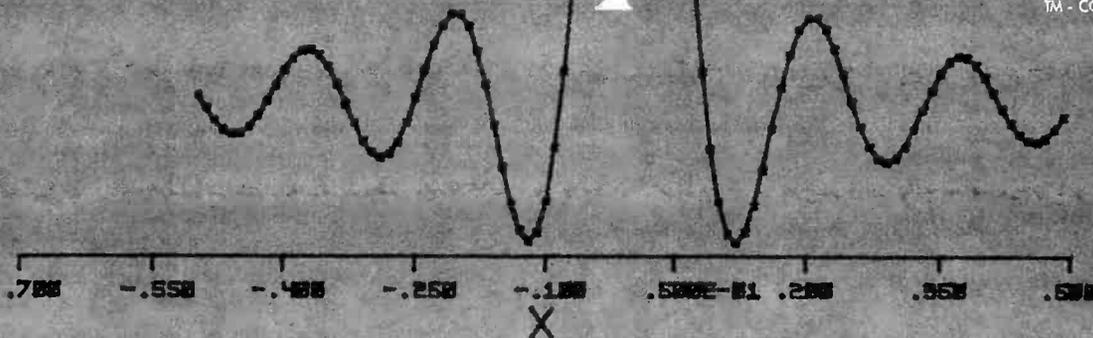
6b FILE NAME ? 63-LA															
NAME	AB	H	HR	RBI	AVE	NAME	IP	H	R	ER	KO	BB	W	L	ERA
FAIRLY-----	22	3	1	1	.136	KOUFAX-----	13	14	8	4	9	5	1	0	2.70
GILLIAM-----	24	12	1	4	.500	DRYSDALE---	17	13	5	4	8	5	0	2	2.12
WILLS-----	24	4	0	1	.167	FERRANOSKI---	9	8	2	1	0	5	1	0	1.00
MCMULLEN---	20	3	0	2	.150	PODRES-----	5	9	6	5	2	1	0	1	9.00
HOWARD-----	21	5	2	4	.238	MILLER-----	0	1	2	0	0	1	0	1	.00
DAVIS W-----	24	8	1	5	.333	RICHERT-----	0	0	0	0	0	0	0	0	.00
DAVIS T-----	25	6	0	4	.240	CALMUS-----	0	0	0	0	0	0	0	0	.00
ROSEBOKO---	21	1	0	0	.048	WILLHITE---	0	0	0	0	0	0	0	0	.00
MOON-----	6	3	0	0	.500	ROEBUCK-----	0	0	0	0	0	0	0	0	.00
TRACEWSKI---	0	0	0	0	.000	SHERRY-----	7	12	6	4	6	6	0	0	4.91
OLIVER-----	14	5	0	3	.357										
WALLS-----	0	0	0	0	.000										
CAMILLI---	0	0	0	0	.000										
ZIMMER---	1	0	0	0	.000										
FERRIA-----	0	0	0	0	.000										
BREEDING---	0	0	0	0	.000										
NEN-----	0	0	0	0	.000										

	202	50	5	24	.248		52	57	29	18	25	23	2	4	3.12

Figure 6: Statistics for six games of the "World Series" between the 1961 Yankees (6a) and the 1963 Dodgers (6b).

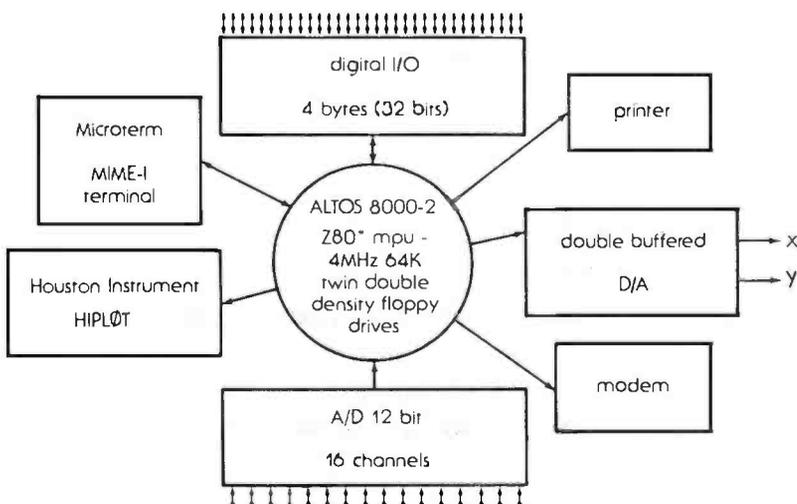
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Listing 6 continued:

```

973 H(G1,G2,G3+4)=H(G1,G2,G3+4)+H(G1,G2,G3)\H(G1,G2,G3)=0\NEXT\NEXT
974 FORG2=0T09\FORG3=4T010\F(G1,G2,G3+7)=F(G1,G2,G3+7)+F(G1,G2,G3)
976 F(G1,G2,G3)=0\NEXT\NEXT\NEXT\FORG1=0T010\W(G1)=0
978 S1(0,G1)=0\S1(1,G1)=0\NEXT\W9=0
990 INPUT RETURN TO END ? *,Z$IFZ$="" THEN 998
992 INPUT LINE-UPS OK ? *,Z$IFZ$<>"" THEN 67
994 !T$(1,10),\INPUT PITCHER ? *,W(2)
995 !T$(1,20),\INPUT PITCHER ? *,W(3)
996 GOTO 100
998 GOSUB 2000 !FREQ(0)\END
1000 !"BOX SCORE"\!""
1010 FORG=0T01\B=(G*10)+10\G1=40*G
1020 !TAB(G1),!$(F-9,B),\NEXT\!""
1022 !""\FORG=0T01\G1=40*G
1024 !TAB(G1),NAME POS AB H HR RBI",
1026 NEXT\!""\!""
1030 !ORF=0T08\FORG1=0T02
1050 G4=0\FORG3=0T01\IFS(G3,G,G1,1)=0 THEN 1080\G5=40*G3\G6=S(G3,G,G1,0)
1060 B=(270*G3)+(10*G6)+10\G4=1\G7=(S(G3,G,G1,1)*2)
1070 !TAB(G5),N$(B-9,B)," ",F$(G7-1,G7)," ",
1075 FORG8=7T010\Z4I,H(G3,G6,G8),\NEXT
1080 NEXT\IFG4=1 THEN !""\NEXTG1\NEXTG
1090 !""\!""\PITCHERS IF H R ER K BB"\!""
1110 FORG1=0T01\FORG2=0T09\IFF(G1,G2,4)>0 THEN 1130
1120 IFF(G1,G2,5)>0 THEN 1130\IFF(G1,G2,8)>0 THEN 1130\GOTO 1160
1130 G3=(G1*270)+170+(10*G2)+1\G4=F(G1,G2,4)/3
1140 !N$(G3,G3+9),Z5F1,G4,
1150 FORG4=5T09\Z3I,F(G1,G2,G4),\NEXT\IFF(G1,G2,10)=100 THEN !" WINNER",
1152 IFF(G1,G2,10)=1 THEN !" LOSER",\!""
1160 NEXT\NEXT\!""\!"" 1 2 3 4 5 6 7 8 9 - T"
1170 !"VISTORS",\FORG1=0T010\Z3I,S1(0,G1),\NEXT\!""
1180 !"HOME ",\FORG1=0T010\Z3I,S1(1,G1),\NEXT\RETURN
2000 FORG=0T01\B=(A*10)+1\OPEN#0,T$(B,H*9)\B=1114
2010 READ#0ZB,C\FORR=0T016\READ#0,H(A,B,7),H(A,B,8),H(A,B,9),H(A,B,10)
2020 FORC=11T014\H(A,B,C)=H(A,B,C)+H(A,B,C-4)\NEXT\NEXT
2030 FORR=0T09\READ#0,F(A,B,4),F(A,B,5),F(A,B,6),F(A,B,7),F(A,B,8)
2035 READ#0,F(A,B,9),F(A,B,10)
2040 FORC=11T017\F(A,B,C)=F(A,B,C)+F(A,B,C-7)\NEXT\NEXT
2050 B=1114\READ#0ZB,C\FORR=0T016
2060 WRITE#0,H(A,B,11),H(A,B,12),H(A,B,13),H(A,B,14)\NEXT
2070 FORR=0T09\WRITE#0,F(A,B,11),F(A,B,12),F(A,B,13),F(A,B,14)
2075 WRITE#0,F(A,B,15),F(A,B,16),F(A,B,17)\NEXT\CLOSE#0
2080 NEXT\RETURN
5900 K=G\IFRND(0)>.6 THEN K=K+1\GOTO 6000
5950 K=1\IFB(1)=0 THEN 6005\IFB(2)=0 THEN 5960\GOTO 6000
5960 B(2)=F+1\GOTO 6005
6000 FORG1 3T01STEP-1\B(G1+K) B(G1)\R(G1)=0\NEXT
6005 IFG 4 THEN B(8)=F+1\IFG<4 THEN B(6)=F+1\G4=0
6010 G2=0\FORG1=4T08\IFR(G1)=0 THEN 6040\G4=G4+1\W=B(G1)-1\B(G1)=0
6020 L=A-1\IFA>9 THEN L=9\S1(B,L)=S1(B,L)+1\W1(B,10)=S1(B,10)+1
6030 B(G1)=0\H(B,F,10)=H(B,F,10)+1\F(D,V,6)=F(D,V,6)+1
6040 NEXT\IFG4<1 THEN 6042\!G4," RUNS SCORE ",
6041 !T$(1,10),S1(0,10)," ",T$(11,20),S1(1,10)
6042 IFG4<2 THEN 6043\W(4+D)=W(4+D)+.025
6043 H=0
6048 IFB(1)=0 THEN 6050\!"RUNNER ON FIRST ",\M=1
6056 IFB(2)=0 THEN 6060\!"RUNNER ON SECOND ",\M=1
6060 IFB(3)=0 THEN 6070\!"RUNNER ON THIRD ",\M=1
6070 IFM=1 THEN !""\IFG4=0 THEN RETURN\GOSUB 6200\GOSUB 6100\RETURN
6100 INPUT F,H, OR B ? *,Z$IFZ$="" THEN RETURN\IFZ$="H" THEN 6150
6110 W(D+4)=0\INPUT F# ? *,Z$IFZ$>9 THEN 6110\W(2+D)=Z\F=Z
6120 IFZ$="F" THEN RETURN
6150 INPUT BATS, P# ? *,Z,Z1\Z=Z-1\IFZ' 8 THEN RETURN\IFZ<0 THEN RETURN
6160 FORG1=0T02\IFS(B,Z,G1,1)=0 THEN NEXT 6180
6170 NEXT\!"" TWO SUBS ALREADY USED THERE\GOTO 6150
6180 S(B,Z,G1,0)=Z1\INPUT POS ? *,Z1\IFZ1>10 THEN Z1=10
6190 S(B,Z,G1,1)=Z1\GOTO 6150
6200 !F#9=0 THEN 6220\IFB+1=W9 THEN RETURN
6210 IFS1(0,10)=S1(1,10) THEN 6230\IFS1(B,10)>S1(D,10) THEN 6220\RETURN
6220 W(B)=D\W(9)=W(2+D)\W(6)=B\W(7)=W(2+B)\W9=1+B\RETURN
6230 W9=0\RETURN
6950 K=1\IFR(1)=0 THEN 7005\IFR(2)=0 THEN 6960\GOTO 7000
6960 R(2)=F+1\GOTO 7005
7000 IFD>2 THEN RETURN\FORG1=3T01STEP-1\R(G1+K)=R(G1)\R(G1)=0\NEXT
7005 IFG=4 THEN R(8)=F+1\IFG<4 THEN R(6)=F+1
7010 FORG1=4T08\IFR(G1)=0 THEN 7040
7020 W=R(G1)-1
7030 R(G1)=0\F(D,V,7)=F(D,V,7)+1
7040 NEXT\RETURN

```

?			
*LI			
ERASE	4	4	2
ERASE2	8	4	2
INPUT	12	6	2
INPUT2	18	6	2
ROSTER	24	6	2
ROSTER2	30	6	2
GAME	36	22	2
GAME2	58	22	2
STATS	80	6	2
STATS2	86	6	2
61-YANKS	92	8	3
69-METS	100	8	3
75-BOSTO	108	8	3
63-LA	116	8	3
62-METS	124	8	3
FIX	132	6	2
FIX2	138	6	2
*			

Table 1: Directory of the disk files consisting of the baseball-simulation programs and data. Each team data file is eight blocks long on this North Star Computer floppy disk system.

determine if the batter gets a base on balls. Assuming that the batter makes an out, a strikeout possibility is determined in a similar manner with a new random number (.169 + .136 x 0.5 = .1525 is the Yastrzemski/Wise strikeout factor). If the batter is not a strikeout victim, another random number is generated to see if he hits into a double play, reaches base on an error, or advances the runners that might be on base.

Hits, Runs, and Errors

On the occasions when a batter gets a hit, a random number is compared first to his double rate, then his triple rate, and finally his home run rate (Yastrzemski has ratings of .205, .212, and .308 for these hits). [By a pleasant coincidence, this article was edited on the same day that Carl Yastrzemski hit his home run number hexadecimal 190...RSS]. If at any point in the comparisons the rate exceeds the random number, the comparison process ceases and the batter is awarded the type of hit currently being considered. If all comparisons fail, the hit is assumed to be a single-base hit. A new random number is generated to see if the possible base runners advance one base more than the hit is valued at (single = 1, double = 2, etc).

The variable array (with seven elements) is used to keep track of base

Text continued on page 134

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Line Numbers	Operation Performed
1 thru 20	a) Generate seed for random number b) dimension variables c) read descriptive data
30 thru 65	Read data from disk files
67 thru 94	Batting order input section
100	Set start and end inning
110 thru 990	Play game
992 thru 998	Select pitchers for new game
1000 thru 1180	Subroutine for printing box game
2000 thru 2080	Subroutine to write updated statistics to disk file
5900 thru 6070	Subroutine to determine run scored and position of base runners
6100 thru 6190	Subroutine for player substitutions
6200 thru 6230	Subroutine for determining winning and losing pitchers
6950 thru 7040	Subroutine for calculating earned runs

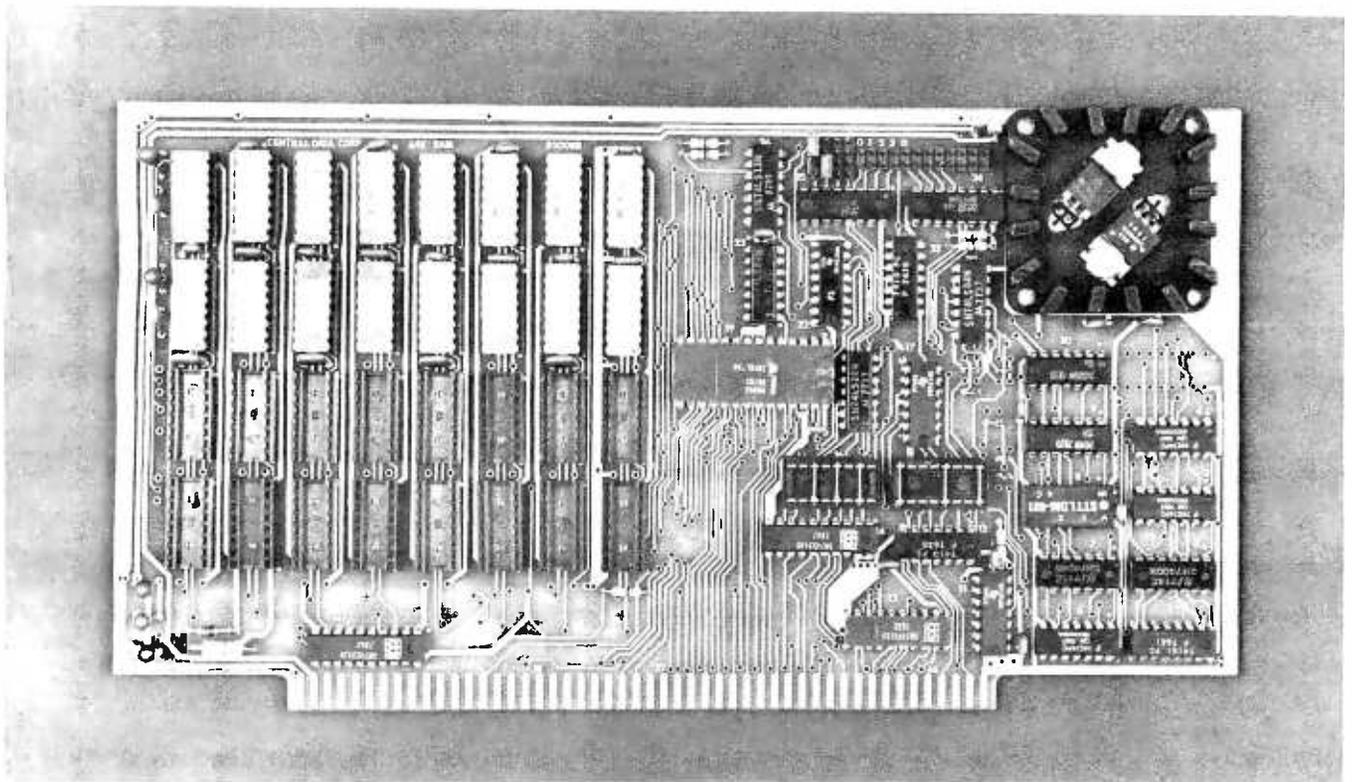
Table 2: Operations performed by various lines of BASIC code in the Game program of listing 6.

Variable and Dimensions	Use
S(1,8,2,1)	1 = Teams 8 = batting order 2 = up to three players in each batting position 1 = identification number and position
T\$(20)	Team names
P\$(20)	Position names
H(1,16,14)	1 = Teams 16 = seventeen players 14 = 0 to 6 = player ratings 7 to 10 = at bats, hits, home runs, and runs batted in for the game 11 to 14 = total at bats, hits, home runs, and runs batted in as read and written to disk
P(1,9,9)	1 = Teams 9 = ten pitchers 9 = 0 to 3 = player ratings 4 to 10 = innings pitched, hits, runs, earned runs, strikeouts, walks and win or loss for the game 11 to 17 = total innings pitched, hits, runs, earned runs, strikeouts, walks and wins or losses as read and written to disk
W(9)	0 who's up (visiting team) 1 who's up (home team) 2 visiting team's pitcher 3 home team's pitcher 4 visiting team pitcher's tiring factor 5 home team pitcher's tiring factor 6 leading team number (0 or 1) 7 identification number for leading pitcher 8 trailing team number 9 identification number for trailing pitcher
B(7)	1 runner on first 2 runner on second 4-3 runner on third 4-7 runs scored
R(7)	same as B(7), but tracks earned runs

Table 3: Use and size of array variables in the Game program of listing 6.

Yastrzemski Hits	= .232
Wise Hits	= .253
Pitcher tiring factor (assume 0)	= .000
Left handed batter versus right handed pitcher	= .015
	$.500 \times .5 = .250$

Table 4: Statistical determination of the probability of batter Yastrzemski producing a safe hit from a pitch thrown by Wise. The hits factors for pitcher and batter are added together, along with a factor for pitcher tiring and a factor for the relationship of a left-handed batter facing a right-handed pitcher. The sum of these factors is multiplied by 0.5 and then compared with a random number. If the random number is less than the computed probability, Yastrzemski has hit safely.



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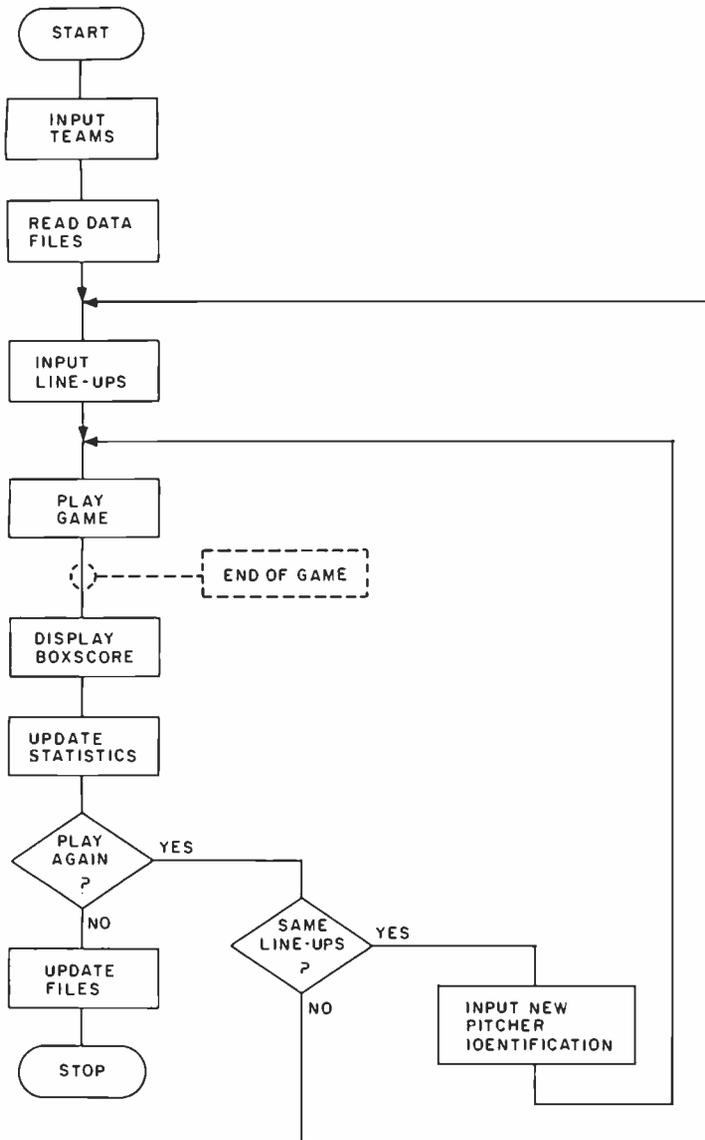


Figure 8: Flowchart of the major divisions of operation of the Game program of listing 6.

Text continued:

runners; all B values are set to 0 every half inning. If a batter gets a single that advances all runners by one base, variable B(4) is set to equal the value of B(3), B(3) is set to B(2), B(2) to B(1), and B(1) is set to a value of 1 plus the opposing pitcher's identification number. If a batter gets a single-base hit that moves runners two bases, B(5) is set to the value of B(3) and B(3) is set to 0, B(4) is set to the value of B(2) and B(2) to 0, B(3) to B(1) and B(1) to 0, and B(1) is set to a value of 1 plus the opposing pitcher's identification number. A similar process is used on outs that advance runners.

This procedure is done in the sub-

routine beginning with line 5900 in listing 6. The second half of this subroutine determines if any runs are scored by seeing how many of the B array elements with subscripts between 4 and 7 are not 0. Each positive number indicates one run. When I first wrote the program, the B array elements were set to either 0 or 1. However, by using the *pitcher's identification number plus 1*, all runs scored can be attributed to the record of the appropriate pitcher.

A similar tracking of runners and runs is recorded in the variable array R (with seven elements). This is needed to register *earned* runs only. All errors are assumed to be outs. Therefore, certain runners and advances

are ignored, and innings end earlier with this variable allowing for the proper calculation of earned runs.

A subroutine for calculating winning and losing pitchers (beginning with line 6200 in listing 6) is consulted after each run is scored. If the particular run scored breaks a tie (the game starts with the score 0 to 0), a new winning pitcher is recorded. If the run causes a tie, the current winning and losing pitchers are removed from their particular status.

As demonstrated in the sample, a substitution can be made only after a run is scored. This is due to the fact that the subroutine at line 6100 is currently consulted only at that point. If you desire the option of a substitution after every play, merely add the program line:

```
122 GOSUB 6100
```

and remove the current:

```
"GOSUB 6100"
```

from line 6070.

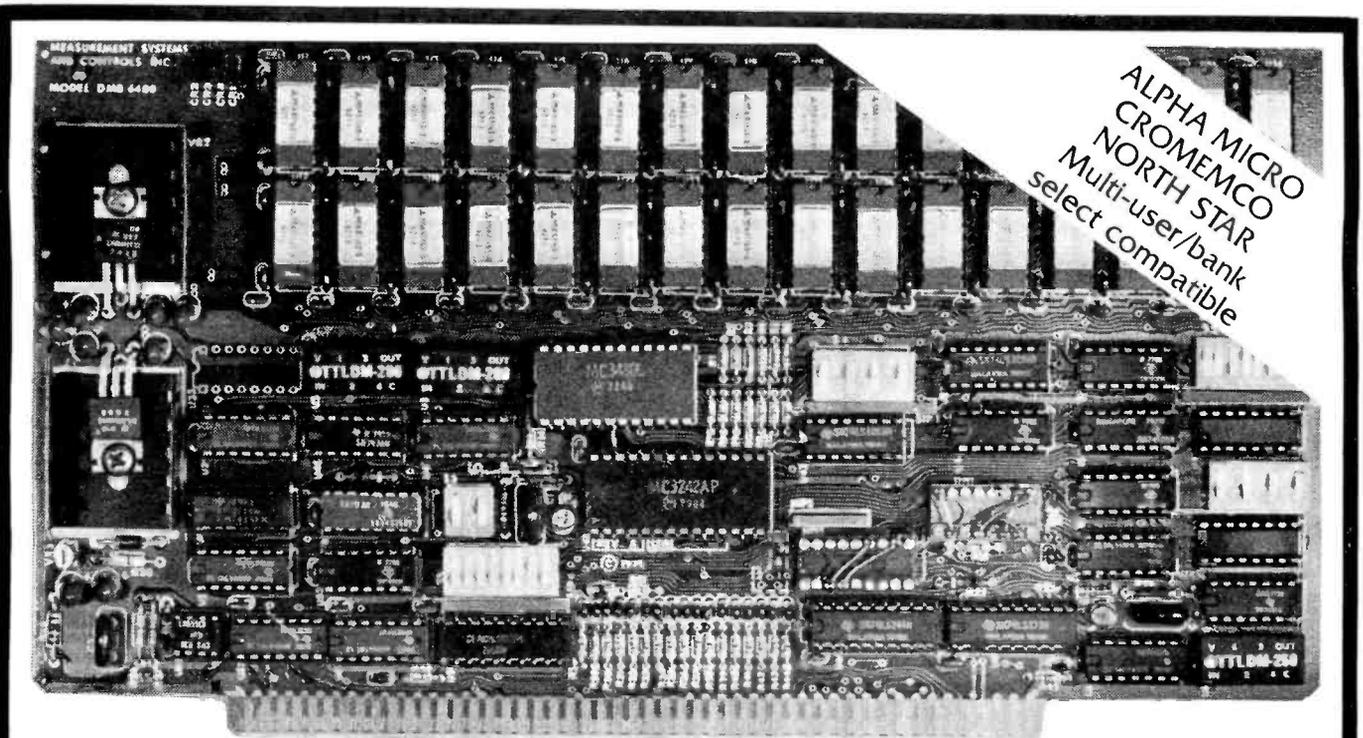
Program Testing

After you enter the Game program into your computer, a test routine will be necessary to check for possible errors made during the program's entry. Changes in line 990 and in line 6100 of listing 6 will permit the program to loop and play numerous games without requiring any input from the user after the lineups are assigned. The revised lines are:

```
990 C9=C9+1: IF C9=50
    THEN 998 : GOTO 100
6100 RETURN
```

These modifications make the program play fifty consecutive games (C9=50 determines the number of games) with the same lineups and without asking the user for any substitutions.

In order to test the program after I wrote it, I played the 1961 New York Yankees against the 1962 New York Mets for fifty games. The results were amazing. The Yankees (who won 109 of 162 real games for a winning percentage of 67% in 1961) won 35 of the 50 games in the simulation for a 70% winning average. The Mets (who won 40 of 160 games, or 25%,



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9a

FILE NAME ?	61-YANKS					NAME	IP	H	R	ER	KO	BB	W	L	ERA
NAME	AB	H	HR	RBI	AVE										
SNOWRON---	176	43	3	7	.244	FORD-----	476	471	228	202	291	251	39	11	3.82
RICHARDSON	233	68	4	27	.292	TERRY-----	0	0	0	0	0	0	0	0	.00
KUREK-----	220	70	6	32	.318	ARROYO----	0	0	0	0	0	0	0	0	.00
BOYER-----	193	48	0	15	.249	STAFFORD---	0	0	0	0	0	0	0	0	.00
MARIS-----	227	71	9	84	.313	COATES-----	0	0	0	0	0	0	0	0	.00
MANTLE-----	184	46	10	29	.359	SHELDON----	0	0	0	0	0	0	0	0	.00
BERRA-----	199	54	9	33	.271	DALEY-----	0	0	0	0	0	0	0	0	.00
HOWARD-----	204	90	25	67	.441	TURLEY-----	0	0	0	0	0	0	0	0	.00
LOPEZ-----	0	0	0	0	.000	RENTFF-----	0	0	0	0	0	0	0	0	.00
BLANCHARD--	194	45	18	38	.232	DUREN-----	0	0	0	0	0	0	0	0	.00
CERV-----	0	0	0	0	.000										
GARDNER----	0	0	0	0	.000										
DEMASTRI--	0	0	0	0	.000										
REED-----	0	0	0	0	.000										
TORGESSON--	0	0	0	0	.000										
GONDE R----	0	0	0	0	.000										
JOHNSON----	0	0	0	0	.000										

1830 555104 332 .303							476	471	228	202	291	251	39	11	3.82

9b

FILE NAME ?	62-METS					NAME	IP	H	R	ER	KO	BB	W	L	ERA
NAME	AB	H	HR	RBI	AVE										
THRONEBERR	0	0	0	0	.000	CRAIG ----	455	555	332	270	158	178	11	39	5.34
NEAL-----	228	48	3	11	.211	HOOK-----	0	0	0	0	0	0	0	0	.00
CHACON-----	170	49	0	14	.288	JACKSON---	0	0	0	0	0	0	0	0	.00
MANTILLA---	0	0	0	0	.000	MACKENZIE--	0	0	0	0	0	0	0	0	.00
ASHBURN----	207	58	4	24	.280	ANDERSON---	0	0	0	0	0	0	0	0	.00
HICKMAN----	195	51	5	29	.262	HILLER-----	0	0	0	0	0	0	0	0	.00
THOMAS-----	220	59	8	35	.268	CISCO-----	0	0	0	0	0	0	0	0	.00
CANNIZZARO	175	39	0	15	.223	DAVIAULT---	0	0	0	0	0	0	0	0	.00
KANEHL-----	0	0	0	0	.000	HUMTER-----	0	0	0	0	0	0	0	0	.00
CHRISTOPHE	192	34	4	23	.188	MILLER-----	0	0	0	0	0	0	0	0	.00
WOODLING---	0	0	0	0	.000										
TAYLOR-----	0	0	0	0	.000										
COLEMAN----	0	0	0	0	.000										
MORGES-----	205	59	27	59	.288										
BOUCHEE---	0	0	0	0	.000										
COOK-----	200	72	0	18	.360										
BELL-----	0	0	0	0	.000										

1792 471 51 228 .263							455	555	332	270	158	178	11	39	5.34

Figure 9: Individual player statistics derived from the simulated play of fifty baseball games between the 1961 New York Yankees (9a) and the 1962 New York Mets (9b). In this fifty-game series the pitcher-tiring factor was set to 0. In team results, the Yankees won 39 of 50 (78%) of the games, and the Mets won 11 of 50 (or 22%).

in 1962) won the other 15 games for a 30% winning average.

The numbers of hits and runs scored in this simulation were a little bit high, since the designated hitter was used (this did not occur in either 1961 or 1962) and the pitchers were never removed after tiring. Every time 2 runs are scored in an inning and for every scoring occasion in an inning after the 2 runs have been scored, the pitcher's hit rating is worsened by 0.025. This is done in line 6042 of the Game program.

A second test of fifty games was run. However, this test eliminated the tiring factor by changing the equation

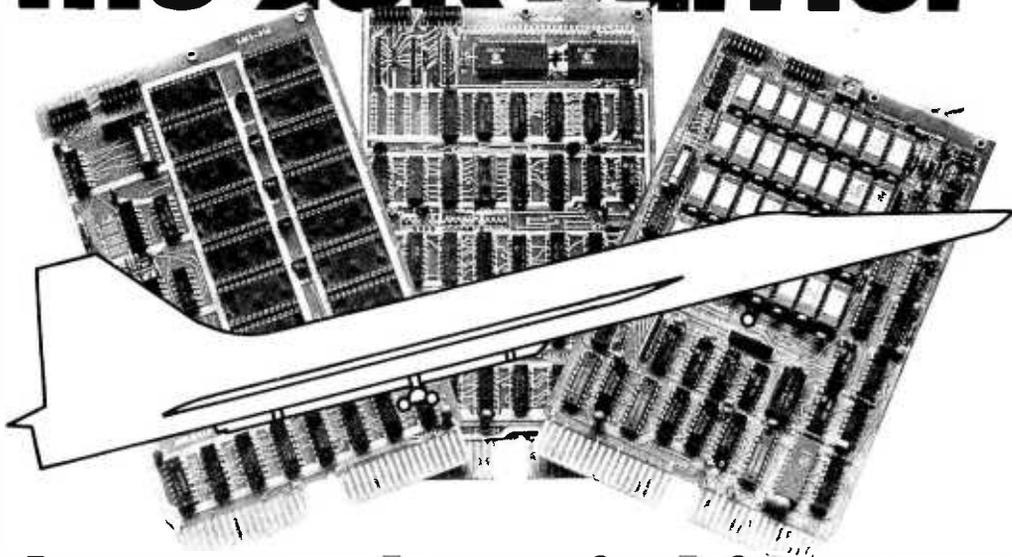
in line 6042. This line is branched to by other program statements; thus it could not be removed. Instead it became a nonfunctioning line: $W(D+4)=W(D+4)$. The program was again tested.

In the second test, the Yankees won 39 (or 78%) of the games, while the Mets won only 11 (or 22%). The individual statistics appeared reasonable and are shown in figure 9. The model was clearly performing accurately with the statistically better team winning the majority of the games. The program Game was modified back to its original form, and the World Series described at the

beginning of this article was run using the model.

Due to memory limitations, other enhancements were left out of this baseball-simulation model. For example, the display message for outs could be replaced by regular baseball scoring (6-3 meaning ground-out from shortstop to the first baseman), home run rates could be determined by the size of the field the simulation is assumed to be played in, and prepared lineups for each team could be stored on disk to facilitate play. If you modify these programs, please write to me. I would like to know the details. ■

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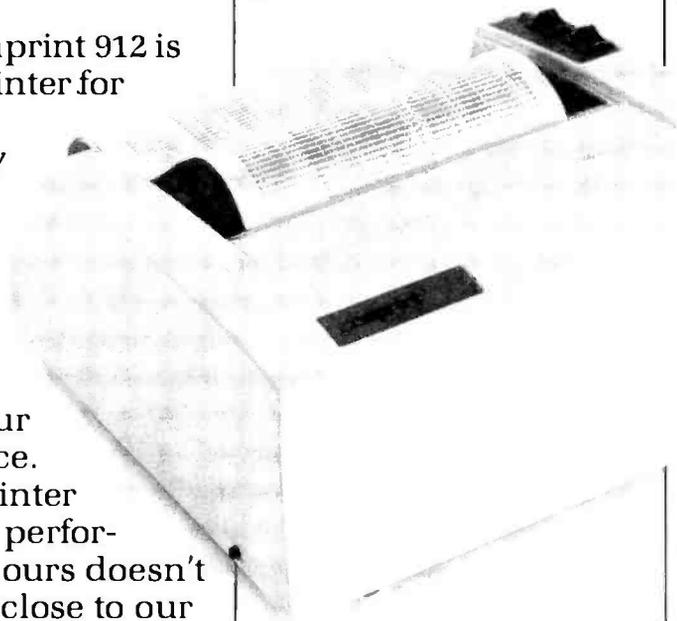
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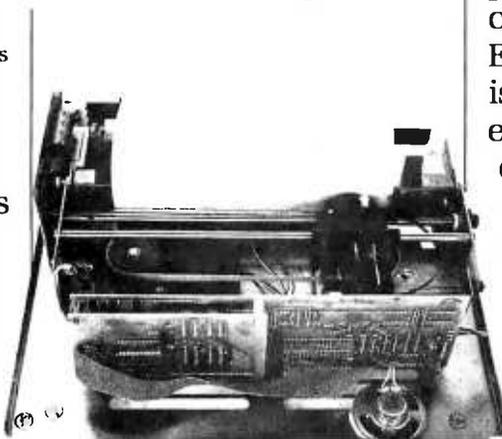


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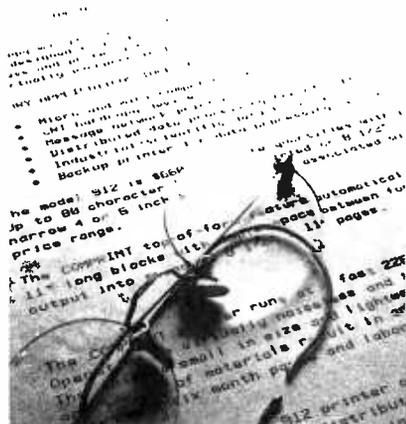
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Most microprocessors currently available employ a stack of some sort. This stack is either a scratch memory in the processor itself or an addressable programmable memory characterized by retrieval of information in the reverse order of storage using a pointer. In the common parlance, a stack is a LIFO (last in first out) mechanism. It is a very useful feature for preserving the proper

order of subroutine call and return points with minimal hassle. Experienced programmers using 8080 type machines quickly discover its other uses; for example, a direct register store instruction is three bytes long on the 8080, whereas a register stack instruction is only one byte. As a result, saving registers used by subroutines and restoring them later is cheaper if the stack is used in preference to some directly addressed memory area. More importantly, perhaps, the availability of such a mechanism greatly simplifies the writing of reentrant routines, i.e.: ones which do not modify themselves in the process of execution. Note, however, that all the mechanisms provided in microprocessors to date for stack operations are explicitly fixed mode and singular. There is only one stack, and it operates on entities of the same width, in number of bits, as the accumulator(s). Moreover, these entities have no attribute other than their fixed width, in bits.

In contrast, several large scale computers, such as the Burroughs 5500 processor with which I am familiar, employ a more generalized stack mechanism in which:

- The storage area for the stack(s) is independent of the central processor's memory, i.e.: not directly addressable.
- The entities being stored and retrieved have attributes of type (integer, logical, real, string, array) and of length (array size).
- Multiple stacks may be processed simultaneously and independently.

To achieve the latter, the stack controller requires a "stack control block" in central processor addressable memory to be uniquely associated with each active stack. Otherwise, such stack controllers bear approximately the same relation to the central processor and its addressable memory as a

Listing 1: PARSE, a translation procedure written in an informal ALGOL

```
STRING PROCEDURE PARSE(Exp);
STRING Exp;
BEGIN
  EXTERNAL INTEGER PROCEDURE Istoken :
  LOGICAL Endinput, Errflag ;
  INTEGER Position, I, J, T ;
  INTEGER ARRAY S = ( 1 1 -2 2 -9,
                    -3 3 4 -4 -9,
                      5 -5 -6 6 -9,
                      -7 7 8 -8 -9,
                      -9 -9 -9 -9 -9);
  STACK Q;

  Errflag := Endinput := false;
  PARSE := null; Position := 0;
  I := Istoken(Exp, Position, Endinput);
  J := Istoken(Exp, Position, Endinput);
  COMMENT I is last token, J is current ;
  IF Endinput THEN Errflag := true
  ELSE WHILE NOT Endinput DO BEGIN
    T := S[I,J]; IF T < U THEN Errflag := true
  ELSE CASE T OF BEGIN
    COMMENT valid sequence of tokens ;
    CASE1: BEGIN
      Q := PARSE PARSE := null
    END;
    CASE2: null;
    CASE3: PARSE := PARSE . Q;
    CASE4: PARSE := PARSE . Exp(Position) . 'S';
    CASE5: BEGIN
      Q := PARSE . 'S'; PARSE := null;
    END;
    CASE6: PARSE := PARSE . Exp(Position);
    CASE7: PARSE := PARSE . Q;
    CASE8: PARSE := PARSE . Exp(Position) . Exp(Position-1);
  END;
  I := J;
  J := Istoken(Exp, Position, Endinput);
END;
WHILE NOT Q = empty DO PARSE := PARSE . Q;
IF Errflag THEN PARSE := null;
END.
```

high speed data channel, in that the data transfers are generally effected through cycle stealing direct memory addressing, and an unmaskable interrupt to the central processor occurs only when an error condition, stack overflow or underflow, is detected.

I don't seriously propose such a stack controller for the representative homebrew computer system. I do propose, however, to show by example that incremental programming development in that direction can provide correspondingly simpler solutions to a large class of computing problems.

A Problem

One of the curious properties of calculators using Polish notation techniques is that any expression using the operators provided on the keyboard can be evaluated in an absolute minimum of keystrokes. Moreover, the required number of temporary storage areas, depth of stack, is at most the number of operands for the most complex operator. In an exactly analogous way, a stack of depth two or a second accumulator is sufficient in digital computers for evaluating any size expression using operators corresponding to native instructions, provided that the terms are calculated in the correct order. The price one pays for this admittedly pleasing property is learning to think things from the inside out. The user mentally seeks the interior of the expression, innermost term in parentheses, and works outward in calculation left to right. The pity is that it doesn't come easily to lots of folks since most people use the algebraic method of solving expressions which is the way they were taught in school. *[If a larger stack is used the expression can be evaluated from the left to right with the intermediate answers pushed onto the stack. . . RC]*

A Solution

The main problem with Polish notation is really one of representation. One wants to enter an expression in the same way it appears in, for example, a statistics handbook. If that could be done, if a way could be found to rearrange expressions from algebraic form to Polish notation, a mathematical calculator or computer could be constructed having the computational efficiency of Polish notation without sacrificing ease of use. In fact, this process of rearrangement has been intrinsic to most higher level programming language compilers and interpreters for many years. The manner in which the rearrangement is done is most easily explained in terms of a program

Input string: 1 + (((A+B)/C) - (D*(E-F)/G)) / H

Position	i	j	t	PARSE	Q
1	4			null	empty
2	4	3	8	+1	
3	3	1	5	null	+1\$
4	1	1	1	null	null, +1\$
5	1	1	1	null	null, null, +1\$
6	1	4	2		
7	4	3	8	+A	
8	3	4	6	+AB	
9	4	2	7		null, +1\$
10	2	3	4	+AB/\$	
11	3	4	6	+AB/\$C	
12	4	2	7		+1\$
13	2	3	4	+AB/\$C-\$	
14	3	1	5	null	+AB/\$C-\$\$, +1\$
15	1	4	2		
16	4	3	8	*D	
17	3	1	5	null	*D\$, +AB/\$C-\$\$, +1\$
18	1	4	2		
19	4	3	8	-E	
20	3	4	6	-EF	
21	4	2	7	-EF*D\$	+AB/\$C-\$\$, +1\$
22	2	3	4	-EF*D\$/\$	
23	3	4	6	-EF*D\$/\$G	
24	4	2	7	-EF*D\$/\$G+AB/\$C-\$\$	+1\$
25	2	2	3	-EF*D\$/\$G+AB/\$C-\$\$+1\$	empty
26	2	3	4	-EF*D\$/\$G+AB/\$C-\$\$+1\$/\$	
27	3	4	6	-EF*D\$/\$G+AB/\$C-\$\$+1\$/\$H	

Figure 1: Sample parsing process resulting from use of program PARSE.

which does just that by use of a stack only slightly more general than the native stack in microprocessors.

Explanation

Listing 1 is a procedure for parsing, computer jargon for rearranging, generalized binary operator expressions. In somewhat less prosaic language: PARSE is a program which takes an algebraic form expression and rearranges it to produce a sub-Polish notation form expression containing references, where needed, to the runtime stack. Its output presumes that the result of each calculation is immediately placed on the stack.

Note that PARSE does not count parentheses. In fact, it does not even use them directly. Instead, it uses an external procedure called INTOKEN to scan the input expression, EXP, and produce encoded tokens depending on the current input:

- 1 for a left parenthesis.
- 2 for a right parenthesis.
- 3 for an operator.
- 4 for a constant or symbol.
- 5 if none of these.

Text continued on page 144



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WK-2-W	WIRE-WRAPPING KIT (WHITE)	\$12 95
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WK-2-R	WIRE-WRAPPING KIT (RED)	\$12 95
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WK-3B (BLUE)	WIRE-WRAPPING KIT	\$16 95
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WK-4B (BLUE)	WIRE-WRAPPING KIT	\$25 99
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WIRE WRAPPING HIT WK-5

BW-630, WSU-30M, CON-1, EX-1, INS-1416, TRS-2, MS-20, 14, 16, 24 and 40 DIP sockets, WWT-1, WD-30-TR1, H-PCB-1.

WK-5	WIRE-WRAPPING KIT	\$74 95
------	-------------------	---------

PC BOARD

4 x 4.5 x 1/8 in. board, glass coated EPOXY laminate, solder coated 1 oz. copper pads. The board has provision for a 22/44 two sided edge connector. .156 in. spacing. Edge contacts are non-dedicated for maximum flexibility.

The board contains a matrix of .040 in. diameter holes on 100 in. centers. Component side contains 76 two-hole pads.

Two independent bus systems are provided for voltage and ground on both sides of the board.

H-PCB-1	HOBBY BOARD	\$4 99
---------	-------------	--------

TERMINAL BOARD

.062 thick glass coated epoxy laminate. Outside dimensions 6.3 in. x 3.94 in. Not plated.

A-PC-01	TERMINAL BOARD	\$3 45
---------	----------------	--------

PC BOARD

Same specifications as A-PC-01 except matrix pattern is copper plated and solder coated on one side.

A-PC-02	PRINTED CIRCUIT BOARD	\$5 95
---------	-----------------------	--------

PC BOARD

Same specifications as A-PC-01. Each line of holes is connected with copper plated and solder coated parallel strips on one side.

A-PC-03	PRINTED CIRCUIT BOARD	\$5 95
---------	-----------------------	--------

PC BOARD

Same specifications as A-PC-01. One side has horizontal copper strips, solder coated. Second side has vertical parallel bars.

A-PC-04	PRINTED CIRCUIT BOARD	\$7 95
---------	-----------------------	--------

PC BOARD

The A-PC-05 features numbered contacts for easy reference along with a numbered matrix for easy hole locations. Made of .062 in. thick epoxy laminate. 4.5 in. x 5 in. Edge Connector Board.

A-PC-05	PRINTED CIRCUIT BOARD	\$5 45
---------	-----------------------	--------

Same as A-PC-05 except outside dimensions are 4.5 in. x 6.5 in. Edge Connector Board.

A-PC-06	PRINTED CIRCUIT BOARD	\$6 95
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Same as A-PC-05 except outside dimensions are 4.5 in. x 7 in. Edge Connector Board.

A-PC-07	PRINTED CIRCUIT BOARD	\$8 95
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TERMINALS

WWT-1	SLOTTED TERMINAL	\$4 98
WWT-2	SINGLE SIDED TERMINAL	\$2 98
WWT-3	IC SOCKET TERMINAL	\$4 98
WWT-4	DOUBLE SIDED TERMINAL	\$1 98

TERMINAL INSERTING TOOL

For inserting WWT-1, -2, -3 and -4 terminals.

INS-1	INSERTING TOOL	\$2 49
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P.C. B. TERMINAL STRIPS

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TS-8	8-POLE	\$2 19
TS-12	12-POLE	\$2 99

MODULAR TERMINAL STRIPS

TS-6MD	2-POLE	\$1 79
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(3 per Package)

PC CARD GUIDES

TR-1	CARD GUIDES	\$1 89
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QUANTITY — ONE PAIR (2 PCS.)

PC CARD GUIDES & BRACKETS

TRS-2	GUIDES & BRACKETS	\$3 79
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QUANTITY — ONE SET (4 PCS.)

PC EDGE CONNECTOR

44 pin, dual read-out, .156 in. spacing, wire-wrap pin.

CON-1	P.C. EDGE CONNECTOR	\$3 49
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SE 14-48	WITH 14 PIN DIP PLUG 48" LONG (1218MM)	\$4.25
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"HOBBY" WIRE WRAPPING TOOL BATTERY POWERED

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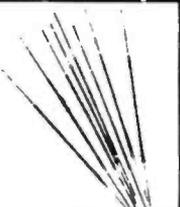
Use "C" size NICAD Batteries, not included. Bits not included.

BT-30	BIT FOR AWG 30	\$3.95
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30 R 50 010	30 AWG, Red Wire, 1' Long	\$.99
30 B 50 020	30 AWG, Blue Wire, 2' Long	\$ 1.07
30 Y 50 020	30 AWG, Yellow Wire, 2' Long	\$ 1.07
30 W 50 020	30 AWG, White Wire, 2' Long	\$ 1.07
30 R 50 020	30 AWG, Red Wire, 2' Long	\$ 1.07
30 B 50 030	30 AWG, Blue Wire, 3' Long	\$ 1.16
30 Y 50 030	30 AWG, Yellow Wire, 3' Long	\$ 1.16
30 W 50 030	30 AWG, White Wire, 3' Long	\$ 1.16
30 R 50 030	30 AWG, Red Wire, 3' Long	\$ 1.16
30 B 50 040	30 AWG, Blue Wire, 4' Long	\$ 1.23
30 Y 50 040	30 AWG, Yellow Wire, 4' Long	\$ 1.23
30 W 50 040	30 AWG, White Wire, 4' Long	\$ 1.23
30 R 50 040	30 AWG, Red Wire, 4' Long	\$ 1.23
30 B 50 050	30 AWG, Blue Wire, 5' Long	\$ 1.30
30 Y 50 050	30 AWG, Yellow Wire, 5' Long	\$ 1.30
30 W 50 050	30 AWG, White Wire, 5' Long	\$ 1.30
30 R 50 050	30 AWG, Red Wire, 5' Long	\$ 1.30
30 B 50 060	30 AWG, Blue Wire, 6' Long	\$ 1.38
30 Y 50 060	30 AWG, Yellow Wire, 6' Long	\$ 1.38
30 W 50 060	30 AWG, White Wire, 6' Long	\$ 1.38
30 R 50 060	30 AWG, Red Wire, 6' Long	\$ 1.38



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TRI-COLOR DISPENSER

WD-30-TRI	TRI-COLOR DISPENSER	\$5.95
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R-30-TRI	REPLACEMENT ROLLS	\$3.95
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WD-30-Y	YELLOW WIRE	\$3.95
WD-30-W	WHITE WIRE	\$3.95
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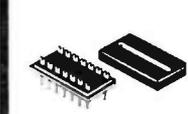
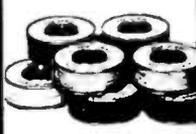
DISPENSER REPLACEMENT ROLLS

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R-30Y-0050	30-AWG YELLOW 50 FT. ROLL	\$1.98
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HK-22	22 AWG	50 FT.	SOLID CONDUCTOR	\$1.35
HK-24	24 AWG	50 FT.	SOLID CONDUCTOR	\$1.35
HK-26	26 AWG	50 FT.	SOLID CONDUCTOR	\$1.35
SHK-18	18 AWG	25 FT.	STRANDED CONDUCTOR	\$1.20
SHK-20	20 AWG	25 FT.	STRANDED CONDUCTOR	\$.98
SHK-22	22 AWG	50 FT.	STRANDED CONDUCTOR	\$1.35
SHK-24	24 AWG	50 FT.	STRANDED CONDUCTOR	\$1.35
SHK-26	26 AWG	50 FT.	STRANDED CONDUCTOR	\$1.35



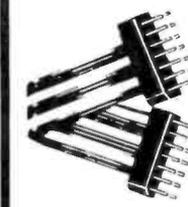
DIP PLUG WITH COVER FOR USE WITH RIBBON CABLE

14-PLG	14 PIN PLUG & COVER	\$1.45
16-PLG	16 PIN PLUG & COVER	\$1.59

QUANTITY 2 PLUGS, 2 COVERS

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DE 14-8	WITH 14 PIN DIP PLUG - 8"	\$3.95
DE 14-12	WITH 14 PIN DIP PLUG - 12"	\$4.07
DE 14-16	WITH 14 PIN DIP PLUG - 16"	\$4.12
DE 14-24	WITH 14 PIN DIP PLUG - 24"	\$4.15
DE 16-2	WITH 16 PIN DIP PLUG - 2"	\$4.15
DE 16-4	WITH 16 PIN DIP PLUG - 4"	\$4.25
DE 16-8	WITH 16 PIN DIP PLUG - 8"	\$4.35
DE 16-12	WITH 16 PIN DIP PLUG - 12"	\$4.47
DE 16-16	WITH 16 PIN DIP PLUG - 16"	\$4.52
DE 16-24	WITH 16 PIN DIP PLUG - 24"	\$4.55
DE 24-6	WITH 24 PIN DIP PLUG - 6"	\$6.05
DE 24-8	WITH 24 PIN DIP PLUG - 8"	\$6.50
DE 24-12	WITH 24 PIN DIP PLUG - 12"	\$6.90
DE 24-16	WITH 24 PIN DIP PLUG - 16"	\$7.10
DE 24-24	WITH 24 PIN DIP PLUG - 24"	\$7.70



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24 DIP	24 PIN DIP SOCKET	\$1.49
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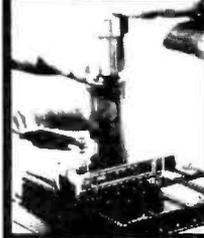
GROUND STRAP NOT INCLUDED

MOS-1416	14-16 PIN, MOS CMOS SAFE INSERTER	\$7.95
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36-40 PIN CMOS-SAFE IC INSERTION TOOL

Aligns bent out pins. Includes terminal lug for attachment of ground strap.

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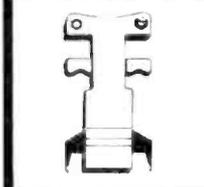
EX-1	EXTRACTOR TOOL	\$1.49
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24-40 CMOS-SAFE EXTRACTOR TOOL

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EX-2	CMOS SAFE EXTRACTOR TOOL	\$7.95
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Listing 2: INTOKEN encodes the current character in the input expression, Exp. As before, an informal ALGOL type notation is used.

```

INTEGER PROCEDURE INTOKEN (Exp, Position, Endinput).
LOGICAL Endinput;
INTEGER Position ;
STRING Exp ;
BEGIN INTOKEN := 0;
IF Position - SIZE(Exp) THEN Endinput := true
ELSE BEGIN
  Position := Position + 1;
  WHILE Exp(Position) = '(' DO Position := Position + 1;
  IF Exp(Position) = '(' THEN INTOKEN := 1
  ELSE IF Exp(Position) = ')' THEN INTOKEN := 2
  ELSE IF Exp(Position) = ANY(' ', '-', '.', '*', '/', ') THEN INTOKEN := 3
  ELSE BEGIN
    INTOKEN := 5;
    COMMENT Presume error or first, determine otherwise later.
    IF NOT (0 > Exp(Position) OR '9' < Exp(Position))
    THEN BEGIN
      INTOKEN := 4;
      WHILE NOT (0 > Exp(Position) OR '9' < Exp(Position))
      DO Position := Position + 1; Position := Position + 1;
      END ELSE
      IF NOT ('A' > Exp(Position) OR 'Z' < Exp(Position))
      THEN BEGIN
        INTOKEN := 4;
        WHILE NOT ('A' > Exp(Position) OR 'Z' < Exp(Position))
        DO Position := Position + 1; Position := Position + 1;
      END;
    END;
  END;
END;
END.

```

Listing 3: Single stack control routines written for the 8080 processor. STACK places a string of characters on a LIFO list, followed by the length of the string. POPSD removes the length of the last entered string, if any, from the list. POPUP removes the last entered string, if any, from the list. (Note: These routines are not debugged, in fact, the symbol STACK is multiply defined, so that it won't assemble correctly. They are included here only to suggest an appropriate technique.)

STACK:	PUSH	PSW	COMMENT The following presumes
	PUSH	B	external procedures ABUF and
	PUSH	D	RBUF whose functions are
	PUSH	H	respectively.
	XCHG		acquire a buffer of byte size
	LHLD	STACK	specified by A, returning
	PUSH	H	address in H.L. or zero if
	POP	B	none available
	ADI	3	release a buffer addressed by
	CALL	ABUF	H.L. to the buffer pool
	MOV	AH	
	ORA	L	STACK: SAVE(H.L.).
	JZ	STKOP	ABUF(A+3). IF 0
	SHLD	STACK	THEN SET(Carry)
	MOV	A,C	ELSE BEGIN
	STAX	H	COMMENT Stack entry contents
	INX	H	+0 addr of previous entry
	MOV	A,B	+2 size of current item
	STAX	H	+3 current item
	INX	H	
	POP	PSW	caller provides size in A.
	MOV	B,A	item data address in H.L.:
	STAX	H	RESET(Carry).
	ORA	A	MEMORY(H.L.) := Stack.
	JZ	STKCX	Stack := (H.L.).
	INX	H	(H.L.) := (H.L.) + 2;
STKCY	LDA	D	MEMORY(H.L.) := A.
	STAX	H	(H.L.) := (H.L.) + 1.
	INX	H	RESTORE(D.E.). SAVE(D.E.).
	INX	D	WHILE NOT A = 0 DO
	DCR	B	BEGIN
	JNZ	STKCY	MEMORY(H.L.) := MEMORY(D.E.).
STKCX	POP	H	(H.L.) := (H.L.) + 1;
	POP	D	(D.E.) := (D.E.) + 1.
	POP	B	A := A - 1.

Listing 3 continued on page 116

Text continued-

Another peculiar property of PARSE, presuming you haven't figured out how it works yet, is that only one complete INTOKEN scan of the input expression is required because of the use of a stack, Q, for retaining the symbols for intermediate expressions. INTOKEN recognition of parentheses (output codes 1 and 2) effectively controls stacking and popping up symbols for intermediate expressions in the required order.

The operation of PARSE depends critically on the array S. In use, its row subscript is presumed the value of the last INTOKEN output, its column subscript the value of the current INTOKEN output. Specifically, if the last input token was a left parenthesis and the current input token was 'E' (a symbol or constant) then INTOKEN's last and current outputs would be 1 and 4; the matching element in S (row 1 column 4) has value 2, so that the statement CASE2 would be performed. Subsequently, J replaces 1 and INTOKEN is again invoked to evaluate J anew; a new element of S is fetched using the new values of 1 and J as subscripts; and the element of the CASE statement list matching the new value taken from S is performed. This process is repeated until INTOKEN sets Endinput true, indicating the end of the input string Exp has been detected. Since the last two tokens might be right parentheses, and PARSE does not in fact process the last token since tokens are used only in pairs, the stack Q is always flushed before PARSE finishes.

PARSE is presented in informal ALGOL only in the hope the process per se of suitably rearranging algebraic form expressions can be made more easily understood than via an equivalent 8080 assembly language program which might prove to be a transliteration nightmare for the novice LSI-11 or PPS-8 programmer. Contrarily, the step by step listing of PARSE and the associated control indices in figure 1 should aid in understanding what PARSE is really doing, with respect to the hypothetical expression. The function of INTOKEN, recognizing and encoding the elements of an expression, is sufficiently straightforward that an explicit statement of it is hardly necessary, but listing 2 is included nonetheless in informal ALGOL. The remaining question, perhaps, is one of making the stack Q of PARSE operable on a microcomputer. To that end, listing 3 shows a hypothetical implementation of single stack control routines STACK, POPUP, and POPSD using 8080 assembler format.

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Now what? Well, for a start let's observe that PARSE will work only with binary operator expressions. Right? Well, not quite. Note that PARSE passes the buck for recognition. If INTOKEN can recognize unary

Listing 3, continued:

```

STC                                ; END:
CMC                                ; END:
RET                                ; RESTORE(H,L);
STKOF: POP      H                  ;
POPUF: POP      D                  ;
      POP      B                  ;
      POP      PSW                 ;
      STC                                ;
      RET                                ;
;
;
POPSD: PUSH     H                  ; POPSD: IF Stack = 0
      STC                                ; THEN SET(Carry)
      LHL      STACK                ; ELSE BEGIN
      MOV     A,H                    ; COMMENT Give caller size
      ORA     L                      ; of next entry to pop, for
      JZ      POPZD                  ; buffering as needed
      INX     H                      ; RESET(Carry);
      INX     H                      ; SAVE(H,L);
      CMC                                ; (H,L):= Stack + 2;
      LDAX   H                      ; A := MEMORY(H,L);
      JMP     POPXD                  ; RESTORE(H,L);
POPZD: SUB      A                  ; END:
POPIXD: POP     H                  ;
      RET                                ;
;
;
; The following must be in R/W
; memory, since Stack is the
; list-origin address, and LHLI
; is externally modified to
; effect an indirect LHL.
LHLI:  LHL      0                  ;
      RET                                ;
STACK: 0                            ;
POPUF: PUSH     PSW                 ; POPUP: IF Stack = 0
      PUSH     B                    ; THEN SET(Carry)
      PUSH     D                    ; ELSE BEGIN
      PUSH     H                    ; COMMENT Target area is
      LHL      STACK                ; specified by caller H,L;
      XCHG                                ; RESET(Carry);
      POP      H                    ; SAVE(D,E,H,L);
      MOV     A,D                    ; (D,E):= Stack;
      ORA     E                      ; B := MEMORY (D,E + 2);
      JZ      POPUF                  ; SAVE(D,E,H,L);
      PUSH     H                    ; (D,E) := (D,E) + 3;
      PUSH     D                    ; WHILE NOT B = 0 DO
      INX     D                      ; BEGIN
      INX     D                      ; COMMENT Zero-length entries
      LDAX   D                      ; are removed but not copied ;
      ORA     A                      ; MEMORY(H,L) := MEMORY(D,E);
      JZ      POPCX                  ; (D,E) := (D,E) + 1;
      INX     D                      ; (H,L) := (H,L) + 1;
      MOV     B,A                    ; B := B - 1;
POPCY: LDAX   D                      ; END:
      STAX   H                      ; RESTORE(D,E,H,L);
      INX   H                      ; Stack := MEMORY(D,E);
      INX   D                      ; RBUF(D,E);
      DCR   B                      ; RESTORE(D,E,H,L);
      JNZ   POPCY                  ; END:
POPCX: POP     D                    ;
      XCHG                                ;
      SHLD   LHLI+1                  ;
      CALL   LHLI                    ;
      SHLD   STACK                    ;
      LHL   LHLI+1                  ;
      CALL   RBUF                    ;
      POP   H                        ;
      POP   D                        ;
      POP   B                        ;
      POP   PSW                      ;
      STC                                ;
      CMC                                ;
      RET                                ;

```

operators, it can also stuff in a dummy operand on the fly, since PARSE initializes Position, and thereafter leaves it alone. That is, the common unary operators are special cases of a binary and either zeroes or ones: NOT FRED is equivalent to ones exclusive-OR FRED; NEGATIVE VIBES is equivalent to 0 - VIBES; and INVERSE HYPOTHESIS is equivalent to 1/HYPOTHESIS.

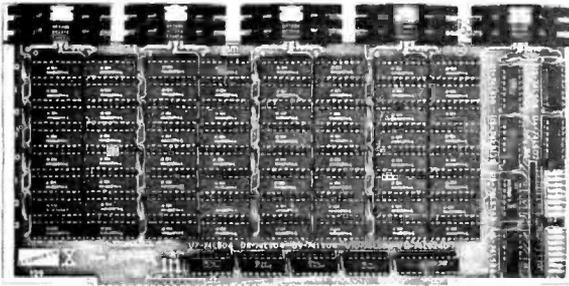
How about the results? PARSE can easily be modified to directly generate machine language code if INTOKEN is modified to create or at least have access to a symbol table; or its output can be used, as is, by an interpretive calculator program. Obviously, 8080 machines and, for that matter, most microprocessors lack multiply and divide instructions, but nonnative operations can easily be interpreted as operator subprogram calls. PARSE makes no presumption about the computer on which it's run except the availability of a stack to use with its output referenced by '\$'. The operators, for example, for which PARSE was developed in the form shown were character string operators of combination and proximity. The PARSE output was interpreted by a program for searching large textual files on an IBM System 360 disk unit. The point is that the results are what you make of them, PARSE being no more than a procedure for rearrangement of expressions.

A final apology before getting under way. FORTRAN freaks may by now have noticed an "error" in that although the tokens 1 and H in the example of figure 1 are at the same parenthesis level, the add-1 parse precedes the divide-H in the final step. Why? I prefer to ask why one bothers anyway with operator priorities so long as the desired order of computation can be explicitly specified by using parentheses. The example of figure 1, in fact, was contrived in part to illustrate that PARSE as shown here presumes a strict left to right evaluation at any parentheses level. Operators are not "ranked" as in FORTRAN and several other higher level programming languages.

One More Time

If the available stack mechanism is only once more generalized, to provide multiple stacks simultaneously, some conceptual simplification of a large class of problems occurs. As a near trivial example, we illustrate in listing 4 a 2 stack sorting procedure. In essence, it removes records (strings) from a file one at a time and manipulates the two stacks, Highside and Lowside, back and forth until the new record fits in the inclusive interval of values bounded by the top

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- (3) Extended addressing (24 address lines). Single block addressable on 4K boundaries.
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Listing 4: A SORT procedure expressed in informal ALGOL type notation demonstrates use of two stacks.

```

STRING ARRAY PROCEDURE SORT(File);
STRING ARRAY File;
BEGIN
  INTEGER          K;
  STRING           This;
  STACK Highside, Lowside;
  Lowside := File (1);
  Highside := File (2);
  COMMENT top function references item
  on the top of some stack;
  IF TOP(Lowside) > TOP(Highside)
  THEN BEGIN
    This := Highside;
    Highside := Lowside;
    Lowside := This;
  END;
  COMMENT size function produces the
  current number of elements in array;
  K := 3;
  WHILE K ≤ SIZE(File) DO
  BEGIN
    This := File(K);
    K := K + 1;
    WHILE This < TOP(Lowside) DO Highside := Lowside;
    WHILE This > TOP(Highside) DO Lowside := Highside;
    Highside := This;
  END;
  WHILE NOT(Lowside = empty) DO Highside := Lowside;
  K := 1;
  WHILE K ≤ SIZE(File) DO
  BEGIN
    SORT(K) := Highside;
    K := K + 1;
  END;
END.

```

elements of the two stacks. The procedure has two virtues:

- It's easy to describe and understand.
- It requires an absolute minimum of workspace.

The price one pays is speed. It's probably one of the two or three slowest sorting algorithms around. ■

The program examples which appear in this article are written in an informal ALGOL type notation. The basic unit of ALGOL is the statement. It can be either a simple statement such as:

```
Position := 0;
```

which is read "position is evaluated as 0," or a compound statement defined by BEGIN . . . END such as:

```

BEGIN
  Q := PARSE; PARSE := null;
END

```

which is read "Q is evaluated parse, PARSE is evaluated null."

The statements defined between the BEGIN and END statements are not restricted to type. A preceding conditional such as (IF . . . THEN . . . ELSE) will affect the entire command statement. One of the constituents of the statement may well be another compound statement. For example, to add an array of samples having subscripts 1 through Limit which is specified elsewhere we could write:

```

BEGIN
  Subscript := 1; Sum := 0;
  WHILE Subscript < Limit DO
  BEGIN
    Sum := Sum + Sample(Subscript);
    Subscript := Subscript + 1;
  END;
END;

```

The WHILE statement's operand (the statements after the DO) rather intuitively is in execution so long as the conditional part (Subscript < Limit) is true.

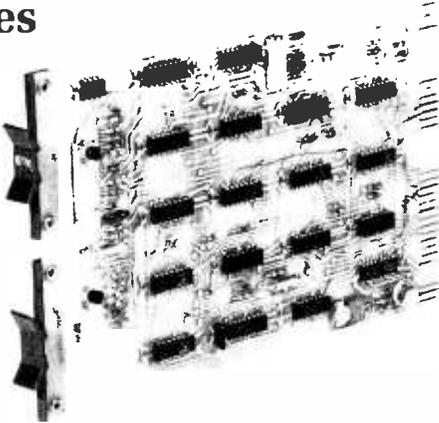
The CASE statement is simpler in effect. It acts approximately like an indexed jump. It has two operands. The first of these (T in the PARSE procedure) is an integer, and the second is a list of statements bracketed by BEGIN and END. The first operand selects for execution the statement from the list whose position matches the value of the index specifier.

Following are the informal extensions that have been made to ALGOL and used in the programs:

- The period indicates concatenation of character strings. Presuming values of 'WHAT' and 'STUFF' for symbols A and B, A . B will have a value of 'WHATSTUFF.'
- Q is declared to be of type STACK which, however implicit in most implementations of ALGOL-60, was not construed to be explicitly available. It is, in effect, a LIFO indexed character string array.
- Null and empty are used for assigning values, respectively, of a character string of length zero and a stack having zero entries.

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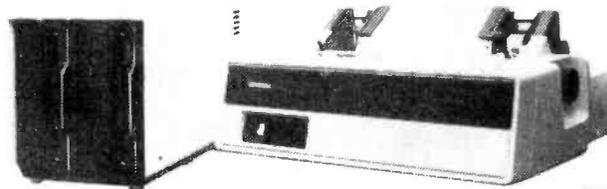
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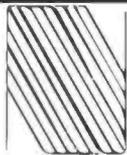
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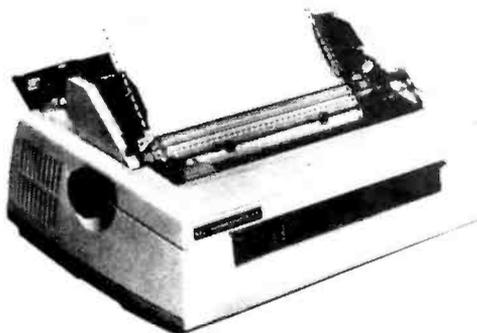
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0100          0010 * A PROGRAM ILLUSTRATING SOME PRINCIPLES OF
0100          0015 * PROGRAMMING AN ANIMATED GAME
0100          0020 *
0100          0025 * COPYRIGHT 1979 TONY ESTEP
0100          0030 *
0100          0035 VMBAS EQU    $C000H
0100          0040 NEDL EQU    $C001H ;ALL THESE RELATE TO 'ME SOL/20 &
0100          0045 CLASH EQU    $C002H ;ETS VEH AND SCREEN CLEAR ROUTE
0100          0047 SCROT EQU    $C003H ;NEEDLE OF LOOSEY LINE
0100          0050 BAR EQU    $3H ;THESE ARE ADDRESS ON KEYBOARD
0100          0055 LAR EQU    $3H
0100          0060 LMR EQU    $7H
0100          0065 DAK EQU    $AH
0100          0070 ORG    100H ;DO IT WILL RUN WITH CPU
0100          0075 LLI    SP,STACK+66
0100          0080 CALL    CLASH ;FOR NED+DOL, WRITE SIMPLE ROUTINE TO CLEAR
0100          0085 LLI    N,VEHBASE
0100          0090 MVI    H, ' '
0100          0095 MEGP: CALL    WAIT
0100          0100 CD    XRA    A ;INITIALISE FLAGS
0100          0105 STB    C
0100          0110 JTA    PEGC
0100          0115 STB    ISCR
0100          0120 STB    POCR
0100          0125 MVI    A,1
0100          0130 STB    OFGC1
0100          0135 STB    RYFL
0100          0140 STB    TROT
0100          0145 CALL    CLSQM
0100          0150 LLI    N,VEHBASE
0100          0155 MVI    H, ' '
0100          0160 LLI    H,NEDL
0100          0165 MLD    CONRG
0100          0170 CALL    SHIP
0100          0175 CALL    DELAY
0100          0180 CALL    DELAY
0100          0185 CALL    DELAY
0100          0190 CALL    DELAY
0100          0195 CALL    DELAY
0100          0200 CALL    DELAY
0100          0205 CALL    DELAY
0100          0210 *****
0100          0215 *MAIN LOOP STARTS HERE
014C          CD    C1 01    0220 RYFL: CALL    YAMP ;PUT BLANKS IN SHIP WING
014E          CD    09 01    0225 SHIP: MVI    FT ON CONLR

```

Listing 1 continued on page 154

It has been quite some time since the arrival of memory-mapped I/O (input/output) boards upon the amateur computer scene, but the voluminous home computer literature rarely contains any listings of animated video games. Since it seems to me that there breathes not a hobbyist with soul so dead that he would not play one of these devilish little time wasters if he had one, I concluded that perhaps the lack of video games was due to some lack of information about how to get one up and going. This was certainly the case with me; I just started with a blank piece of paper and began scratching. But as the reader will see, there really is no mystery to it, and the results are well worth the effort.

A video game works just the same as an animated cartoon; there are a series of frames, each of which shows one or more of the objects in the picture in a slightly different position. Since the viewer's visual system has a certain persistence, the effect is one of continuous motion. In the case of a television picture, each frame is a single rewriting of the raster. This is very fast, and the flicker is seldom noticeable. A computer can pop information in and out of screen memory much faster than the monitor can

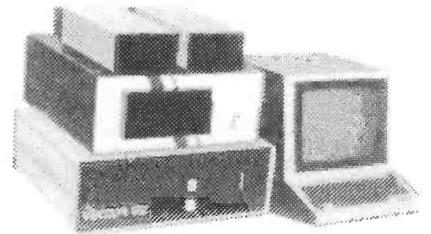
Text continued on page 158

MUFS FOR EVERYONE (ESPECIALLY DEALERS)

MULTIPLE FLOPPY SYSTEM

MUFS is a prom resident supervisor for the Vector Graphic System B which allows menu selection of all the following operating and disk system configurations* without changing a single board on the system, or plugging in and unplugging peripherals.

Disk Drive Configuration	Disk Size	Disk Controller	Disk Density	Drive Assignment	Operating System
Persi 277	8"	Micromation	Single/Double	A, B	CP/M
Shurgart SA450	5 1/4"	Northstar	Single/Double	C, D	CP/M
Persi 277	8"	Micromation	Single/Double	A, B	CP/M
Micropolis MODII	5 1/4"	Micropolis	Quad	C, D	CP/M
Persi 277	8"	Micromation	Single/Double	A, B	CP/M
Shurgart SA450	5 1/4"	North Star	Single/Double	A, B	CP/M
Micropolis MODII	5 1/4"	Micropolis	Quad	A, B	CP/M
Micropolis MODII	5 1/4"	Micropolis	Quad	0, 1	MDOS
Micropolis MODII	5 1/4"	Micropolis	Quad	1, 2	MZOS
Micropolis MODII	5 1/4"	Micropolis	Quad	A, B	OASIS
Shurgart SA450	5 1/4"	North Star	Single/Double	1, 2	DOS
Persi 277	8"	Alpha Micro*	Single	1, 2	AMOS*



Those configurations using two types of drives permit file copy from one type to another with the facilities of 'PIP'. MUFS includes Vector Graphics complete System B, all the above mentioned disks/controllers with operating systems fully configured and operational on the System B. OASIS, AMOS and the ALPHA MICRO CPU/Disk Controller are extra. MUFS also includes UNIVID (Universal Video, which allows the mindless terminal which comes with the System B to emulate the Hazeltine 1500 and Adam-3A). Additionally, MUFS also includes the communications software (IC) described below (IC is available separately). With MUFS, computer/software dealers can develop/copy/demo most all of their software on a single system with the snap of a disk drive door! Since MUFS supports multiple terminals, the 'Mime' terminal is available as an option. If purchased, this allows MUFS to run software designed specifically for either memory mapped or serial I/O (most software works on either).

IC FOR CP/M** INTERSYSTEM COMMUNICATIONS

- Communicates with other computers through a user selected RS232-C Port
- Transmits ASCII Data to/from all computers (Maxi, Mini, Micro, Time Sharing and Single User). Transmits ASCII and Binary Data between CP/M Systems.
- Supports multiple terminals and printers which can be local or remote, and can be logged on and off the system.
- Supports 9600 Baud to printers with the X-on/X-off feature
- Permits an IC installed computer to function both as a computer, and as a terminal or systems console to other computers, with software switching between the two modes.
- Permits dealers to operate customers computers remotely, patching software, sending new software, testing the customer's computer, etc.
- When sending data, IC is programmed to automatically wait for the receiving computer if it cannot keep up with a steady Baud rate.
- Thoroughly tested with 7 different computer systems, full and half duplex.
- Software available on diskette only, or diskette/prom (prom version boots faster)
- Does not require an interrupt capability

DOC FOR NORTH STAR

OPTIMIZATION

- #### DOCUMENTATION
- Prints formatted program listings with user selected spacing, titling, dating, and paging
 - Prints an alphabetized cross reference listing of all variables with an ordered list of the line numbers they are used in.
 - For all lines which are the destination of a 'GOTO' type statement prints a list of all line numbers containing a reference to the selected destination line.

- Optimizes speed of execution primarily through reduction in execution time of 'GOTO' type statements. This results from a reduction in the number of statements through statement concatenation.
- Optimizes program size through removal of all unnecessary blanks. Optionally removes REM statements. Saves 3 BYTES for every short statement concatenated into a longer statement.

CONFIDENTIALITY

- Protects the confidentiality of your programs by inhibiting the North Star list and edit functions once a program has been optimized by DOC. Offers virtually as much protection as compiler basics.

PRICES:

MUFS \$9,500.00 OASIS OPTION - \$500.00
 IC DISKETTE VERSION \$150.00
 DOC \$59.00

MIMETERMINAL OPTION \$825.00

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*Amos is not menu selectable, and does require removal and insertion of some board's in the S-100 Bus
 **CP/M is a trademark of Digital Research

Listing 1 continued:

```

0152 2A F2 02      0230      LLD  H
0153 E3            0235      PUSH H
0154 2A F4 02      0240      LLD  (D)
0155 E3            0245      PUSH H
0156 2A F6 02      0250      LLD  CORR:
015D C1            0255      POP  B
015E 09            0260      LLD  B
015F D1            0265      POP  D
0160 19            0270      DAD  D
0161 22 F6 02      0275      LLD  CORR ;NEW LOCATION FOR SHIP
0164 CD AC 01      0280      CALL MOVE ;PUT GRAPH IN SHIP PAGE
0167 CD C5 01      0285      CALL SHIP ; PUT IT ON SCREEN
016A CD D9 01      0290      CALL CYCLE ;CHECK KEYBOARD
016D CD D5 02      0295      CALL STOP ;CHECK TO SEE IF WE'RE AT TOP OR BOTTOM OF SCR.
0170 CD 59 02      0300      CALL BREAK ;IS A CALLOUT DROPPING?
0173 CD 6A 02      0305      CALL DELAY
0176 CD 60 03      0310      CALL PRT1
0179 CD C9 03      0315      CALL INACK ;IS THERE A BROADER OR SATEER?
017C CD 56 05      0320      CALL PRDP ;WAS IT OFF KEYB
017F AF            0325      STA  I
0180 32 E7 04      0330      STA  SHIP
0183 CD BA 04      0335      SCRR1 CALL SCORE ;UPDATE SCORE
0186 CD 4C 01      0340      JEP  RIGHT
0189              0345      *****
0189 2A F6 02      0350      SHIP LLD  CORR ;MOVES MEMORY IMAGE OF SHIP
018C CD 48 04      0355      CALL HTF ; ONO SCREEN
018F 3A FA 02      0360      LD  LRD
0192 77            0365      MOV  C,A
0193 23            0370      INX  H
0194 CD 48 04      0375      CALL HTF
0197 3A F5 02      0380      LD  BLK
019A 77            0385      MOV  C,A
019B 23            0390      INX  H
019C CD 4B 04      0395      CALL HTF
019F 3A FE 02      0400      LD  WHT
01A2 77            0405      MOV  C,A
01A3 23            0410      INX  H
01A4 CD 46 04      0415      CALL HTF
01A7 3A FE 02      0420      LD  RETD
01AA 77            0425      MOV  C,A
01AB C9            0430      RET
01AC 3E 10         0435      POPD  IWI ;SAVE GRAPHICS WHICH TAKE UP THE SHIP
01AE 32 F8 02      0440      STA  WHT ;ARE MADE INTO A PICTURE IN MEMORY
01B1 3E 90         0445      IWI  A,90H
01B3 32 F9 02      0450      STA  BLK
01B6 3E 3C         0455      IWI  A,3CH
01B8 32 FA 02      0460      STA  LRD
01BB 3E 3E         0465      IWI  A,3EH
01BD 32 FB 02      0470      STA  RETD
01C0 C9            0475      RET
01C1 3E 20         0480      TAKOF IWI  A,* ;REPLACES SHIP GRAPHICS WITH BLANKS
01C3 32 F8 02      0485      STA  WHT ;SO THAT 'SHIP' ROUTINE WILL BLANK
01C6 32 F9 02      0490      STA  BLK ;OUT PICTURE OF SHIP
01C9 32 FA 02      0495      STA  LRD
01CC 32 FB 02      0500      STA  RETD
01CF C5            0505      RET
01D0 DB FA        0510      STATUS IN  OF/JI ;THESE INPUT ROUTINES ARE FOR SOL
01D2 2F            0515      CMA
01D3 E6 01        0520      AND  1

```

Listing 1 continued on page 156

WILD & CRAZY ASSEMBLY PROGRAMMERS

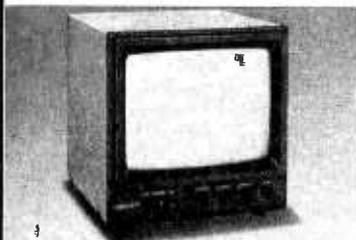
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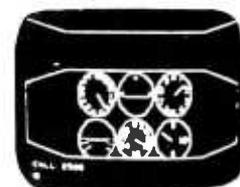
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Listing 1 continued:

```

01D5 C9          0525      RET
01D6 DB FC      0530      IMP      IN      OFCH
01D8 C9          0535      RET
01D9 CD D0 01   0540      KYCRK   CALL   STATUS
01DC C8          0545      RZ
01DD CD D6 01   0550      CALL   IMP
01E0 FE 93      0555      CPI     RAR ;RIGHT ARROW
01E2 CA FA 01   0560      JZ      RIGHT
01E5 FE 81      0565      CPI     LAR ;LEFT ARROW
01E7 CA 05 02   0570      JZ      LEFT
01EA FE 97      0575      CPI     UAR ;UP ARROW
01EC CA 10 02   0580      JZ      UP
01EF FE 9A      0585      CPI     DAR ;DOWN ARROW
01F1 CA 1B 02   0590      JZ      DOWN
01F4 FE 20      0595      CPI     ' ' ;SPACE BAR DROPS BALLOON
01F6 CA 53 02   0600      JZ      BLANSET
01F9 C9          0605      RET
01FA 2A F2 02   0610      RIGHT  RLD   LR ;THESE ROUTINES UPDATE THE OFFSETS TO
01FD 11 01 00   0615      LXI    D,1 ;THE SHIP POSITIONS
0200 19          0620      DAD    D
0201 22 F2 02   0625      SHLD   LP
0204 C9          0630      RET
0205 2A F2 02   0635      LEFT   LLD   LR
0208 11 FF FF   0640      LXI    D,-1
020B 19          0645      DAD    D
020C 22 F2 02   0650      SHLD   LR
020F C9          0655      RET
0210 2A F4 02   0660      UP     LLD   UD
0213 11 C0 FF   0665      LXI    D,-64 ;64 CHARACTER WIDE SCREEN SO YOU GO U/D 1 LINE
0216 19          0670      DAD    D
0217 22 F4 02   0675      SHLD   UD
021A C9          0680      RET
021B 2A F4 02   0685      DOWN  LLD   UD
021E 11 40 00   0690      LXI    D,64
0221 19          0695      DAD    D
0222 22 F4 02   0700      SHLD   UD
0225 C9          0705      RET
0226 3E 01      0710      CALL   FVI   A,1
0228 32 FD 02   0715      STA   BLNF
022B 2A F6 02   0720      LLD   CORN:
022E 11 41 00   0725      LXI    D,41H
0231 19          0730      DAD    D
0232 22 FE 02   0735      SHLD   BLNK
0235 2A FE 02   0740      BLN:   LLD   BLNK ;BLNK CUR BALLOON
0238 36 20      0745      FVI   E,' '
023A 11 40 00   0750      LXI    D,64 ;MOVE IT DOWN A LINE
023D 19          0755      DAD    D
023E 22 FE 02   0760      SHLD   BLNF
0241 36 8C      0765      FVI   H,8CH
0243 7C          0770      MOV   A,H
0244 FE 1C      0775      CPI   0D0H
0246 CA 4A 02   0780      JZ     BLN: ;HIT BOTTOM
0249 C9          0785      RET
024A 3E 00      0790      BLN:   FVI   A,0
024C 32 FC 02   0795      STA   BLND
024F 32 FD 02   0800      STA   BLNF
0252 C9          0805      RET
0253 3E 01      0810      BLNSET FVI   A,1
0255 32 FC 02   0815      STA   BLND

```

Listing 1 continued on page 158

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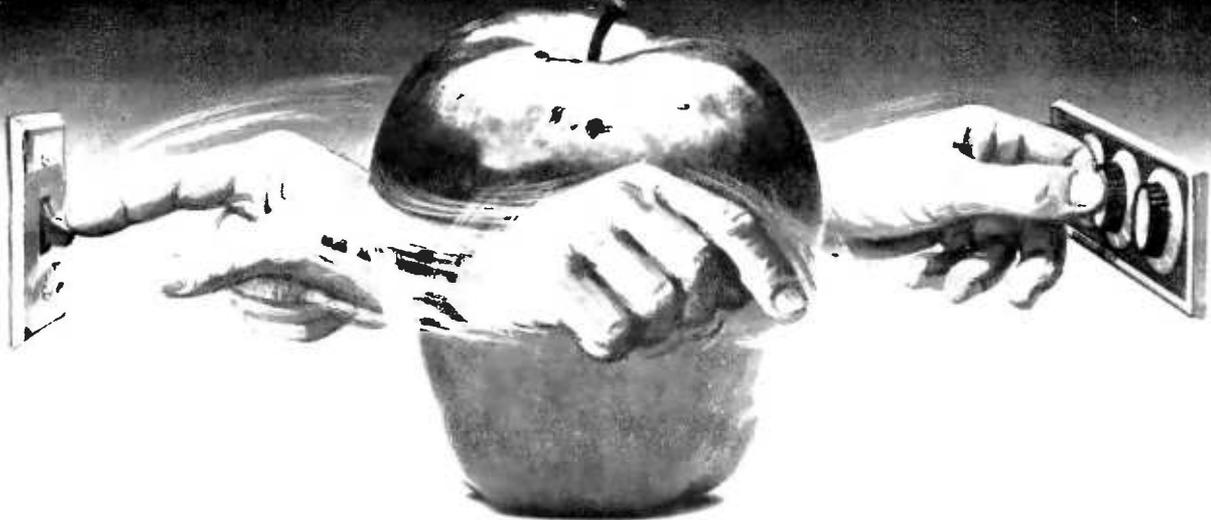
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- Specify an interval of time for an event.
- Rate device wattages for a running account of power consumption during your schedule for energy management.
- Used with our Apple Clock™ your schedules may run in "background" while other programs may run at the same time in "foreground."

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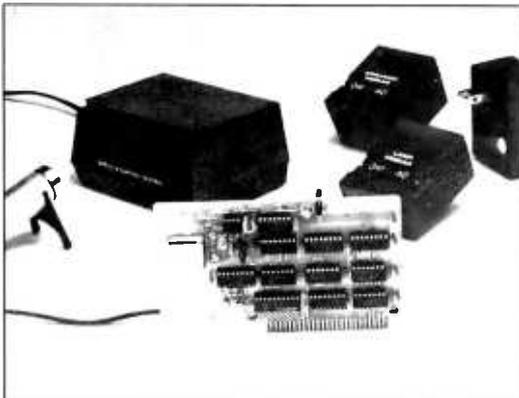
The Introl Controller board plugs into a peripheral slot of your Apple. With an ultrasonic transducer it transmits control signals to the BSR/X-10 Command Console which may be plugged into any convenient AC outlet near your computer. On command, signals are sent to remote modules located at the devices you wish to control. Up to 16 remote module addresses may be controlled from your Apple.

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The Introl/X-10 System consists of the Introl Controller board with timer and ultrasonic transducer, the X-10 Command Console and three remote modules. \$279. Complete and tested. If you already have a BSR System X-10, the Introl Controller board is available separately for \$189. Additional remote modules are available at \$15. See your computer dealer for a demonstration. Or, return the coupon below for complete information.

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*Apple is a trademark of Apple Computer Inc.
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Sounds great.

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Listing 1 continued:

```

0258 C9          0820 RET
0259 3A FD 02    0825 BUNCH LDA BLNF
025C FE 01      0830 CPI 1
025E CA 35 02   0835 JZ BLNF
0261 3A FC 02   0840 LDA BLNF
0264 FE 01      0845 CPI 1
0266 C0         0850 RZ
0267 CD 26 02   0655 CALL BALN
026A ES         0860 DELAY PUSH H ;A USEFUL ALLPURPOSE TIMING ROUTINE
026B 27 6E 05   0865 LHL D SPEED
026E EB         0870 XCHG
026F 15         0875 DELAI DCR D
0270 C2 6F 02   0880 JNZ DELAI
0273 1D         0885 DCR E
0274 C2 6F 02   0890 JNZ DELAI
0277 E1         0895 POP H
0278 C9         0900 RET
0279 21 DA CD   0905 WAIT LXI H,VMBAS+474
027C 11 94 05   0910 LXI D,MSG
027F CD 64 05   0915 CALL PRINT
0282 21 14 CE   0920 LXI H,VMBAS+532
0285 11 A2 05   0925 LXI D,MSG2
0288 CD 64 05   0930 CALL PRINT
028B 21 D0 CF   0935 LXI H,VMBAS+976
028E 11 70 05   0940 LXI D,MSG1
0291 CD 64 05   0945 CALL PRINT
0294 CD D0 01   0950 IN1 CALL STATUS
0297 CA 94 02   0955 JZ IN1
029A CD D6 01   0960 CALL INP
029D FE 30      0965 CPI '0'
029F CA 00 00   0970 JZ OH ;REBOOT CP/M
02A2 FE 31      0975 CPI '1'
02A4 CA B9 02   0980 JZ FAST
02A7 FE 32      0985 CPI '2'
02A9 CA CD 02   0990 JZ MED
02AC FE 33      0995 CPI '3'
02AE CA C7 02   1000 JZ SLOW
02B1 FE 34      1005 CPI '4'
02B3 CA CE 02   1010 JZ SPASTIC
02B6 C3 79 02   1015 JMP WAIT ;GOT A BAD CHAR
02B9 21 19 00   1020 FAST LXI H,19H
02BC 22 6E 05   1025 SHLD SPEED ;HERE WE SET PARAMETERS FOR DELAY LOOP
02BF C9         1030 RET
02C0 21 24 00   1035 MED LXI H,24H
02C3 22 6E 05   1040 SHLD SPEED
02C6 C9         1045 RET
02C7 21 32 00   1050 SLOW LXI H,32H
02CA 22 6E 05   1055 SHLD SPEED
02CD C9         1060 RET
02CE 21 38 00   1065 SPASTIC LXI H,38H
02D1 22 6E 05   1070 SHLD SPEED
02D4 C9         1075 RET
02D5 2A F6 02   1080 TOPB LHL CORNR
02D8 7C         1085 MOV A,H
02D9 FE 0C      1090 CPI 0CCH ;TOP 2 DIGITS OF VMBAS
02DB CA E4 02   1095 JZ TOP
02DE FE 0F      1100 CPI 0CFH ;BOTTOM OF SCREEN
02E0 CA EB 02   1105 JZ BOT
02E3 C9         1110 RET

```

Listing 1 continued on page 160

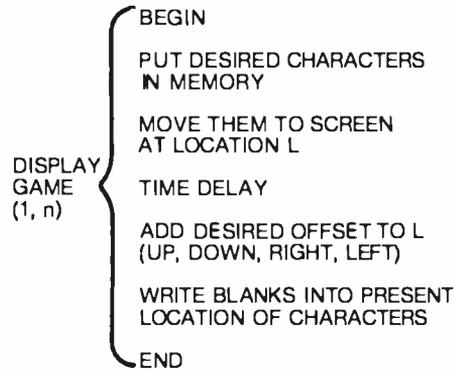


Figure 1: A Warnier-Orr diagram describing the steps involved in simulating motion.

Text continued:

rewrite its screen, so the programmer might think that computer games could represent extremely smooth movement.

However, the movement has to be represented in finite increments, which will be determined by the minimum distance between the characters or points that can be written on the screen. In the case of a typical video display board which can put 1024 characters on the screen, the user must move in increments of $\frac{1}{16}$ th the height of the screen when moving vertically and $\frac{1}{16}$ th the width of the screen when moving horizontally. This means that the movement will necessarily be a little jerky, but smooth enough for games.

The whole essence of writing an animated game is to put a picture on

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Microsoft's Level III BASIC is an enhancement to the Level II, loading from a cassette tape right on top of the Level II ROM. It contains all Disk BASIC features not already in Level II, except for file management commands. And it adds six new Level III exclusives not available in Level II or Disk BASIC.

No one knows better than Microsoft how to increase your TRS-80's BASIC power. Microsoft created the TRS-80 Level II and Disk BASIC plus the industry standard Microsoft BASIC.

Advanced graphics is Level III's most exciting addition to the TRS-80—and it's exclusive. Draw a line, outline or solid box by specifying just two points, then save it and put it back with BASIC statements. You'll find yourself writing more programs with charts, graphs and even animation.

Other Level III exclusives include 26 user-definable single stroke instructions so you can enter any command, statement or string with a shift-key entry. New SAVE and LOAD commands improve the reliability of loading tape programs by eliminating problems with cassette recorder volume sensitivity. Aggravating keyboard bounce is also eliminated. INPUT # LEN and LINE INPUT # LEN statements allow you to write programs with a time limit. And, joy of joys, Level III has automatic line renumbering.

TRS-80 power increases with Level III's seven Disk BASIC features. Ten user-defined subroutines can be used in a program. Error messages are spelled out. LINE INPUT instruction accepts punctuation marks within a string and eliminates the automatic "?" from the INPUT

prompt. A more flexible MID\$ increases string manipulation power. INSTR function searches a string for a specified substring. And Level III performs hex and octal conversion.

Level III even adds new capabilities to a TRS-80 system with an expansion interface by outputting to the RS-232 port in BASIC and setting and reading time and date from BASIC.

Level III occupies only 5.2K RAM with something for every TRS-80 from the 16K Level II minimum system requirement and up. It can be stored on disk as a file, but it only works in conjunction with Level II; it will not operate with Disk BASIC. Programs written in Level III BASIC are stored on cassette tape.

The users manual is full of how-to-use descriptions, sample programs and a complete graphics section. The reference card provides a quick-find list of commands, statements, functions and other Level III features. Manual, reference card and Level III cassette tape for only \$49.95.

Microsoft Level III BASIC is sold at Computer retailers nationwide. If your local computer store doesn't have Level III, ask them to call us. You can call us, too, for the name of your nearest Microsoft dealer. Phone (206) 454-1315. Or write Microsoft Consumer Products, 10800 Northeast Eighth, Suite 819, Bellevue, WA 98004

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Listing 1 continued:

```

02E4 21 40 00      1115  TOP  LXI  H,64
02E7 22 F4 02      1120  SHLD  UD
02EA C9            1125  RET
02EB 21 C0 FF      1130  ROT  LXI  H,-64
02EE 22 F4 02      1135  SHLD  UD
02F1 C9            1140  RET
02F2 00 00         1145  LR   DV  0
02F4 00 00         1150  UD   DV  0
02F6 1E CL         1155  CORN: LX: 0CE1H ;STARTS AT MIDDLE OF SCR#
02F8 10           1160  WAIT DB  10H ;SHIP GRAPHICS
02F9 90           1165  DADR DB  90H
02FA 3C           1170  LEAD DB  3CH
02FB 3E           1175  REED DB  3EH
02FC 00           1180  BIRD DC  0
02FD 00           1185  BIRD DB  0
02FE 00 00         1190  BIRD DV  0
0300 3A A3 03      1195  PEAL LDA  C1
0303 FE 01         1200  CPI  1
0305 CA 3D 03      1205  JZ   SHOT1
0308 CD A4 03      1210  CALL RND
030B D6 F0         1215  SUI  OFG#
030D D8            1220  RC
030E 87            1225  ADD  A
030F 87            1230  ADD  A
0310 5F            1235  MOV  E,A
0311 16 00         1240  MVI  D,0
0313 21 C0 CF      1245  LXI  H,SCOT ;MIDDLE OF BOTTOM OF SCR#
0316 19            1250  DAD  D
0317 22 45 04      1255  SHLD PLOC1
031A 36 18         1260  MVI  H,18H
031C 23            1265  INX  H
031D 36 18         1270  MVI  H,18H
031F 23            1275  INX  H
0320 36 18         1280  MVI  H,18H
0322 11 BF FF      1285  LXI  D,-65
0325 19            1290  DAD  D
0326 36 96         1295  MVI  H,96H
0328 11 C0 FF      1300  LXI  D,-64
032B 19            1305  DAD  D
032C 19            1310  DAD  D
032D 22 A1 03      1315  SHLD PY1
0330 3E 01         1320  MVI  A,1
0332 32 A3 03      1325  STA  G1
0335 AF            1330  XRA  A
0336 32 47 04      1335  STA  BFIG1
0339 CD 98 03      1340  CALL GFF1
033C C9            1345  RET
033D CD 0F 05      1350  SHOT1 CALL JETON:
0340 CD 8E 03      1355  CALL QH
0343 CD D6 03      1360  CALL RZD4
0346 FE 01         1365  CPI  1
0348 CA EB 04      1370  JZ   JET1
034B FE 02         1375  CPI  2
034D CA EB 04      1380  JZ   JET1
0350 2A A1 03      1385  TEND LHD) PY1
0353 22 C7 03      1390  SHLD B1.1
0356 3E 01         1395  MVI  A,1
0358 32 9E 03      1400  STA  FIG1
035B CD DC 03      1405  CALL RND4

```

Listing 1 continued on page 164

the screen, leave it there for a short length of time, then write blanks over the parts wanted to be moved and re-write them in the next space of the motion sequence. After another delay, the process is repeated. It does not take much thinking to realize that the main body of the game will be a loop with these essential elements, plus whatever keyboard checking, score updating, message displaying, and the like are wanted as the game progresses.

This lends itself to a fairly modular program structure (see figure 1). The program I am going to use to illustrate this process is quite simple; elaborate discussion of program logic. Let us start with a description of the program from the point of view of a player.

Let us write a program in which the player flies a motorized delta-wing over his friend's backyard computer-controlled peashooter. The peashooter fires a pea and a water jet at you as you cruise past. When you are hit the peashooter receives 100 points. You try to position yourself directly over your friend's backyard and drop a water balloon on the peashooter. If you hit him with the balloon, you receive 100 points. To make it interesting, we will have the gunner appear and disappear at random times and places.

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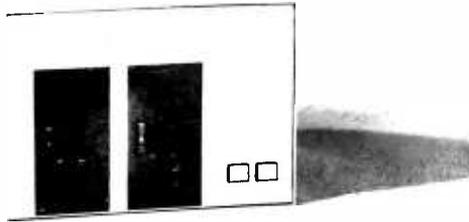
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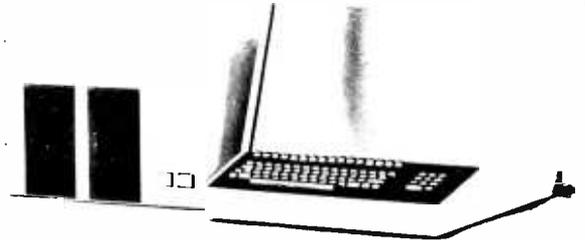
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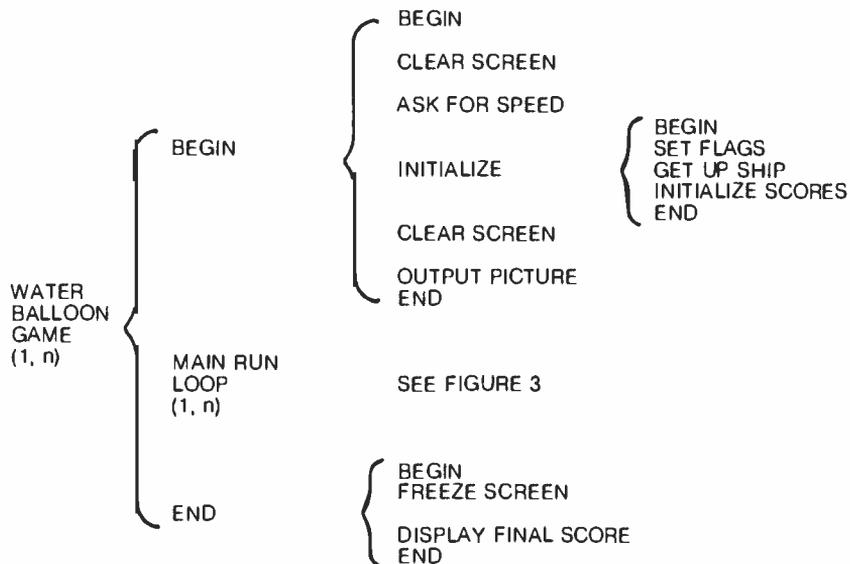


Figure 2: The modular components of the balloon game.

assembler, consider what functions must be added to those in figure 1 to round out the whole game. To get everything ready to play, an initialization routine is needed to clear the screen, set the scores to 0, and so on. After waiting for the player to set the speed, put the delta-wing on the screen, give him a chance to get his fingers on the buttons and survey the situation, and then we will enter the main loop.

The main loop, figure 2, will contain the functions described before; it will put the peashooter and ship on, leave them there for a short time, then write blanks over them and rewrite them, in a new location if required. In addition, there will be keyboard checks to see if the player has fired his acceleration rockets to change the movement of the delta-wing, and update the score. Check for hits by a water balloon or peashooter and see if a water balloon is being dropped. Move the peas and water jet which are being fired, and put on impact marks if any hits have been scored.

Figure 3 summarizes the functions performed in the main loop, and names the subroutines which perform those functions. There are a number of possible changes that could be made in this program to tailor the program to the user's personal taste. The programmer should be able to figure out where to put the wrench by reference to the diagrams and the comments in the listing.

Most of the housekeeping functions of this program are no different from those found in any assembly-language program, so it will be assumed that the user can find the way through those, but a few more comments about the animation techniques might be worthwhile. For an illustration, follow the progress of a pea fired from the peashooter.

Starting at line 1195 the program checks to see if a peashooter is on the screen, since you want peas to come only from a real peashooter. If one is there, jump to SHOT1, where you check to see if a water jet is already on the screen (water jets last for two

Text continued on page 168



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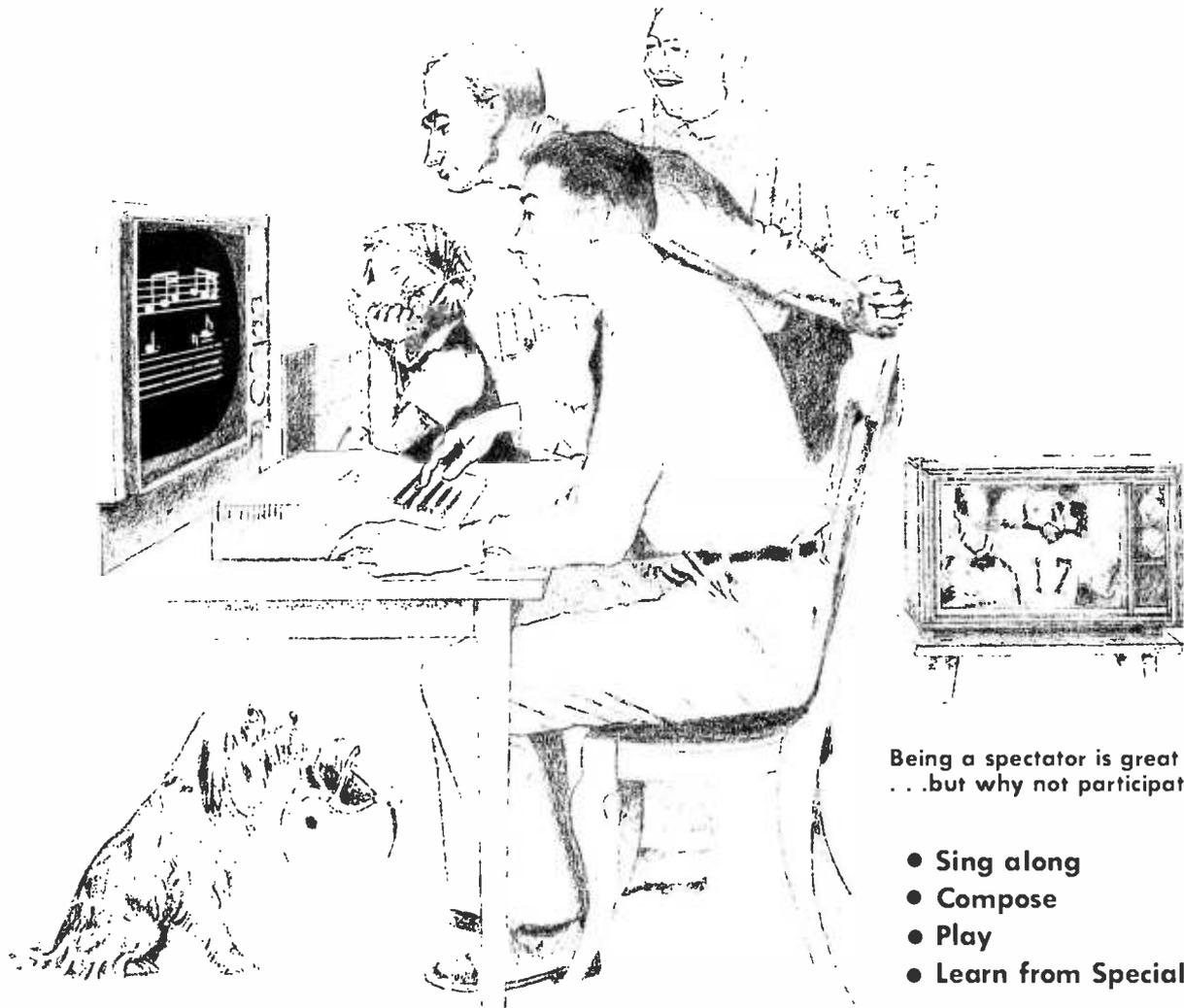
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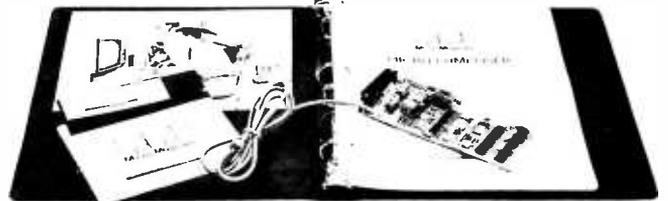
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Listing 1 continued:

035E 5F	1410	MOV	E,A
035F 16 00	1415	MVI	D,0
0361 21 BB FF	1420	LXI	H,-C9
0364 19	1425	DAD	D
0365 22 9F 03	1430	SHLD	HXCH
0368 2A 9F 03	1435	SHLD	HXCH
036B ES	1440	PUSH	H
036C 01	1445	POP	D
036D 2A C7 03	1450	SHLD	BL1
0370 36 20	1455	MVI	H, ' '
0372 01 40 00	1460	LXI	B,64
0375 09	1465	DAD	B
0376 36 20	1470	MVI	H, ' '
0378 2A C7 03	1475	SHLD	BL1
037B 19	1480	DAD	D
037C 7C	1485	MOV	A,H
037D FE CB	1490	CPI	0CDH ;MISSILE IS OFF TOP OF SCREEN
037F CA 96 03	1495	JZ	OFF1
0382 16 07	1500	MVI	(1,07)H
0384 22 C7 03	1505	SHLD	BL1
0387 11 40 00	1510	LXI	D,64
038A 19	1515	DAD	D
038B 36 0A	1520	MVI	M,0AH
038D C9	1525	RET	
038E 3A 9E 03	1530	ORL	LDA
0391 FE 01	1535	CPI	1
0393 C0	1540	RZC	
0394 F1	1545	POP	PSH
0395 C3 6E 03	1550	JMP	SHL1
0398 3E 00	1555	JFF1	MVI
039A 32 9E 03	1560	STA	FLG1
039D C9	1565	RET	
039E 00	1570	FLG1	DB
039F 00 00	1575	HXCH	DB
03A1 00 00	1580	PY1	DB
03A3 00	1585	G1	DB
03A4 21 C0 03	1590	RND	LXI
03A7 EB	1595	XCIC	;REPEAT FOR 40,000 TRIES
03AB 21 C2 03	1600	LXI	H,(RND)
03AB 7E	1605	MOV	A,H
03AC 3C	1610	INR	A
03AD 0F	1615	RRC	
03AE 47	1620	MOV	B,A
03AF 1A	1625	LDAX	D
03B0 07	1630	RLC	
03B1 80	1635	ADD	B
03B2 77	1640	MOV	H,A
03B3 78	1645	MOV	A,B
03B4 12	1650	STAX	D
03B5 C9	1655	RET	
03B6 CD 7A 03	1660	RND4	CALL
03B9 1F	1665	RFR	
03BA 1F	1670	RAR	
03BB E6 07	1675	ANI	7
03BD C6 01	1680	ADI	1
03BF C9	1685	RET	
03C0 00 00	1690	RNDM	DB
03C2 00 00	1695	RND1	DB
03CA C3 50 03	1700	SHLD	JMP

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03C7	C0	CF	1705	CLL	DI	SCXGT
03C9	3A	47	1710	FXZCH	LDA	BFLG
03CC	FC	01	1715		CPI	1
03CE	CD		1720		RZ	
03CF	3A	EA	1725		LDA	STRIF
03D2	FE	01	1730		CPI	1
03D4	CD		1735		FZ	
03D5	2A	45	1740	LHLD	PLCC1	
03D8	7E		1745	MOV	A,H	
03D9	FE	20	1750		CPI	' '
03DB	CA	ED	1755		JZ	XPLD1
03DE	23		1760		INX	H
03DF	7E		1765		MOV	A,H
03E0	FE	20	1770		CPI	' '
03E2	CA	ED	1775		JZ	XPLD1
03E5	23		1780		INX	H
03E6	7E		1785		MOV	A,H
03E7	FE	20	1790		CPI	' '
03E9	CA	ED	1795		JZ	XPLD1
03EC	C9		1800		RET	
03ED	22	24	1805	XPLD1	SHLD	BLO ; A VERY DUMB-LOOKING EXPLOSION
03F0	3E	01	1810		MVI	A,1
03F2	32	47	1815		STA	BFLG
03F5	3E	2B	1820		MVI	A,'+' ; THESE ARE CHARACTERS WHICH INDICATE A HIT
03F7	CD	2G	1825		CALL	BLOP
03FA	CD	6A	1830		CALL	DELAY
03FD	3E	23	1835		MVI	A,'#'
03FF	CD	2G	1840		CALL	BLOP
0402	CD	6A	1845		CALL	DELAY
0405	3E	20	1850		MVI	A,' '
0407	CD	2G	1855		CALL	BLOP
040A	2A	C7	1860		LHLD	DL1
040D	77		1865		MOV	H,A
040E	01	40	1870		LXI	B,G
0411	09		1875		DAD	B
0412	77		1880		MOV	H,A
0413	3E	00	1885		MVI	A,0
0415	32	A3	1890		STA	G1
0418	3A	89	1895		LDA	PSCR
041B	C6	01	1900		ADI	1
041D	32	89	1905		STA	PSCR
0420	32	9E	1910		STA	FLG1
0423	C9		1915		RET	
0424	00	00	1920	BLC1	DW	0
0426	06	05	1925	BLOP	MVI	B,5
0428	2A	24	1930		LHLD	BLO ;
042B	11	FC	1935		LXI	D,-4
042E	19		1940	DLP1	DAD	D
042F	77		1945		MOV	H,A
0430	23		1950		INX	H
0431	77		1955		INX	H,A
0432	23		1960		INX	H
0433	77		1965		MOV	H,A
0434	23		1970		INX	H
0435	77		1975		MOV	H,A
0436	77		1980		MOV	H,A
0437	23		1985		INX	H
0438	77		1990		MOV	H,A
0439	23		1995		INX	H
043A	77		2000		MOV	H,A
043B	23		2005		INX	H
043C	77		2010		MOV	H,A
043D	11	BA	2015		LXI	D,-70
0440	05		2020		DCR	D
0441	C8		2025		RZ	
0442	C3	2E	2030		JMP	BLP1
0445	C0	CF	2035	PLCC1	DW	SCXGT
0447	00		2040	BFLG1	DE	0
0448	7E		2045	INX	A,H	' '
0449	FE	20	2050		CPI	' '
044B	C0		2055		RZ	
044C	FE	10	2060		CPI	10H
044E	C0		2065		RZ	
044F	FE	90	2070		CPI	90H
0451	C0		2075		RZ	
0452	FE	3C	2080		CPI	3CH
0454	C0		2085		RZ	
0455	FE	3E	2090		CPI	3EH
0457	C0		2095		RZ	
0458	22	24	2100	SHLD	BLO ;	
045B	3E	2A	2105		MVI	A,'*'
045D	CD	26	2110		CALL	BLOP
0460	CD	6A	2115		CALL	DELAY
0463	3E	4F	2120		MVI	A,'G'
0465	CD	2G	2125		CALL	BLOP
0468	CD	6A	2130		CALL	DELAY
046B	3E	20	2135		MVI	A,' '
046D	CD	26	2140		CALL	BLOP
0470	3A	88	2145		LDA	PSCR
0473	C0	01	2150		ADI	1
0475	J2	88	2155		STA	PSCR
0478	21	00	2160		LXI	H,0

Listing 1 continued on page 166

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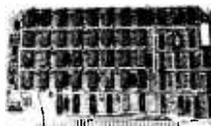
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047B 22 F4 02      2165  SHLD  UD
047E 22 F2 02      2170  SHLD  LR
0481 21 1E CE      2175  LXI   H,MIDL
0484 22 F6 02      2180  SHLD  CORNR
0487 C9             2185  RET
0488 00             2190  MSCR  DB  0
0489 00             2195  PSCR  DB  0
048A 21 04 CC      2200  SCORE LXI   H,VDMBAS+4
048D 11 BC 05      2205  LXI   D,BLMSG
0490 CD 64 05      2210  CALL  PRINT
0493 23             2215  INX   H
0494 3A 89 04      2220  LDA   PSCR
0497 CD AB 04      2225  CALL  SCOUT
049A 21 30 CC      2230  LXI   H,VDMBAS+40
049D 11 C4 05      2235  LXI   D,TMMSG
04A0 CD 64 05      2240  CALL  PRINT
04A3 23             2245  INX   H
04A4 3A 88 04      2250  LDA   MSCR
04A7 CD AB 04      2255  CALL  SCOUT
04AA C9             2260  RET
04AB FE 0A         2265  SCOUT CPI  0/NI ;A VERY DUMB HEX-TO-DECIMAL CONVERTOR
04AD D2 BA 04      2270  JNC   LTR
04B0 C6 30         2275  ADI   30H
04B2 77           2280  MOV   M,A
04B3 23           2285  INX   H
04B4 36 30         2290  MVI   M,30H
04B6 23           2295  INX   H
04B7 36 30         2300  MVI   M,30H
04B9 C9           2305  RET
04BA FE 14         2310  LTR  CPI  20
04BC D2 CC 04      2315  JNC   TWEN
04BF 36 31         2320  MVI   M,31H
04C1 23           2325  INX   H
04C2 C6 26         2330  ADI   38
04C4 77           2335  MOV   M,A
04C5 23           2340  INX   H
04C6 36 30         2345  MVI   M,30H

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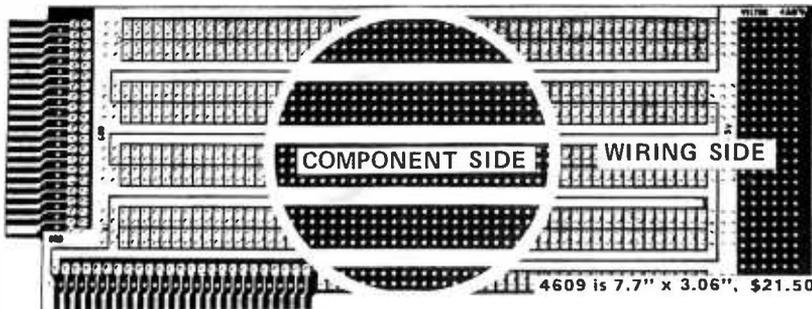
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04C8 23           2350  INX   H
04C9 36 30         2355  MVI   M,30H
04CB C9           2360  RET
04CC 36 32         2365  TWEN MVI   M,32H
04CE 23           2370  INX   H
04CF C6 1C         2375  ADI   28
04D1 77           2380  MOV   M,A
04D2 23           2385  INX   H
04D3 36 30         2390  MVI   M,30H
04D5 23           2395  INX   H
04D6 36 30         2400  MOV   M,30H
04D8 FE 35         2405  CPI   35H
04DA CA DE 04      2410  JZ    OVER
04DD C9           2415  RET
04DE 21 96 CD      2420  OVER LXI   H,VDMBAS+400
04E1 11 CC 05      2425  LXI   D,FIMMSG
04EA CD 64 05      2430  CALL  PRINT
04E7 C3 0B 01      2435  JMP   BEGIN
04EA 00           2440  STIMP DB  0
04EB 36 03         2445  JETI MVI   A,3
04ED 32 30 05      2450  STA   RAFL
04F0 CD B6 03      2455  CALL  NIDA
04F3 5F           2460  MOV   E,A
04F4 16 00         2465  MVI   D,0
04F6 21 BE FF      2470  LXI   H,-66
04F9 19           2475  DAD   D
04FA 22 9F 03      2480  SHLD INCD1
04FD 2A 9F 03      2485  SHLD INCD1
0500 E5           2490  PUSH H
0501 D1           2495  POP  D
0502 2A A1 03      2500  SHLD PY1
0505 06 0C         2505  MVI   B,12
0507 19           2510  DAD   D
0508 36 04         2515  MVI   M,4
050A 05           2520  DCR  B
050B C2 07 05      2525  JNZ  RX2
050E C9           2530  RET
050F 3A 30 05      2535  JETON LDA  RAFL
0512 FE 01         2540  CPI   1
0514 C8           2545  RZ
0515 3D           2550  DCR  A
0516 32 30 05      2555  STA  RAFL
0519 FE 01         2560  CPI   1
051B C2 31 05      2565  JNZ  RNS
051E 2A 9F 03      2570  SHLD INCD1
0521 E5           2575  PUSH H
0522 D1           2580  POP  D
0523 2A A1 03      2585  SHLD PY1
0526 06 0C         2590  MVI   B,12
0528 19           2595  DAD   D
0529 36 20         2600  MVI   M,20H
052B 05           2605  DCR  B
052C C2 28 05      2610  JNZ  RX3
052F C9           2615  RET
0530 01           2620  RAFL DB  1
0531 F1           2625  RNS POP  PSW
0532 F1           2630  POP  PSW
0533 C3 4C 01      2635  JMP  INTRP
0536 CD A4 03      2640  PENOP CALL  RD
0539 D6 D2         2645  SUI  0D2H
053B D8           2650  RC
053C D6 03         2655  SUI  3
053E D0           2660  RNC
053F 2A 45 04      2665  SHLD PLOC1
0542 06 20         2670  MVI   D,20H
0544 70           2675  MOV  M,B
0545 23           2680  INX  H
0546 70           2685  MOV  M,E
0547 23           2690  INX  H
0548 70           2695  MOV  M,B
0549 11 BF FF      2700  LXI  D,-65
054C 19           2705  DAD  D
054D 70           2710  MOV  M,B
054E AF           2715  XRA  A
054F 32 A3 03      2720  STA  G1
0552 32 9E 03      2725  STA  PLOC1
0555 3E 01         2730  MVI  A,1
0557 32 47 04      2735  STA  EFLG1
055A 2A C7 03      2740  SHLD D11
055D 70           2745  MOV  M,B
055E 11 40 00      2750  LXI  D,64
0561 19           2755  DAD  D
0562 70           2760  MOV  M,B
0563 C9           2765  RET
0564 1A           2770  PRIMP LDAX D
0565 FE 00         2775  CPI  0
0567 C6           2780  RZ
0568 77           2785  MOV  M,A
0569 23           2790  INX  H
056A 13           2795  INX  D
056B C3 64 05      2800  JMP  INTRP
056E 00 00         2805  SPEED DA  0

```



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Listing 1 continued on page 168

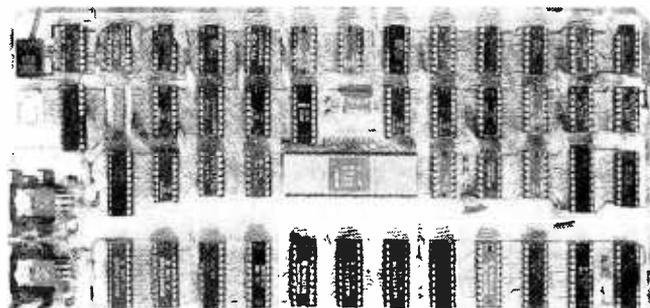
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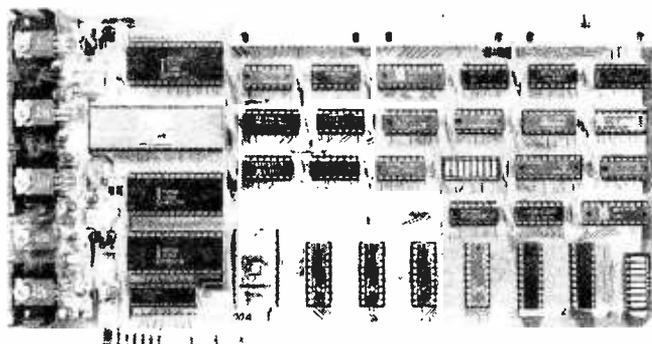
8086 CPU

This card brings state-of-the-art performance to the S-100 bus. It may be used to upgrade existing 8-bit systems by "swapping" the CPUs or it may form the foundation for a high performance 16-bit system. It will operate with 8-bit, 16-bit, or mixed memory and peripherals. It has a 1-megabyte addressing range. It can be factory upgraded at nominal cost from 4 Mhz. to 8 Mhz. when the faster CPU chip is available. Price — \$895.



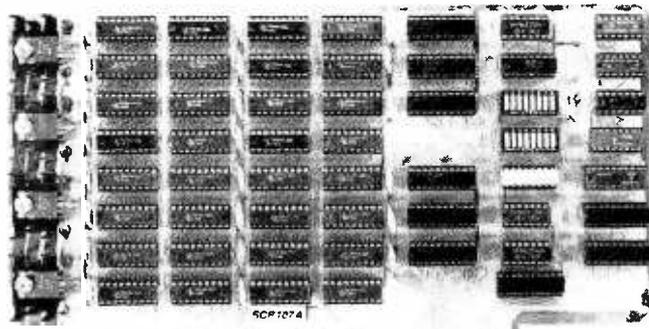
CPU Support Card

This is a companion to our 8086 CPU. It includes a 2K monitor with machine language debugger and disk bootstrap loader, serial port with software-selected baud rate, time-of-day clock with battery backup capability, two general purpose timers/counters, and a vectored interrupt controller with 7 interrupts generated on board and 8 accepted from the bus. Price — \$395.



8/16 Memory Card

Through the use of the sXTRQ line of the proposed IEEE Standard, this memory board will appear to be 8K by 16 bits to our 8086 CPU or 16K by 8 bits to 8-bit CPUs. It is offered with 250 nsec. memory chips only and will perform without wait states with our 8086 CPU using an 8 Mhz. clock. It has 24-bit extended addressing. Price — \$595.



(Prototypes shown)

Z80/8086 Cross Assembler

This cross assembler runs under CP/M and its derivatives. Its mnemonics are the same as or similar to Intel's ASM-86. It is available in 5" soft-sectored, 5" North Star, or 8" soft-sectored (IBM) formats. Price — \$250.

Microsoft BASIC-86

Microsoft's BASIC interpreter for the 8086 is essentially identical in features to their 5.0 release for the 8080 and is ANSI compatible. It is a "stand-alone" version and includes all disk and terminal I/O drivers. Programs written for any earlier version of Microsoft BASIC will run under BASIC-86 with little or no modification. Price — \$350.

MCS-86 User's Manual

By Intel — Feb., 1979, edition. This is the primary hardware and software reference manual for the 8086 CPU. Price — \$6.25. (Includes shipping)

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Listing 1 continued

```

0570 2A 2A 53 45      2610 18C3  AOC  ***GAS 24420 1 1000 00 10000000 ***
      54 70 55 50
      45 49 44 3C
      20 31 20 54
      40 52 55 20
      34 2C 20 31
      30 4C 41 53
      54 45 53 54
      20 2A 2A
0580 00              2615      M:      0
0594 2A 2A 20 42      2620 18C3  AOC  *** BELLMAN ***
      41 4C 4C 4F
      4F 4E 20 2A
      2A
05A1 00              2625      M:      0
05A2 43 6F 70 79      2630 18C2  AOC  *Copyright 1979 Tony Gately*
      72 69 67 6E
      74 20 33 39
      37 39 20 54
      6F 6E 74 20
      45 73 74 65
      70
05B0 00              2635      M:      0
05BC 44 52 4F 50      2640 18A8C  AOC  *UNRAFLK*
      50 45 52
      2645      M:      0
05C3 00              2650 18A8C  AOC  *SPOOFER*
05C4 53 48 4F 4F
      54 45 52
05CB 00              2655      M:      0
05CC 2A 2A 20 46      2660 18A8C  AOC  *** FDMAL 50386 ***
      49 4E 41 4C
      20 53 43 4F
      52 45 20 2A
      2A
05D0 00              2665      M:      0
05DE 2670 27AC  D6      50
0ALH 0226 08A# 026A 80C# 0108 014G1 0447
BLJ 0277 08A# 0279 8A#C 050C 18A1 0235
BLK1 0258 14AD 029C 08A# 027D 0LJ# 027C
BLNGC 0253 0LOP 0426 08A# 0426 0LJ# 042K
OOT 028D 0LQ# 0805 080# 0276 0W# 009#
0GLA1 026F 0CLAY 026# 0C# 021E 1A8T 0279
F1H8S 052C 18C1 039E 01 03A3 0L 0186
HTT 0448 2R1 0294 0LQ# 036F 0R# 0356
JCT1 048D 1C10# 050F 0C1# 0L10 1JZ 00A1
LEZF 0205 1A#D 027# 1P 0272 1YR 048A
HEB 02C0 1HDL 0C1C 1B#C1 0488 18C 0594
H8C1 0570 18C2 05# 0C#1 0398 18C 03#E
08A 0408 18A# 0300 18A# 02C9 18A# 053F
PLOC1 0445 1R1#T 0564 18C2 048# 1V1# 01#C
PY1 03A1 1A#L 0530 1A# 00#3 0R#D 027#
1R#R# 017# 1#D 03# 1#D1 03C2 1R# 03#8
R#R# 03C0 1A#T# 01#C 18C 05#7 10L 052#
18S 0531 18A#T 0C#D 08A# 048# 18A1 0183
SCOUT 04#D 2#H1 036# 0#E1 03C6 1#1# 018#
SPOF1 033# 18A1 02C7 0R#T# 02C2 1P#D# 056#
STACK 05DE 0T#T# 01#D 0T#T# 042# 1A#C# 01C3
T8P 035# 18A#C 05C4 18C 02E# 10#V 02#5
T8Q# 04C# 1A# 0097 18 027# 18 021#
V8#A 0C0# 1A#T 027# 18T# 027# 18L# 03#D

```

Text continued:

cycles, as you will see when you play). If there is no water jet there, then a random number test decides whether to shoot a pea or water jet. If it is a pea, control falls through to TEMP. This locates the starting point for the pea line and then sets the flag that tells the program that a pea is being fired. The program keeps track of that, since it will be on for several program cycles, until it makes a hit or goes off the screen.

Next, we determine the random direction of fire, and at last the program is ready to start the pea in motion. An increment is computed and stored at lines 1425 thru 1450.

Note at SHB1 that the user should reload the HL register pair with the same values that are already in it. This is a practice I always follow when I will be coming to an entry point from a number of different places. The idea is to eliminate parameter passing, or rather to pass the parameters through a named storage location, which makes it much easier to debug. Be that as it may, you can readily see how in the ensuing instructions, the heart of the matter is reached. Write hexadecimal 20 into the area occupied by the pea and its trail (hexadecimal 07 and 0A respectively in the Processor Technology video display module (VDM) character set), then add the increment. Check to see if it is off the screen, and if not put the characters into the new

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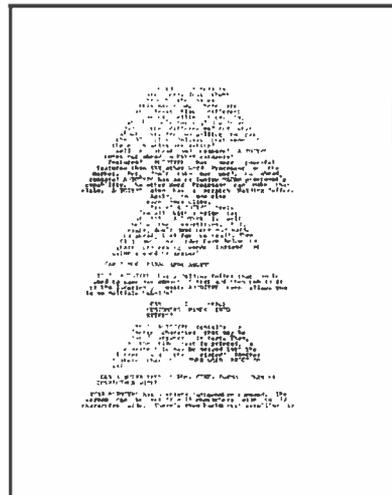
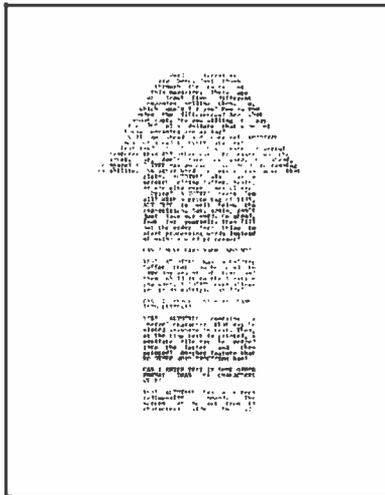
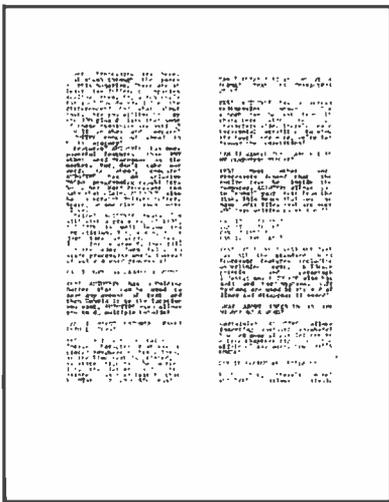
BONUS: An 8080 assembly file for a bi-directional print driver.

\$50: OOCMAIL system on 8" diskette, sample files and manual.

\$10: Manual only.

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Word Processors are here. Just thumb through the pages of this magazine. There are at least five different companies selling them. So, which one's for you? How do you judge the differences? And what about cost. Are you willing to pay the 300 plus dollars that some of the companies are asking?

Well go ahead and compare! AUTOTYPE comes out ahead in EVERY category!

Features? AUTOTYPE has more powerful features than ANY other Word Processor on the market. But, don't take our word. Go ahead, compare! AUTOTYPE has an exclusive MACRO programming capability. No other Word Processor can make that claim. AUTOTYPE also has a scratch Holding Buffer. Again, no one else even comes close.

Price? AUTOTYPE beats 'em all! With a price tag of \$195, AUTOTYPE is well below the competition. But, again, don't just take our word. Go ahead, look for yourself. Then fill out the order form below to start processing words instead of using a word processor!

CAN I MOVE PARAGRAPHS AROUND?

YES! AUTOTYPE has a Holding Buffer that can be used to save any amount of text and then Unhold it to the location you want. AUTOTYPE even allows you to do multiple Unholds!

CAN I MERGE CUSTOMERS NAMES INTO LETTERS?

YES! AUTOTYPE contains a "merge" character that may be placed anywhere in text. Then, at the time text is printed, a separate file may be merged into the letter and then printed! Another feature that NO OTHER WORD PROCESSOR has!

CAN I ENTER TEXT IN SOME OTHER FORMAT THAN 64 CHARACTERS WIDE?

YES! AUTOTYPE has a screen redimension command. The screen can be set from 16 characters wide to 120 characters wide. There's even horizontal scrolling to view the text! Once more, we're far beyond the competition!

CAN IT HANDLE TEXT LARGER THAN MY COMPUTERS MEMORY?

YES! Most other Word Processors demand that the entire text be inside the computer. AUTOTYPE allows you to "spool" your text from the disk. This means that you can have edit files that are over 200 type written pages long!

**CAN IT UNDERLINE?
CAN IT BOLDFACE?
CAN IT INDENT?
CAN IT HYPHENATE?**

YES! YES! YES! YES! AUTOTYPE has ALL the standard Word Processor features including underlining text, boldface printing and paragraph indentation. AUTOTYPE also has soft and hard hyphens. Soft hyphens are used at the end of lines and disappear if moved!

WHAT ABOUT INSERTING IN THE MIDDLE OF A WORD?

Certainly! AUTOTYPE allows inserting anything anywhere! You can move single letters or entire chapters right into the middle of any word. Now THAT'S POWER!

CAN IT SEARCH AND REPLACE?

YES! But, there's more! AUTOTYPE allows simple searches or search and replace. AUTOTYPE also allows wild card characters in the search string for probable matching! A very simple feature that AUTOTYPE makes very powerful!

CAN IT DO AUTOMATIC PAGE NUMBERING AND TITLING?

Of Course! Any length title up to the current line length. Page numbers can start anywhere. And if that's not enough, the number of blank lines below the title is adjustable!

DOES IT HAVE "DYNAMIC" PRINT FORMATTING?

OH YES! And with a flare! The pages that you see printed here were all printed from the same file. Only the print MACRO was altered. What's more, they were all printed on a standard serial printer. Complete "dynamic" print formatting can be accomplished with NO alteration of text! Let's see the competition make that claim!

CAN IT DO SUBSCRIPTS AND SUPERSRIPTS?

YES! Once again, AUTOTYPE has the features to be called a true processor of words and not just another word processor.

CAN IT VERTICAL TAB?

YES! And do negative vertical tabs to the top of page also! This is invaluable for two column printing.

CAN YOU ADJUST THE INDENT, LINE LENGTH AND JUSTIFICATION?

COMPLETELY! Either in the text itself, by manual formatting commands or with a print MACRO. Only AUTOTYPE gives you that kind of choice!

WILL IT EXECUTE A SERIES OF COMMANDS AUTOMATICALLY?

YES! That's one of AUTOTYPE's standard features. No other Word Processor has the ease of use or the powerful commands that AUTOTYPE has.

ARE THE TABS ADJUSTABLE?

All tabstops are displayed graphically with a simple command. Tab removal and setting are simple cursor movements and a single key command! No more "guessing" where your tabs are set. They're all laid out in front of you!

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*Available Nov-Dec of 1979

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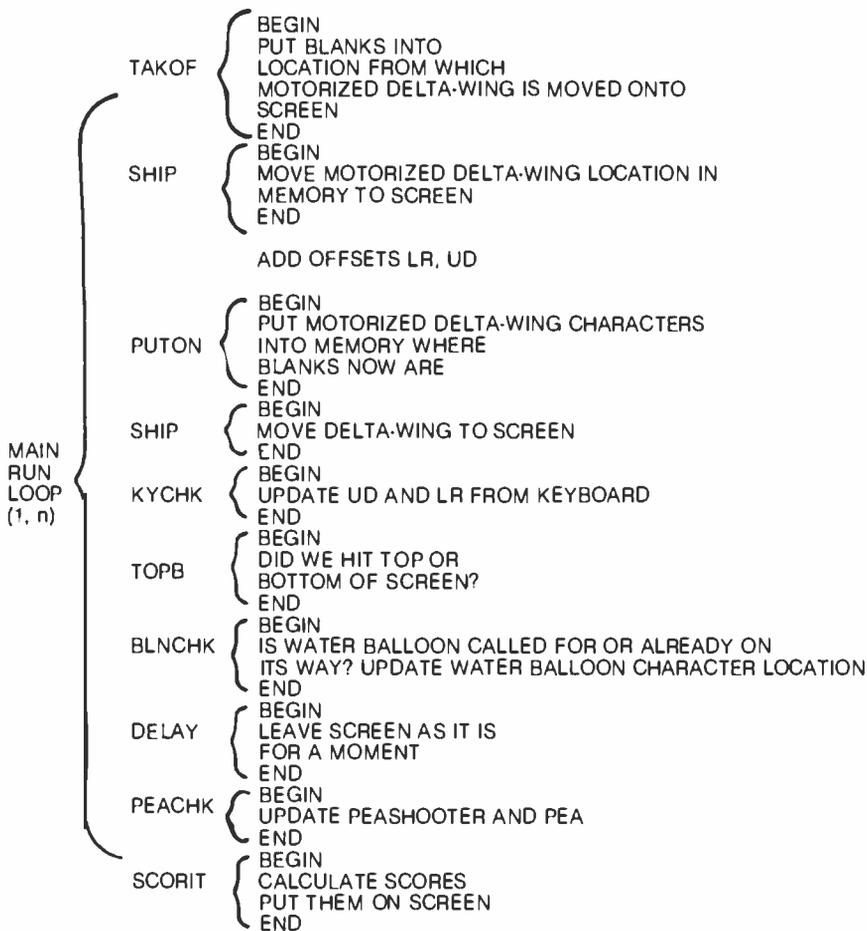


Figure 3: A summary of the functions performed in the main loop, along with a definition of the individual tasks executed by each subroutine.

locations, and return. Checking for a hit is done when the ship is displayed.

I hope that playing around with this program will prove to be as much fun for you as it was for me. In order to adapt it to your system, you may need to change the control keys, the clear routine, and the display location, but if you have a SOL-20 it will work as is. If you tackle the development of an animated game, you will find the simple principles embodied in this program will work in much more elaborate games. One final note: when you first play this, you will be positive that it is impossible to win. The "random" peashooter seems to have an incredible sixth sense about where to aim his pea. However, it can be done . . . in fact, my seven-year-old can beat it on speed 1, so hang in there! Good luck, and have fun. ■

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- 02 = *ENTER/PRINT INVOICES
- 03 = *ENTER PURCHASES
- 04 = *ENTER A/C RECEIVABLES
- 05 = *ENTER A/C PAYABLES
- 06 = ENTER/UPDATE INVENTORY
- 07 = ENTER/UPDATE ORDERS
- 08 = ENTER/UPDATE BANKS
- 09 = EXAMINE/MONITOR SALES LEDGER
- 10 = EXAMINE/MONITOR PURCHASE LEDGER
- 11 = EXAMINE/PRINT INCOMPLETE RECORDS
- 12 = EXAMINE PRODUCT SALES

SELECT FUNCTION BY NUMBER

- 13 = PRINT CUSTOMER STATEMENT
- 14 = PRINT SUPPLIER STATEMENTS
- 15 = PRINT AGENT STATEMENTS
- 16 = PRINT TAX STATEMENTS
- 17 = PRINT WEEK/MONTH SALES
- 18 = PRINT WEEK/MONTH PURCHASES
- 19 = PRINT YEAR AUDIT
- 20 = PRINT PROFIT/LOSS ACCOUNT
- 21 = UPDATE END MONTH FILES
- 22 = PRINT CASH FLOW FORECAST
- 23 = ENTER/UPDATE PAYROLL (NOT YET AVAILABLE)
- 24 = RETURN TO BASIC

WHICH ONE? (ENTER 1-24)

Each program goes to sub menu, e.g.:

- (9) allows: A LIST ALL SALES; B, MONITOR SALES BY STOCK CODES;
- C. RETRIEVE INVOICE DETAILS; D. AMEND LEDGER FILES;
- E. LIST TOTAL ALL SALES

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Now that you are the proud owner of one of the least expensive microprocessor kits, what can be done with it? Before that question is answered, why do you own the SC/MP to begin with? You may be someone interested in learning about microprocessors or computers, and since you are a cautious person of modest means, you have chosen to begin slowly.

No computer is useful unless it has a means of communicating with the outside world. The SC/MP is no exception. The SC/MP kit by itself provides no such capability. Thus, some sort of I/O (input/output) hardware must be obtained, such as a teletypewriter. This article assumes that you have the minimum of I/O hardware, probably a video display, which is likely to cost three times as much as the computer. (This is an important thing to know about computers. They are worse than automobiles because the accessories really account for most of the cost. This is even true with the big number-crunching computers).

The main limitation of such a system is it is not feasible to attempt to write very large programs. This is not only because of the SC/MP's rather meager amount of memory (256 bytes). It is also due to the fact that, without any means of assembling, editing, and backing up programs, it becomes humanly impossible to do any serious programming endeavors. For this reason, the programs in this article have been kept short and simple. For more ambitious readers, these programs can be combined or added to in order to accomplish more sophisticated tasks.

Input and Output on the SC/MP

A thorough search of the manuals provided with the SC/MP kit provides little information about programming input and output functions. Clearly, input and output are possible, because the KITBUG monitor program provided in read only memory is able to perform those functions. The assembly listing of KITBUG, which is provided in the *SC/MP Kit User's Manual*, shows how input and output are accomplished. The input and output portions of the monitor are located at the end of the listing, and occupy hexadecimal locations 186 thru 1FB of the read only memory (over 100 bytes).

The main reason those functions require so much coding is that the SC/MP has neither a parallel I/O port nor an internal universal asynchronous receiver/transmitter (UART), as a more sophisticated processor might. Instead, it is necessary to have a program which simulates the primary functions of a universal asynchronous receiver/transmitter, namely converting between parallel-byte data and asynchronous serial data (ANSI). For example, the output program transmits a 0 (note that the actual bits are inverted). This is the start bit. The program must then idle for 1/110 second because the transmission rate is 110 baud. The least significant bit (LSB) of the data byte is then transmitted, and the program again idles for 1/110 second. This is repeated until all data bits are transmitted. Finally, the program outputs a 1 and idles for 1/55 second for the 2 stop bits needed by a teletypewriter. For input, a similar procedure is operated in reverse.

After study of these programs, it should be possible to imitate these processes and incorporate them into our own programs. Although studying other people's programs is often a good way to learn how to program, copying these programs is not the best thing to do here.

As every good programmer knows, basic processes should be written in the form of subroutines which can be called from various places in the main program. This rule was followed by the writers of KITBUG, and all the various areas of the program assume the form of subroutines. These subroutines can be called from anywhere, including your own program area. In particular, there are 4 subroutines which are useful for all kinds of programs:

PUTC	This subroutine prints a single ASCII character on the output device.
GECO	This program reads 1 character typed in at the keyboard, and returns the ASCII code.
PHEx1 and PHEx2 GHEx	Here are 2 different entry points to a subroutine which converts a byte into a 2-digit hexadecimal number and prints it.
	This program reads a hexadecimal number of up to 4 digits, and returns the 16-bit value as 2 bytes.

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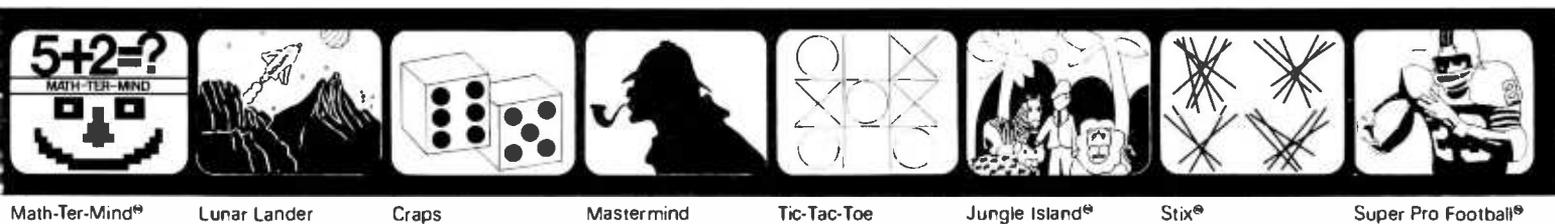
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Using System Subroutines

Before these subroutines can be used, or any subroutines written by someone else, you must be familiar with all of the usage conventions of the subroutines. These conventions include:

- how to call and return from the subroutine
- how to pass information back and forth
- special conventions, such as the saving and restoring of registers, temporary storage used, etc

The standard method for calling subroutines in KITBUG is to use pointer register 3 to contain the return address. This is done by loading pointer register 3 with the address of the subroutine. Then execute the instruction XPPC P3; this exchanges pointer register 3 and the program counter. This leads to the subroutine, and since the program counter value at the time of the call is saved in pointer register 3, the subroutine returns the same way it was called, with XPPC P3.

Of special note here is a peculiarity of the SC/MP processor. Most computers increment their program counters between the fetch and execute cycles. In the SC/MP, the program counter is incremented after the execute cycle. This is, in effect, the same as incrementing it just before the next fetch. The result is that whenever a jump is executed (such as the XPPC instruction), the effective address must be one less than the actual address where you want to jump. For example, the PUTC sub-

routine is located at hexadecimal 01C5, so when you call PUTC, you must load 1C4 into pointer register 3.

Note that after control has been returned from the subroutine, pointer register 3 no longer has its initial value. In fact, it has the last value that the program counter had in the subroutine, and thus points to the end of the subroutine. Normally this would mean that pointer register 3 would have to be reloaded in order to call the subroutine a second time. Actually, the writers of KITBUG foresaw this problem, and were kind enough to make life simple. Every return instruction (XPPC P3) is followed by a jump back to the beginning of the subroutine. This allows a subroutine to be called several times, merely by executing XPPC P3 instructions.

The second matter pertaining to subroutine calling conventions is concerned with how data is passed back and forth between the calling program and the subroutine. The first 3 of the subroutines, PUTC, GECO, and PHEX, deal only with a single byte of information. For these subroutines, the byte is simply passed by means of the accumulator. For example, PUTC prints a single character. When PUTC is called, the ASCII code of the character to be printed must be loaded into the accumulator, then the subroutine is called by executing XPPC P3. (It is assumed that pointer register 3 has already been set up.)

For example, the following program segment would cause an A to be displayed:

```
LDI    C4      ; this loads
XPAL   P3      ; 1C4 into pointer register 3
LDI    01      ; note 1C4 = 1C5 - 1
XPAH   P3      ; the location of PUTC
LDI    41      ; 41 is ASCII code for A
XPPC   P3      ; call PUTC
                          ; control is returned here
```

Subroutine GHEX is not quite as simple, because the data being transferred is a 16-bit quantity, and therefore will not fit in the accumulator. The answer to what GHEX does with its results lies in the third category of subroutine conventions: special conventions.

All of the subroutines in KITBUG use a special convention for dealing with temporary data, saving registers, etc. Note that KITBUG cannot use its own program area for storing data. KITBUG resides in read only memory. KITBUG must then be able to use some of the 256 bytes of programmable memory for its storage needs. It does this through a common storage area known as the *stack*. The stack is an array which holds data in a last-in-first-out fashion. The stack resides in the higher addresses of programmable memory, and advances downward as data is added. Pointer register 2 is used to point to the most recently added piece of information on the stack. Since all of the KITBUG subroutines use the stack, pointer register 2 may not be used except in carefully prescribed and compatible ways.

When the program is started, KITBUG loads pointer register 2 from locations OFFB and OFFC. (Note that because of the addressing overlap, these locations are the same as 02FB and 02FC.) Unless these locations are

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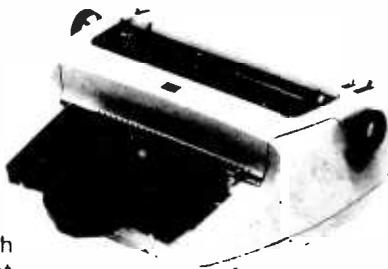
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modified, they will contain 0. Thus, pointer register 2 will initially be 0. When an item is stored on the stack, it is done with the instruction ST @-1(P2). Negative auto-indexing is performed before the effective address is computed. Therefore, the effective address is OFFF. (Note that borrows and carries do not propagate into the most significant 4 bits during effective address computation.) Since the address OFFF is the same as 02FF on the SC/MP, the stack will effectively start at the high end of the programmable memory and proceed downward. This is probably the best place for the stack anyway, so the best thing to do about initializing the stack is nothing.

Program 1: Output

The first program, listing 1, is a simple program which can be used for checking out the machine. It also illustrates how to use subroutine PUTC.

The program is written in an infinite loop and repeatedly prints a message. The message is stored in the form of an ASCII character string starting at location hexadecimal 0220. An ASCII code for 0 is used to terminate the message. Control characters such as carriage return and line feed must be included in the message. In

the example, the message is simply "HELLO." However, any message could be put in its place. If the I/O (input/output) device is a video display, rather than a teletypewriter, some interesting geometric patterns can often be formed by typing messages with random characters and control characters mixed together.

The functioning of the program is quite simple: locations 200 thru 205 set pointer register 1 equal to 0220, the beginning of the message string. Hexadecimal locations 0206 thru 020B set pointer register 3 to point to PUTC, the printout subroutine. At 020C a character is loaded into the accumulator. Auto-indexing is used, so that repeated executions of this instruction will cause successive characters to be fetched. At 020E there is a jump back to the beginning if the zero end code is reached; otherwise, PUTC is called at location 0210, which causes the character in the accumulator to be printed. Then jump back to 0206 to print the next character. (Note that as stated above, it is not necessary to reload pointer register 3 every time the subroutines are called. Therefore, there could be a jump to location 020C and the program would work just as well. This can be done by changing location 0212 to F9.)

Text continued on page 178

Listing 1: The program will print an ASCII message over and over. The message is a string of ASCII character codes followed by a 0.

```

1          .NLIST TTH
2          .TITLE PROGRAM #1
3          ;THIS PROGRAM PRINTS OUT A MESSAGE
4          ;OVER AND OVER FOREVER.
5          ;THE MESSAGE TAKES THE FORM OF
6          ;ANY STRING OF ASCII CHARACTER CODES
7          ;FOLLOWED BY A TERMINATION CODE OF ZERO
8
9          0200      C4 20  START: LD1  ^L<STRING>  ;P1 IS USED AS A
10         0202      31          XPAL P1           ;POINTER TO THE
11         0203      C4 02          LD1  ^U<STRING>  ;MESSAGE STRING
12         0205      35          XPAH P1
13         0206      C4 C4  LOOP:  LD1  ^L<PUTC>-1  ;P3 MUST BE ONE LESS
14         0208      33          XPAL P3           ;THAN THE ADDR/SS
15         0209      C4 01          LD1  ^U<P(UTC)  ;OF PUTC = IC5
16         020B      37          XPAH P3
17         020C      C5 01          LD  0(P1)       ;GET NEXT CHARACTER
18         020E      98 F0          ;Z START      ;ZERO IS END CODE
19         0210      3F          XPPC P3           ;OTHERWISE PRINT CHARACTER
20         0211      90 F3          JMP  LOOP      ;AND LOOP
21         0220      48 45          .,0220
22         0222      4C 4C  STRING: .ASCII /HELLO<CR><LF><0>
23         0224      4F 0D
24         0226      0A 00
25
26         0001      P1=X1
27         0002      P2=X2
28         0003      P3=X3
29         01C5      PUTC=01C5
30         000D      CR=0D
31         000A      LF=0A
32         0200      .END  START

```

SYMBOL TABLE

CR	= 000D	LF	= 000A	LOOP	0206
PUTC	= 01C5	P1	= X0001	P2	= X0002
P3	= X0003	START	0200	STRING	0220

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FREE CORE: 17525. WORDS

.PROG1=PROG1

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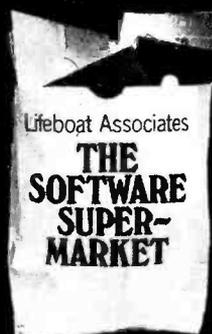
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Text continued:

In order to run this, or any program in this article, it is necessary to initialize the register save locations of KITBUG. These are OFF7 thru OFFF. (In the kit setup these are equivalent to 02F7 thru 02FF.) Locations OFF7 and OFF8 should contain 0200 (02 in OFF7, 00 in OFF8). The remaining locations, especially OFFB and OFFC (the stack initialization), should contain 0. Typing G to KITBUG then causes the program to run.

Program 2: Output and Input

The second program, listing 2, is much longer than the first, but is not conceptually more complex. This program combines some message printout with some input.

The program is designed to do the following: first, it prints out HELLO, I'M A COMPUTER, WHO ARE YOU? The computer then waits for a name to be typed, such as JOHN DOE. It responds HI, JOHN DOE, I'M PLEASSED TO MEET YOU, and jumps back to the monitor. The initialization registers are saved, so that the program can be rerun by simply typing G.

The input is managed by subroutine GECO. GECO is called by executing XPPC P3, as usual. Routine GECO waits until something is typed at the keyboard. It then returns to the program with the ASCII code for the character typed in the accumulator.

Printout for program 2 is handled by a subroutine of my own called PRINT. This is found starting at line 49 of the listing. PRINT is basically the same as program 1, but modified to have the form of a subroutine. Instead of looping endlessly, when done printing a message, it returns from where it was called. Note that PRINT calls PUTC. Whenever a subroutine calls another subroutine, pointer register 3 must be saved for the return. PRINT uses the stack for this purpose. Note the basic rules for using the stack. Whatever is added to the stack by a subroutine must be removed before exiting. PRINT uses pointer register 1 to point to the message it is printing. Pointer register 1 must be set by the main program before PRINT is called.

The first thing program 2 does is to save pointer register 3. The reason is that KITBUG treats the program as if it were a subroutine. Saving pointer register 3 makes it possible to return to KITBUG when it is done. There is a catch, however. Because of the peculiarity of how the SC/MP treats the program counter, KITBUG must subtract 1 from the number in memory locations OFF7 and OFF8 before using it as a jump address. Unfortunately, this will get you into a loop if you try to get subsequent entries to the program by typing G a second time. The problem is that KITBUG does not add 1 back on to the program counter value when you return. To get around this, put 200 into pointer register 3, and then return using an XPPC P1. This fools KITBUG into working properly. The rest of the program is straightforward, and consists of calls to PRINT and GECO.

To keep this program as short as possible, advantage was often taken of the fact that registers (particularly the high-order parts of pointer registers) already contain the right value. Thus, these registers are not reloaded. This saves 2 or 3 bytes of program here and there, and since the programs are being entered into the computer by

Listing 2: This program outputs a prompt, accepts some input, and then outputs another message which has your input embedded.

```

1          .NLIST TTY
2          .TITLE PROGRAM #2
3          :THIS PROGRAM TYPES A MESSAGE
4          :PROMPTING YOU TO TYPE SOMETHING.
5          :IT THEN ANSWERS WITH A MESSAGE
6          :WHICH HAS YOUR TYPEIN EMBEDDED.
7
8          0200          .#200
9          0200 C4 3E START: LDI ^L<PRINT>-1 ;SET UP TO
10         0203 CE FF XPAL P3 ;CALL THE
11         0205 C4 02 ST @-(P2) ;PRINT SUBROUTINE
12         0207 C7 02 LDI ^U<PRINT> ;BUT SAVE THE OLD
13         0208 CE FF XPAL P3 ;VALUE OF P3 ON
14         020A C4 60 ST @-(P2) ;THE STACK
15         020C C4 60 LDI ^L<MSG1> ;SET P1
16         020D C4 02 XPAL P1 ;TO POINT
17         020F C4 02 LDI ^U<MSG1> ;TO
18         0210 C4 3F XPAL P3 ;FIRST MESSAGE
19         0211 C4 85 XPPC P1 ;CALL PRINT
20         0213 C3 33 LDI ^L<GEOD>-1 ;SET UP
21         0214 C4 01 LDI ^U<GEOD> ;TO CALL
22         0216 C7 37 XPAL P3 ;INPUT ROUTINE
23         0217 C4 90 LDI ^L<MSG2> ;IN KITBUG
24         0219 C4 90 LDI ^L<MSG2> ;P1 POINTS TO INPUT
25         021A C4 3F LOOP: XPPC P3 ;BUFFER (HIGH PART OF P1 OK)
26         021B CD 01 ST @!(P1) ;CALL GEO
27         021D E4 0D XRI CR ;SAVE CHARACTER IN BUFFER
28         021F 9C F9 XNZ LOOP ;COMPARE WITH CR
29         0221 CD FF ST @-(P1) ;LOOP UNTIL CR TYPED
30         0223 C4 3E LDI ^L<PRINT>-1 ;CHANGE CR TO ZERO
31         0225 C3 33 XPAL P3 ;SET UP CALL
32         0226 C4 02 LDI ^U<PRINT> ;TO PRINT AGAIN
33         0228 C7 37 XPAL P3
34         0229 C4 B0 LDI ^L<MSG3> ;P1 POINTS TO MESSAGE 3
35         022B C4 31 XPAL P1 ;(HIGH PART OF P1 OK)
36         022C C4 3F XPPC P3 ;CALL PRINT
37         022D C4 90 LDI ^L<MSG2> ;P1 POINTS TO BUFFER
38         022F C4 31 XPAL P1 ;(HIGH PART STILL OK)
39         0230 C4 3F XPPC P3 ;CALL PRINT
40         0231 C4 C0 LDI ^L<MSG4> ;P1 POINTS TO MESSAGE 4
41         0233 C4 31 XPAL P1 ;(HIGH PART STILL OK)
42         0234 C4 3F XPPC P3 ;CALL PRINT
43         0235 C6 01 LD @!(P2) ;GET ORIGINAL P3 OFF
44         0237 C6 01 XPAL P1 ;STACK AND PUT IN P1
45         0238 C6 01 LD @!(P2) ;WE HAVE TO DO FUNNY
46         023A C4 31 XPAL P1 ;BUSINESS WITH P3 SO THAT
47         023B C4 00 LDI 0 ;IT WILL EQUAL 200
48         023D C4 33 XPAL P3 ;FOR RESTART (HIGH ORDER PART OK)
49         023E C4 3D XPPC P1 ;RETURN TO KITBUG
50         023F C4 C4 PRINT: LDI ^L<PUTC>-1 ;PRINT SUBROUTINE
51         0241 C4 33 XPAL P3 ;P3 IS SET TO PUTC
52         0242 CE FF ST @-(P2) ;BUT IS ALSO SAVED
53         0244 C4 01 LDI ^U<PUTC> ;ON STACK FOR
54         0246 C7 37 XPAL P3 ;RETURN
55         0247 CE FF ST @-(P2)
56         0249 C6 01 PLOOP: LD @!(P1) ;GET CHARACTER
57         024B 98 03 JZ POUT ;DONE IF ZERO
58         024D C4 3F XPPC P3 ;OTHERWISE CALL PUTC
59         024E 90 F9 JMP PLOOP ;AND LOOP
60         0250 C6 01 POUT: LD @!(P2) ;RESTORE
61         0252 C7 37 XPAL P3 ;P3
62         0253 C6 01 LD @!(P2) ;FROM
63         0255 C3 33 XPAL P3 ;STACK
64         0256 C4 3F XPPC P3
65         0257 90 E6 JMP PRINT ;J1
66         0259 90 E4 JMP PRINT ;JUMP BACK IF RECALLED
67
68         0260          .#260
69         0260 48 45 MSC1: .ASCII /HELLO, I'M A COMPUTER.<CR><LF>
70         0262 4C 4C
71         0264 4F 2C
72         0266 20 49
73         0268 27 4D
74         026A 20 41
75         026C 20 43
76         026E 4F 4D
77         0270 50 55
78         0272 54 45

```

Listing 2 continued on page 180

Listing 2 continued:

```

0274      52 2E
0276      0D 0A
69 027B      57 4B      .ASCIZ  /WHO ARE YOU?<CR><LF>
027A      4F 20
027C      41 52
027E      45 20
0280      59 4F
0282      55 3F
0284      0D 0A
0286      00
70      0290      MSG2=290
71      02B0      .#02B0
72 02B0      0A 0A      MSG3:  .ASCIZ  <LF><LF><LF><LF>/HI /
02B2      0A 0A
02B4      4B 49
02B6      21 20
02B8      00
73      02C0      .#02C0
74 02C0      2C 0D      MSG4:  .ASCIZ  /,<CR><LF>/I'M PLEASED TO MEET YOU./
02C2      0A 49
02C4      27 4D
02C6      20 50
02C8      4C 45
02CA      41 53
02CC      45 44
02CE      20 54
02D0      4F 20
02D2      4D 45
02D4      45 34
02D6      20 59
02DB      4F 55
02DA      2E 00
75      0001      P1=*1
76      0002      P2=*2
77      0003      P3=*3
78      000D      CR=0D
79      000A      LF=0A
80      01B6      GECO=*1B6
81      01C5      PUTC=*1C5
82      0200      .END      START

```

SYMBOL TABLE

CR	= 000D	GECO	= 01B6	LF	= 000A
LOOP	021A	MSG1	0260	MSG2	= 0290
MSG3	02B0	MSG4	02C0	PLOOP	0249
POUT	0250	PRINT	023F	PUTC	= 01C5
P1	*X0001	P2	*X0002	P3	*X0003
START	0200				

ERRORS DETECTED: 0

hand, it is worth it. However, in the broader sense of programming, taking advantage of these kinds of savings is not a good practice because it destroys the possibility of incorporating programs into a larger system.

Program 3: Time

The third program, listing 3, has some practical utility. It is a digital clock. The logic of the program is simple, consisting of one major loop containing a counter and a delay loop. The delay loop is adjusted so that the time around the entire loop is exactly 1 minute. The count is displayed each time through the loop.

This program was designed to produce output for a video display, so each line overwrites the previous line. The program could be modified to produce output on a teletypewriter, by adding a line feed to the output.

Output for this program uses the routine PHEX, which prints out the 2-digit hexadecimal numbers contained in the accumulator. In this case we are dealing with decimal, not hexadecimal, but since the SC/MP has decimal

instructions this only means that neither digit will be greater than 9.

PHEX has two entry points, PHEX1 and PHEX2, the difference being PHEX1 follows its output with a space, and PHEX2 does not. PHEX2 is generally used when a multi-byte number is to be printed. Here two 2-digit numbers for hours and minutes are being printed, so PHEX1 is used. This occurs in lines 8 thru 15 of the program.

The minutes are then incremented. When 60 is reached, go back to 0 and increment the hours. Thirteen hours gets reset to 1.

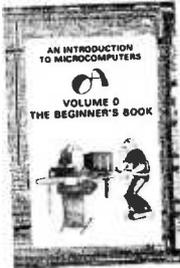
The program then delays for the remaining part of a minute, and then loops, printing out the next minute's time.

The delay is controlled by the numbers at locations 0228, 022C, and 022E. The numbers shown in the listing worked for the author's own setup, and kept time within a few seconds a day. The timing is controlled by the actual crystal frequency on the SC/MP board. Other

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Listing 3: Looping through several time delays is used to keep track of time. This program displays the time accurate to the minute.

```

1      .WLST TIM
2      .TITLE PROGRAM #3
3      :THIS PROGRAM DISPLAYS THE
4      :TIME OF DAY ON A CRT
5      :THE TIME IS RE-WRITTEN
6      :EVERY MINUTE
7
8      0200      .*200
9      0200      C4 3D START: LDI ^L(PREX1)-1 :GET ADDRESS
10     0202      33          XPAL P3          :OF NUMERIC
11     0203      C4 01          LDI ^U(PREX1) :PRINT ROUTINE
12     0205      37          XPAR P3          :IN P3
13     0206      C0 39          LD HOUR      :GET HOUR
14     0208      3F          XPPC P3          :CALL PBEX1
15     0209      C0 37          LD MINUTE     :GET MINUTE
16     020B      3F          XPPC P3          :CALL PBEX1
17     020C      C0 34          LD MINUTE     :GET MINUTE
18     020E      02          CCL             :CLEAR LINK
19     020F      EC 01          DAI          :ADD ONE
20     0211      CB 2F          ST MINUTE   :STORE NEW VALUE
21     0213      EC 40          DAI 40       :DOES MINUTE = 60?
22     0215      9C 10          JWZ DELAY    :NO SO DELAY ONE MINUTE
23     0217      CB 29          ST MINUTE   :MINUTE = 0
24     0219      C0 26          LD HOUR      :GET HOUR
25     021B      EC 00          DAI 0        :ADD 1 (LINK = 1)
26     021D      CB 22          ST HOUR     :HOUR = HOUR + 1
27     021F      EC 07          DAI 07       :IS HOUR = 13?
28     0221      9C 04          JWZ DELAY    :NO SO DELAY
29     0223      C4 01          LDI 1       :OTHERWISE
30     0225      CB 1A          ST HOUR     :HOUR = 1
31     0227      C4 1E          DELAY: LDI #1E :WE WILL DELAY
32     0229      CB 18          ST COUNT   :225 = (FF-1E) TIMES
33     022B      C4 22          DL: LDI 22    :THEN DELAY
34     022D      BF FF          DLY 0FF    :131070 MICRO CYCLES
35     022F      AB 12          ILD COUNT   :INCREMENT COUNT
36     0231      9C FB          JWZ DL     :LOOP UNTIL OVERFLOW
37     0233      C4 C4          LDI ^L(PTC)-1 :GET CHARACTER PRINT
38     0235      33          XPAL P3          :IN P3
39     0236      C4 0D          LDI CR     :LOAD CARRIAGE RETURN
40     0238      3F          XPPC P3          :CALL PTC
41     0239      90 C5          JMP START  :GO BACK TO THE BEGINNING
42
43     0240      HOUR=240
44     0241      MINUTE=241
45     0242      COUNT=242
46     000D      CR=0D
47     0001      P1=#1
48     0002      P2=#2
49     0003      P3=#3
50     013E      PBEX1=#13E
51     01C5      PTC=#1C5
52     .END START

```

SYMBOL TABLE

COUNT = 0242	CR = 000D	DELAY = 0227
DL = 022B	HOURL = 0240	MINUTE = 0241
PBEX1 = 013E	PTC = 01C5	P1 = #0001
P2 = #0002	P3 = #0003	START = 0200

ERRORS DETECTED: 0

crystals might require different settings. Location 022C has the fine setting; the other values give a coarser setting.

Programs 4 and 5: Calculation

Programs 4 and 5, listings 4 and 5, are designed to perform calculator-like arithmetic functions. Program 4 is an

adder, and program 5 is a multiplier. The functions were kept separate in order to make the programs simple; however, an enterprising reader could easily combine the functions into a single program, and even include subtraction and division.

Both programs use the decimal addition instruction, as did program 3. Multiplication is performed in a very sim-

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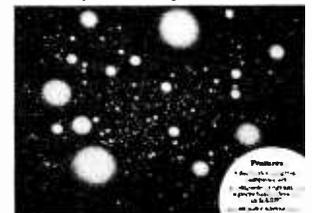
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Listing 4: Calculator functions can be easily programmed into the SC/MP. This routine inputs 2 numbers and outputs the sum.

```

1      .NLIST TTM
2      .TITLE PROGRAM #4
3      ;THIS PROGRAM ADDS
4      ;TWO NUMBERS. WHEN TYPED IN AS
5      ;"253+792"
6      ;INPUT HAS FOUR DIGIT MAX
7      ;OUTPUT IS FIVE DIGITS
8
9      @200      .#200
10     0200      C4 DF      START: LD1      ^L(GHEX)-1      ;SET P3
11     0202      33        XPAL      P3              ;TO ADDRESS
12     0203      C4 @0     LD1      ^L(GHEX)         ;OF
13     0205      37        XPAH      P3              ;GHEX
14     0206      3F        XPPC      P3              ;CALL GHEX TWICE
15     0207      3F        XPPC      P3              ;TO GET TWO NUMBERS
16     0208      02        CCL        ;CLEAR OLD CARRY
17     0209      C2 @1     LD        1(P2)           ;GET LOW HALF 2D NO
18     020B      EA @3     DAD        3(P2)           ;ADD TO LOW HALF 1ST NO
19     020D      CA @3     ST         3(P2)           ;STORE AT BOTTOM OF STACK
20     020F      C6 @2     LD        @2(P2)          ;GET HIGH HALF 2D NO
21     0211      EA @0     DAD        @1(P2)          ;AND BUMP STACK POINTER
22     0213      CA @0     ST         @1(P2)          ;ADD HIGH HALF 1ST NO
23     0215      C4 C4     LD1      ^L(PTC)-1        ;STORE ON TOP OF STACK
24     0217      33        XPAL      P3              ;P3 SET FOR CHARACTER PRINT
25     0218      C4 30     LD1      30              ;HIGH P3 IS OK (REALLY)
26     021A      F4 @0     ADI        0              ;GET ASCII @
27     021C      3F        XPPC      P3              ;ADD CARRY FOR FIFTH DIGIT
28     021D      C4 @3     LD1      ^L(PREX2)-1      ;PRINT @ OR 1
29     021F      33        XPAL      P3              ;P3 SET FOR BYTE PRINT
30     0220      C6 @1     LD        @1(P2)          ;POP HIGH BYTE OFF STACK
31     0222      3F        XPPC      P3              ;AND PRINT
32     0223      C6 @1     LD        @1(P2)          ;POP LOW BYTE
33     0225      3F        XPPC      P3              ;AND PRINT
34     0226      C4 C4     LD1      ^L(PTC)-1        ;P3 SET AGAIN FOR CHARACTERS
35     0228      33        XPAL      P3              ;HIGH P3 STILL OK
36     0229      C4 @D     LD1      CR              ;GET CARRIAGE RETURN
37     022B      3F        XPPC      P3              ;PRINT
38     022C      C4 @A     LD1      LF              ;GET LINE FEED
39     022E      3F        XPPC      P3              ;PRINT
40     022F      90 CF     JNP       START           ;LOOP TO BEGINNING
41     @001      P1=X1
42     @002      P2=X2
43     @003      P3=X3
44     @00D      CR=@D
45     @00A      LF=@A
46     @0E0     GHEX=@0E0
47     @1C5     PUTC=@1C5
48     @144     PREX2=@144
49     @200     .END START

```

SYMBOL TABLE

CR	= @00D	GHEX	= @0E0	LF	= @00A
PREX2	= @144	PTC	= @1C5	P1	= @001
P2	= @002	P3	= @003	START	= @200

ERRORS DETECTED: @

ple way by repeated addition. Thus 573×426 is computed by adding 426 to itself 573 times. This may seem like a very slow procedure, but in fact, the SC/MP is fast enough that computation time does not become noticeable until the multiplier is in the 1000s. The computational delay is then about 1.2 seconds per 1000.

Input to the program is performed using GHEX. This program reads a 4-digit hexadecimal number from the keyboard. Since these numbers are decimal, not hexa-

decimal, this means only that digits greater than 9 must be avoided. Since a 4-digit number cannot fit in 1 byte, GHEX cannot return its answer in the accumulator, as did the other subroutines. GHEX returns the 2-byte result on the stack. (The least significant byte is first, or at the higher address.)

The first 6 lines of both programs cause the data to be read in. Notice that lines 5 and 6 simply call GHEX twice.

Text continued on page 188

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Listing 5: As an extension of the addition routine, the multiplication routine inputs 2 numbers and multiplies them.

```

1      .NLIST   TTM
2      .TITLE  PROGRAM #5
3      ;THIS PROGRAM MULTIPLIES
4      ;TWO NUMBERS WHEN TYPED IN AS
5      ; "3578942"
6      ; INPUT HAS FOUR DIGIT MAX
7      ; OUTPUT IS EIGHT DIGITS
8
9      0200      C4 DF      . = 200
10     0202      33      START: LD1    ^1<GHEX>-1      ;SET P3
11     0203      C4 00      XPAL    P3                ;TO ADDRESS
12     0205      37      LD1    ^0<GHEX>             ;OF
13     0206      3F      XPAH    P3                ;CHEX
14     0207      3F      XPPC    P3                ;CALL CHEX TWICE
15     0208      C4 06      XPPC    P3                ;TO GET TWO NUMBERS
16     020A      C8 65      LD1    6                ;SET UP LOOP
17     020C      C4 00      ST     TEMP             ;TO PUT SIX ZEROS
18     020E      CE FF      L1:   LD1    0                ;ON STACK
19     0210      B8 5F      ST     @-1(P2)          ;LAST FOUR ZEROS ARE
20     0212      9C FB      DLD    TEMP             ;INITIAL PRODUCT
21                                     ;FIRST TWO EXTEND MULTIPLICAND
22     0214      02      L2:   CCL.                ;TO EIGHT DIGITS
23     0215      C2 09      ;CLEAR OLD CARRY
24     0217      EC 99      ;AND SUBTRACT
25     0219      CA 09      DAI    99              ;ONE FROM
26     021B      C2 08      ST 9(P2)             ;MULTIPLIER
27     021D      EC 99      LD     8(P2)           ;BOTH HALVES
28     021F      CA 08      DAI    99              ;IN TENS COMPLIMENT
29     0221      06 08      ST 8(P2)           ;THERE IS NO CARRY ON
30     0222      94 13      CSA                ;LAST ADD 0-1 = 9999
31     0224      02      JP     OUT              ;SO GET OUT
32     0225      C6 04      CCL.                ;OTHERWISE CLEAR CARRY
33     0227      C4 04      LD     @4(P2)         ;TEMPORARILY BUMP STACK BY 4
34     0229      C8 46      LD1    4                ;COUNT = 4 DIGITS
35     022B      C6 FF      ST     TEMP             ;FOR LOOP
36     022D      EA 04      L3:   LD     @-1(P2)         ;NOW ADD
                                     DAD    4(P2)           ;MULTIPLICAND TO

```

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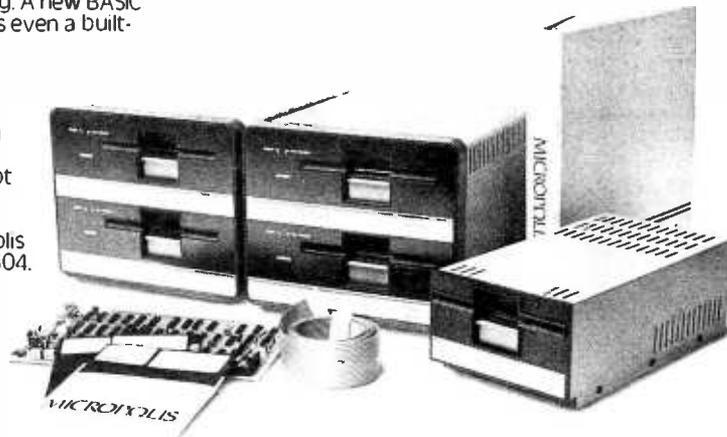
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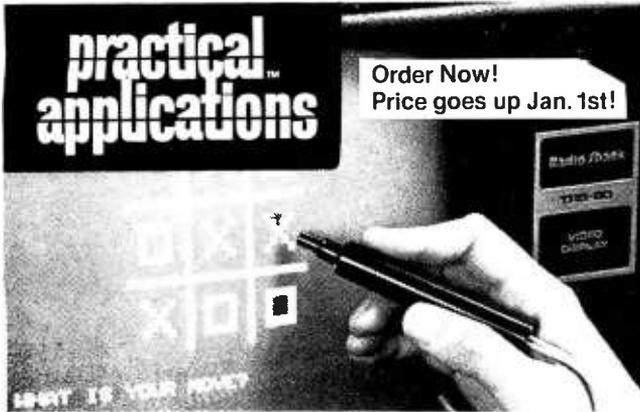
37  022F  CA  00          ST  0(P2)          ;PRODUCT AS EIGHT DIGIT
38  0231  B8  3E          DLD  TEMP          ;OR FOUR BYTE ADD
39  0233  9C  F6          JNZ  L3          ;LOOP UNTIL DONE, THEN
40  0235  90  DD          JMP  L2          ;DECREMENT MULTIPLIER AGAIN
41  0237  C4  94  OUT:   LD1  4          ;WHEN DONE
42  0239  C8  36          ST  TEMP        ;PRINT OUT FOUR BYTES
43  023B  C4  43  L4:   LD1  <1,<PHEX2>-1 ;SET P3 TO PHEX2
44  023D  33          XPAL P3         ;HIGH P3 IS OK
45  023F  C6  01          LD  0(P2)       ;POP PRODUCT OFF STACK
46  0240  3F          XPPC P3        ;PRINT
47  0241  B8  2E          DLD  TEMP        ;DECREMENT AND LOOP
48  0243  9C  F6          JNZ  L4          ;NOTE INSTRUCTIONS AFTER L4
49                                     ;CANNOT BE SKIPPED
50  0245  C6  06          LD  0(P2)       ;BUMP GARBAGE OFF STACK
51  0247  C4  C4          LD1  <1,<PUTC>-1 ;SET P3 TO PUTC
52  0249  33          XPAL P3         ;HIGH P3 IS OK
53  024A  C4  0D          LD1  CR         ;PRINT CARRIAGE RETURN
54  024C  3F          XPPC P3        ;THEN
55  024D  C4  0A          LD1  LF         ;LINE FEED
56  024F  3F          XPPC P3        ;AND
57  0250  90  AF          JMP  START      ;GO BACK TO BEGINNING
58          0270          TEMP=270
59          00E0          GHEX=00E0
60          0144          PHEX2=0144
61          01C5          PUTC=01C5
62          0001          P1=%1
63          0002          P2=%2
64          0003          P3=%3
65          000D          CR=0D
66          000A          LF=0A
67          0200          .END      START

```

SYMBOL TABLE

CR	=	000D	GHEX	=	00E0	LF	=	000A
L1		020C	L2		0214	L3		022B
L4		023B	OUT		0237	PHEX2	=	0144

Listing 5 continued on page 188



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Listing 5 continued:

```
PUTC = 01C5      P1      =%0001  P2      =%0002
P3      =%0003  START    '0200  TEMP    = 0270
```

ERRORS DETECTED: 0
FREE CORE: 17525. WORDS

, PROC5= PROC5

Text continued:

This causes 2 numbers to reside in the top 4 locations on the stack. GHEX "knows" a number has been typed when a nonhexadecimal character, such as W, is typed. Thus, to add 2 to 2 with program 4, the programmer could type 2W2W. "2+2 =" could also be typed, which is much more impressive when demonstrating the program. (Note that GHEX always gives a 2-byte result, even though fewer than 4 digits are typed.)

Lines 14 thru 21 add the 2 numbers, leaving the result on the stack. Note that there may be overflow indicating a fifth digit of 1. Lines 22 thru 26 create this fifth digit of 0 or 1 and print it. (Note the comment on line 23. Originally, the high part of pointer register 3 was 00, but GHEX will leave it as 01. *nb* earlier comments on this programming practice.)

Lines 27 thru 32 pop the rest of the sum off the stack and print it. Lines 33 thru 39 type a carriage return and line feed and loop back to the beginning to solve another problem.

Program 5 is designed to produce an 8-digit or 4-byte result, because the product of two 4-digit numbers can have 8 digits. Steps 14 thru 19 form a loop which places 6 0s on the stack. The lower 4 0s form an accumulator for the product. The 2 other 0s combine with the 2-byte multiplicand to extend its precision to 4 bytes or 8 digits. This simplifies addition of the multiplicand to the product accumulation.

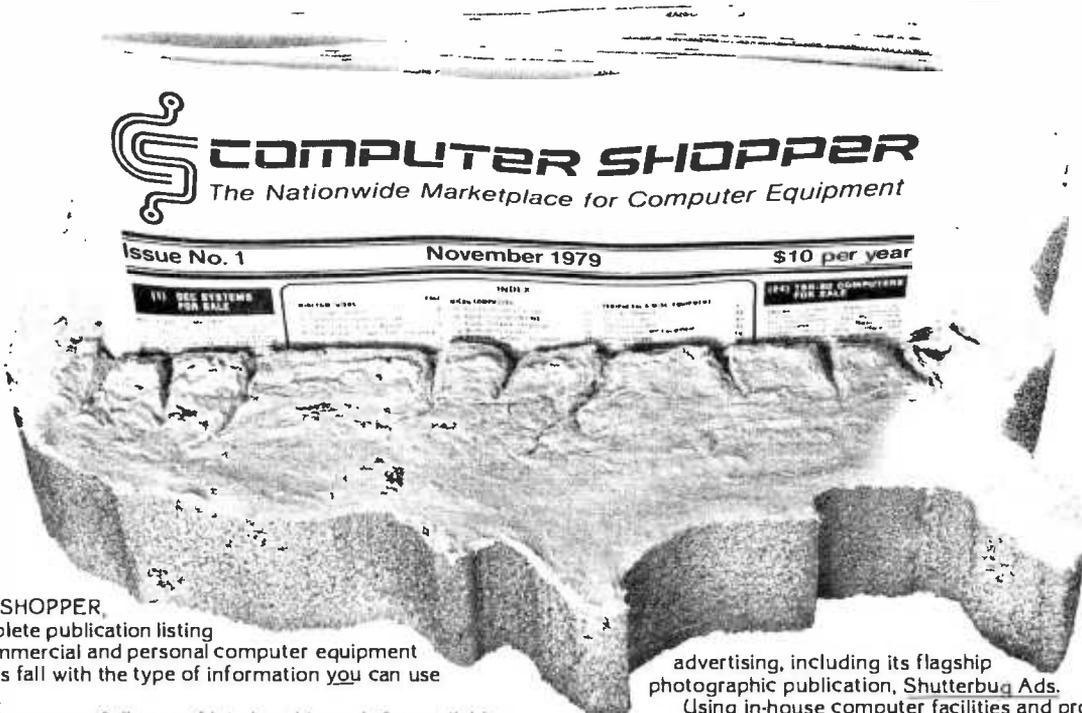
Lines 20 thru 39 form a loop for adding the multiplicand to the product accumulator. The multiplier is decremented each time through the loop. Decrementing is accomplished by adding 9999, which is a 10's complement negative 1.

Finally, steps 40 thru 56 print the result and loop back to the beginning. Note that in the loop beginning at line 42, pointer register 3 is reloaded each time through the loop. If this were not done, subsequent calls would end up at PHEX1 rather than PHEX2, and blank spaces would be interspersed in the result.

Conclusion

The 5 programs described in this article are intended to be simple demonstration programs that can be easily hand loaded into a minimal system. They are also designed to illustrate some of the basic concepts involved in programming the SC/MP. I hope that these programs will give the reader some ideas which can be used to design the applications for the SC/MP. The reader may also be able to apply the concepts of this article to other microcomputer kits, since many of them, such as the KIM-1, have useable system subroutines in read only memory. ■

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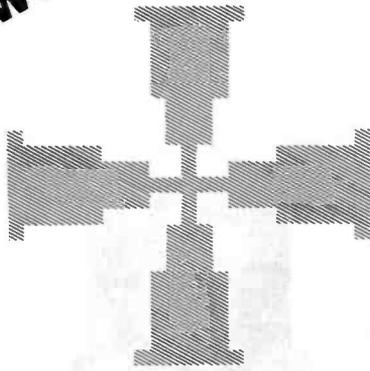
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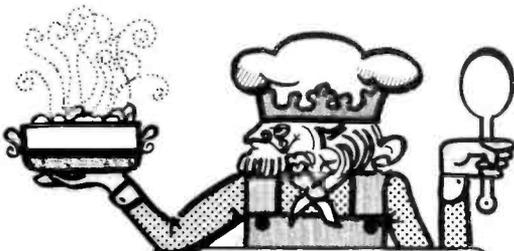
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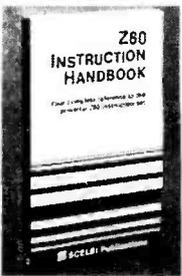
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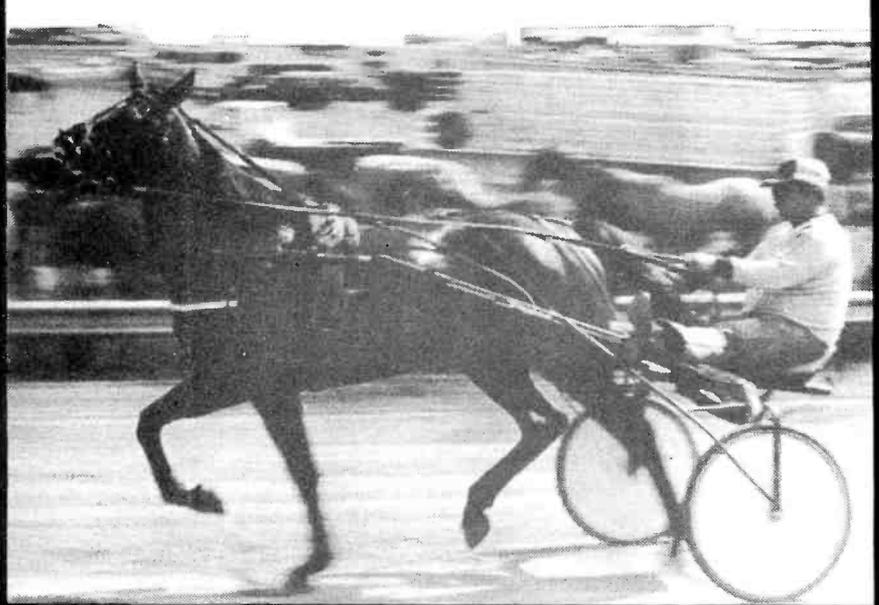


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These problems usually force a choice between two unpleasant alternatives. One alternative is to rely on complex error checking and error messages. The other is to guarantee operation for only a small set of rigidly defined inputs. Error checking sometimes takes more lines of code than the routine that will eventually process the data, while rigidly defined input specifications result in an unfriendly and unforgiving user interface.

The routine KEYIN, shown in listing 1, circumvents these problems by checking as narrow or wide a range of data inputs as desired by the calling routine. KEYIN will not return an invalid input to the calling routine, and bad data can be rejected by a single error message. KEYIN will also convert hexadecimal, decimal, or octal digits to binary while it is doing the error checking. KEYIN may be called by routines with vastly different requirements for alphanumeric data checking.

Knowledge of two variables and the table on which they operate is central to understanding how KEYIN works. The variables are stored in locations TBLPNT and TBLCNT. TBLPNT holds the address pointer for the table, and TBLCNT holds the number of entries in the table. The table these variables operate on may be placed in read-only or programmable memory. If the table is in read-only memory, TBLPNT can move up or down the table as subroutines require larger or smaller sets of input characters. If the table is in programmable memory, one may put its contents under program control in addition to moving TBLPNT.

For example, a subroutine may want to allow entry of one or more hexadecimal digits followed by an alphabetic command such as G for go or R for run. The table for this example would be constructed as shown in listing 2. The routine that calls KEYIN should place the address of TABLE in the location TBLPNT and the number of entries in the table (18 in this example) in location TBLCNT. The variable BASE should be set to 16 for hexadecimal decoding.

When KEYIN is called, routine KEYIN2 will load reg-

Listing 1: Z80 assembler code for the KEYIN routine. The program uses a table, as shown in listing 2, to determine acceptable input.

```

LINE  ADDR  R  OBJECT
-----
15
16 F200          TBLPNT EQU 0F200H
17 F201          TBLCNT EQU 0F201H
18 F204          BASE  EQU 0F204H
19 0007          BELL  EQU 07H
20
21
22 F000          *MARS
23 F000  D5      KEYIN:  CODE 0F000H
24 F001  C5      KEYIN:  PUSH DE
25 F002  F5      KEYIN:  PUSH BC
26 F003  210000  KEYIN:  LD HL,0
27 F006  E5      KEYIN1:  PUSH HL
28 F007  2A00F2  KEYIN2:  LD HL, (TBLPNT)
29 F00A  ED4B02F2 KEYIN2:  LD BC, (TBLCNT)
30 F00E  CD4AF0  KEYIN2:  CALL CHARNE
31 F011  EDB1  KEYIN2:  CPR
32 F013  2B07  KEYIN2:  JR Z, KEYIN3
33 F015  3C07  KEYIN2:  LD A, BELL
34 F017  CD3BF0  KEYIN2:  CALL CHAROUT
35 F01A  1BEF  KEYIN2:  JR KEYIN2
36 F01C  CD3BF0  KEYIN3:  CALL CHAROUT
37 F01F  E1  KEYIN3:  POP HL
38 F020  47  KEYIN3:  LD B,A
39 F021  79  KEYIN3:  LD A,C
40 F022  ED5H04F2 KEYIN3:  LD DE, (BASE)
41 F026  8B  KEYIN3:  CP E
42 F027  300A  KEYIN3:  JR NC, KEYIN4
43 F029  2B08  KEYIN3:  JR Z, KEYIN4
44 F02B  29  KEYIN3:  ADD HL, HL
45 F02C  29  KEYIN3:  ADD HL, HL
46 F02D  29  KEYIN3:  ADD HL, HL
47 F02E  29  KEYIN3:  ADD HL, HL
48 F02F  85  KEYIN3:  ADD A, L
49 F030  6F  KEYIN3:  LD L, A
50 F031  1B03  KEYIN3:  JR KEYIN1
51 F033  F1  KEYIN4:  POP AF
52 F034  7B  KEYIN4:  LD A,B
53 F035  C1  KEYIN4:  POP BC
54 F036  D1  KEYIN4:  POP DE
55 F037  C9  KEYIN4:  RET
56
57 EE'E         DECIDE EQU 0EEFEH
58
59
60
61
62 F038  C5      CHAR01:  PUSH BC
63 F039  F5      CHAR01:  PUSH AF
64 ;-----HARDWARE DEPENDENT CODE-----
65 F03A  01FEE2  CHAR01:  LD BC, DECODE ;I/O ADDRESS DECODING
66 F03D  ED78  CHAR01:  IN A,(C) ;CHECK STATUS OF OUTPUT DEVICE
67 F03F  C66F  CHAR01:  BIT S, A ;IF NOT READY
68 F041  2BFA  CHAR01:  JR Z, CHAR01 ;THEN LOOP
69 F043  0EFF  CHAR01:  LD C, 0FFH ;ELSE SET DECODE FOR DATA INH
70 ;-----
71 F045  F1      CHAR01:  POP AF
72 F046  ED79  CHAR01:  OUT (C),A ;WRITE TO OUTPUT DEVICE
73 F048  C1      CHAR01:  POP BC
74 F049  C9      CHAR01:  RET
75 ;
76 F04A  C5      CHARNE:  PUSH BC
77 ;-----HARDWARE DEPENDENT CODE-----
78 F04B  01FEE2  CHARNE:  LD BC, DECODE ;I/O ADDRESS DECODING
79 F04E  ED78  CHARNE:  IN A,(C) ;CHECK STATUS OF INPUT DEVICE
80 F050  C477  CHARNE:  BIT 6, A ;IF NOT READY
81 F052  2BFA  CHARNE:  JR Z, CHARNE ;THEN LOOP
82 F054  0EFF  CHARNE:  LD C, 0FFH ;ELSE SET DECODE FOR DATA IN
83 ;-----
84 F056  ED78  CHARNE:  IN A, (C)
85 F05B  C1  CHARNE:  POP BC
86 F059  C9  CHARNE:  RET
87 END

```

```

ERROR COUNT 11
CPU (SEC)=7
ASSEMBLY COMPLETE - NO ERRORS

```

Listing 2: Table setup to allow KEYIN to recognize the commands G and R for go and run, along with a hexadecimal number.

```

TABLE:  DEFM 'GR'
        DEFM 'FEDCBA9876543210'

```

Listing 3: Multiple tables allow KEYIN to search for one of several different valid commands. Here tables are set up to search for RUN, RES (reset) and REG (register).

```
TABLE:   DEFM 'R'
TABLE1:  DEFM 'EU'
TABLE2:  DEFM 'SG'
```

ister pair HL with the table pointer and load register pair BC with the number of entries in the table. The routine CHARNE is called and it will accept one character from the keyboard without echoing the character. The routines CHAROUT and CHARNE are hardware dependent and are shown here only to illustrate how KEYIN interacts with the user. CHAROUT can be any routine that sends one character to an output device, and CHARNE can be any routine that accepts one character from an input device. The keyboard entry is passed back from CHARNE to KEYIN in register A.

After CHARNE accepts an entry, the CPIR instruction in KEYIN2 begins searching TABLE for a valid entry. If a valid entry is found, the input character is echoed back to the terminal. If a valid entry is not found, an error message may be returned or the input may simply be ignored or rejected with an audible signal as it is here. Routine KEYIN2 will be reexecuted until it recognizes a valid entry.

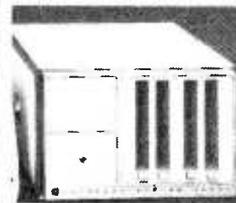
The CPIR instruction decrements the BC register pair as it compares the input character against the characters in the table. This is important since the value that is left in the BC register pair will be the binary value of the hexadecimal input when the CPIR instruction terminates. When a valid entry is found, KEYIN checks register C against the variable BASE. If the value in register C is greater than or equal to BASE, KEYIN will return to the calling routine with hexadecimal input in register pair HL and the nonhexadecimal character in register A. If the value in register C was less than BASE, its binary value will be placed in the register pair HL and KEYIN will reset the table pointer and counter and wait for another character.

Another use of KEYIN is searching a tree for valid input. As an example, assume that a program would like to evaluate three similar commands and reject all others. For this example, valid command strings are RESET, REGISTER, and RUN. TABLE would be set up with R as the root letter followed by branches EU and SG, as shown in listing 3. Before KEYIN is called, TBLPNT is set to address TABLE, TBLCNT is set to one and BASE is set to zero. On the first call to KEYIN, all inputs will be rejected except R. Once R is input, the calling routine sets TBLPNT to TABLE1 and TBLCNT to two. Now only the letters E and U will be accepted by KEYIN. If a U is input, a valid command has been found and the appropriate action can be taken. If the input was an E, the calling routine sets TBLPNT to TABLE2 and KEYIN is called again. KEYIN will now only accept the letters S and G, and the appropriate action may be taken once a valid input is accepted.

In general, KEYIN will allow n-way branching from the root or any branch of a tree by setting TBLCNT to n, TBLPNT to the first of the n acceptable inputs, and BASE to zero for character input. ■

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A Proposed Graphics Software Standard, Part 1

Vincent C Jones, 1913 Sheely Dr, Ft Collins CO 80526

A major stumbling block to making good software available in the personal computer market is the lack of standardization. Each manufacturer and software developer establishes internal standards for software and hardware interfaces, and they are usually incompatible with one another. Reasons for this vary from the experimenter's attempts to save 1 byte of memory in a 14 K byte program, to the mainframe manufacturer seeking to protect a development investment. The net result is the same. Extensive modifications are typically required to run software on any machine that differs from the original development's hardware and software configuration.

In an effort to prevent this fragmenting effect from overwhelming graphics applications programming, the following graphics interface software protocol is proposed as a standard.

This two-part article presents a complete microcomputer-oriented graphics software protocol and the algorithms required to implement it on typical raster scan graphics displays. The functions of hardware initialization, screen erase, point display, line generation, character generation, and animation are defined, and their implementation is demonstrated with a sample 8080/Z80 assembly language version for the Cromemco Dazzler. The power of a standard protocol is illustrated by a diagnostic demonstration program using the proposed 1 K byte 8080 assembly language protocol standard.

The standard actually proposes two separate but dependent protocols. The top-level protocol is machine independent. It defines a standard display coordinate system, several standard display modes, the available functions, and what these functions do. For example, a request for a red line from the center of the screen to the bottom right corner would always require the following command sequence:

CHAR (RED)	Set the current color to RED
CURSOR (128,128)	Move to the center of the screen
LINE (255,0)	Draw the line

Obviously, not all displays are capable of color; a black and white display would draw a white line instead. To compensate for any deficiencies in the hardware that is being used, a feedback path is included to inform the

user program of the available capabilities. General-purpose programs can check to verify that the display being used is suitable and, if necessary, display an error (or warning) message, or use a different algorithm to accomplish the task at hand. For example, a TV tennis game could check to see if full color was available. If so, it could use red paddles, a yellow ball, a green court, and white boundaries. If only three colors were available, the paddles and ball could be the same color. If only a black and white display was available, all markings could be in white with a black court and background.

The lower-level protocol defines the calling sequences used in a particular programming language. When necessary, it also defines where the routines are loaded in memory, and the addresses of their calling vectors. Returning to the example of drawing a red line, an 8080 (or Z80) assembly language program would use the instruction sequence:

```
MVI  A,11H      ;Code for Red
CALL  0113H     ;Vector for CHAR
LXI   H,8080H   ;X = 128, Y = 128
CALL  010AH     ;Vector for CURSOR
LXI   H,FF00H   ;X = 255, Y = 0
CALL  0110H     ;Vector for LINE.
```

Similarly, a BASIC program would read:

```
REM — Set the current color to RED
CHA 17
REM — Move to the center of the
      screen
CUR 128,128
REM — Draw the line down to corner
LIN 255,0.
```

Suitable standards for other languages remain to be developed. Reader suggestions are welcome.

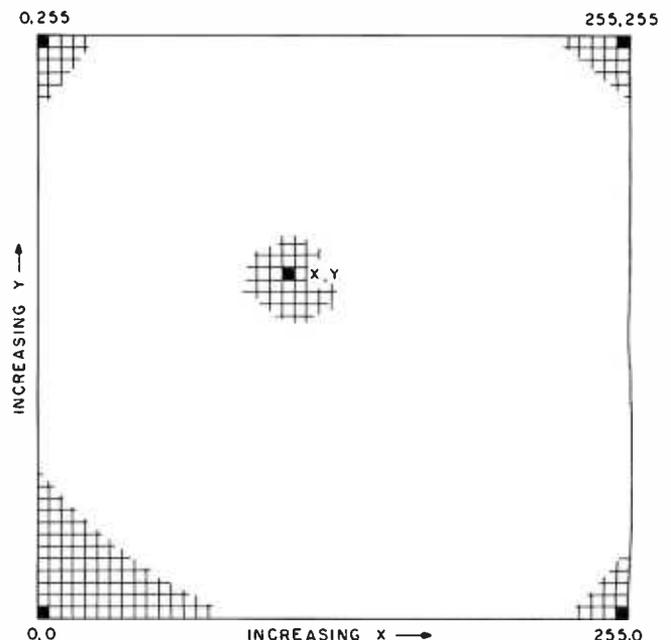
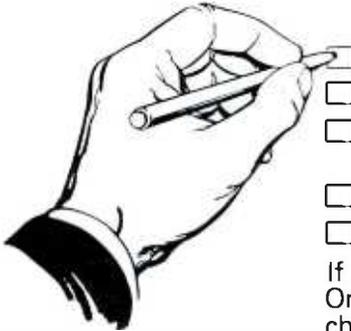


Figure 1: Standard coordinate system used in the proposed graphics software standard.

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The Standard Display

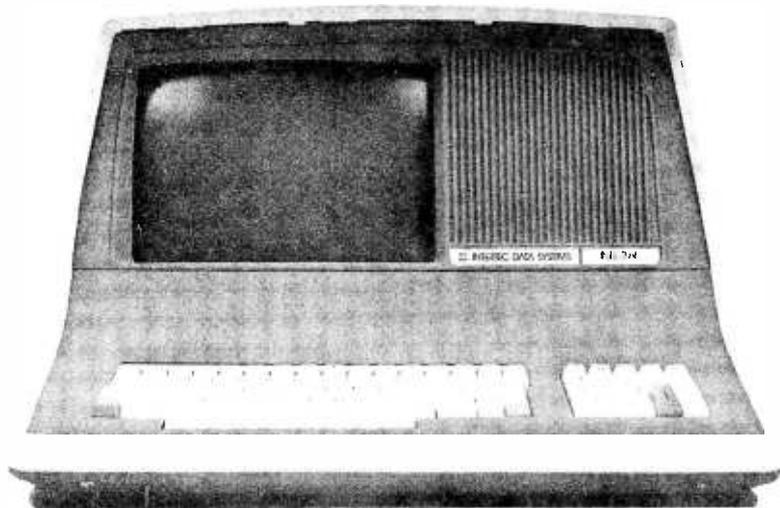
The protocol defines a standard display device to cir-
cumvent hardware differences. The standard device
displays 256 lines with 256 points on each line. As shown
in figure 1, the origin (X = 0, Y = 0) is defined as the bot-
tom leftmost point on the display. X increases to a max-
imum value of 255 as you move to the right, Y increases
to 255 as you rise to the top. This defines the first
quadrant of the standard Cartesian coordinate system.
Each picture element (pixel) may be black, white, red,
green, blue, yellow, cyan, or magenta (any combination
of the three primary colors).

The display to be used is programmed to imitate the
standard. To facilitate this procedure, four standard
display modes are defined. Mode 0 requests the max-
imum possible resolution while mode 1 requests the max-
imum choice of colors. This allows for displays, such as
the Cromemco Dazzler, which offer a trade-off between
resolution and color. Two additional modes provide the
ability to deliberately select larger pixels. Mode 2 is 128
by 128 resolution and mode 3 is 64 by 64 resolution.
Regardless of the resolution actually used, the coordinate
system remains at 256 by 256, as defined above. General-
purpose applications programs can check to determine
the available resolution and range of colors, whether the
display is black and white or color, whether or not
individual points can be erased, and if dual-buffered
animation is available.

The Standard Functions

A five command repertoire is generally considered to
be the bare minimum for a general-purpose graphics
display. These commands provide all the output
capabilities normally found on commercial nonintelligent
graphics terminals, such as the Tektronics 4010. The
routines are:

- PAGE:** Next page, ie,
erase the entire
screen.
- CURSOR (X,Y):** Position the cur-
sor at the point
X,Y.
- DOT:** Set the pixel
defined by the
cursor position to
the currently
selected color.
- LINE (X,Y):** Set the pixels
along the line
connecting the
current cursor
position to the
point X,Y to the
currently selected
color.
- CHAR (VAL):** Display the
character whose
ASCII value is
VAL at the cur-
rent cursor posi-
tion using the
currently selected
color.



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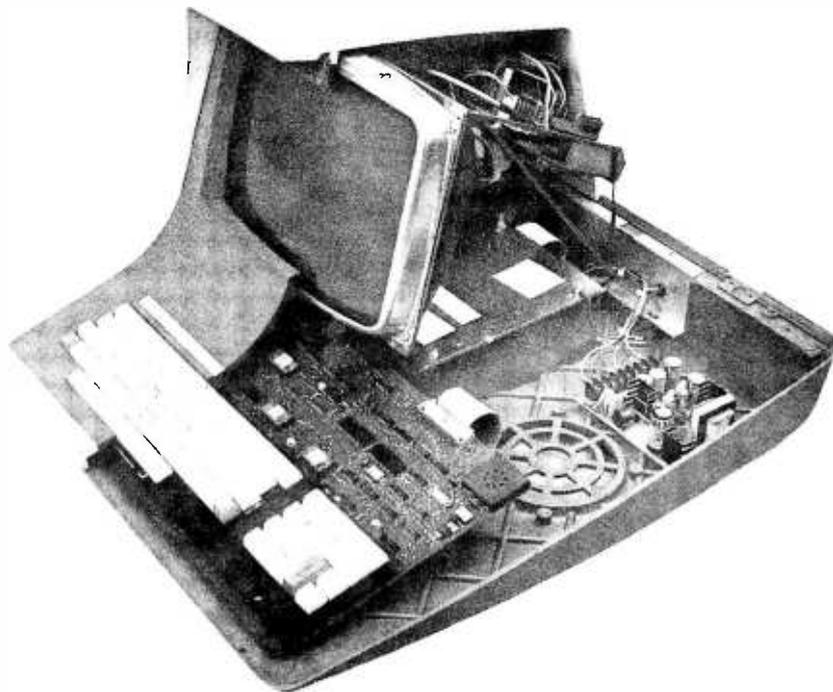
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To facilitate matching the hardware requirements of many displays, an initialization command is also required:

INITG: Initialize the graphics subsystem.

Finally, a 2-buffer animation command is included for interactive graphics and game playing:

ANIMAT: Display the refresh buffer currently being filled and open a second refresh buffer for filling.

Display mode and current color selection are provided by the routine CHAR through ASCII control characters. Standard carriage control characters are also recognized. Display description parameters are returned by the routine INITG.

Let us now examine the function of each of the seven routines in detail.

INITG

The INITG function serves three primary functions. As an aid to the user, the display software is initialized to a standard configuration; the cursor is positioned at $X = 0$, $Y = 0$, the current color is set to white, the display is cleared, animation is disabled, and the display mode is set for maximum resolution (mode 0). Special options peculiar to the particular display are also disabled so that

general-purpose programs do not have to be aware of them to function correctly. Secondly, this routine performs any initialization functions required by the display hardware. For those displays which refresh from program memory, the routine establishes the refresh buffers. If the display is under program control, it is turned on. Finally, INITG sets the display description variables to the appropriate values. Failure to initialize the display before using any of the other functions may lead to unpredictable and potentially disastrous results.

PAGE

The PAGE function clears the display screen. No other changes are made to the state of the display: the cursor is not moved, the current color is not changed, and the display mode is unaffected.

CURSOR

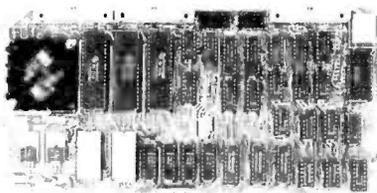
The CURSOR function sets the display cursor to a particular pixel on the screen. This establishes the initial location for the display functions which affect individual pixels on the screen. Coordinates are always interpreted on the 256 by 256 pixel matrix regardless of the actual resolution of the display. This is true even when the display mode is deliberately set to a lower resolution mode.

When in a lower resolution mode, the low-order bits of the position requested are ignored. For example, when in 128 by 128 resolution mode (mode 2), the points (8,4), (8,5), (9,4), and (9,5) will all be interpreted as the same pixel (the low-order bit in each coordinate has no effect).

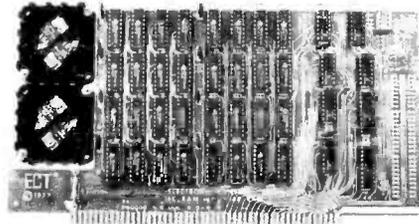
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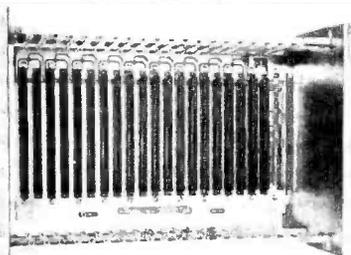
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Mnemonic	ASCII	Hexadecimal	Standard Function
MAXR	NUL	00	Display Mode Selection
MAXC	SOH	01	Maximum resolution
R128	STX	02	Maximum colors
R64	ETX	03	128 by 128
RXXX	EOT	04	64 by 64
			Undefined
BS	BS	08	Carriage Control
HT	HT	09	Backspace (optional)
LF	LF	0A	Horizontal tab (optional)
VT	VT	0B	Line feed
FF	FF	0C	Vertical tab (optional)
CR	CR	0D	Form feed
			Carriage return
SO	SO	0E	Character Style
SI	SI	0F	Undefined
			Undefined
BLK	DLE	10	Current Color Selection
RED	DC1	11	Black
BLU	DC2	12	Red
MAG	DC3	13	Blue
GRN	DC4	14	Magenta
YEL	NAK	15	Green
CYN	SYN	16	Yellow
WHI	ETB	17	Cyan
NONE	ETX	18	White
	to	to	Eight
	GS	1F	optional colors

Table 1: Standard control character functions.

When changing between display modes, cursor position is not required to be maintained by the interface software. To avoid erroneous results, all changes to display mode should be followed by a cursor positioning command.

DOT

The DOT function sets the display pixel indicated by the cursor to the currently selected color. With some displays in low-resolution mode, several physical pixels may be affected. For example, the Matrox ALT-256**2 turns on (or off, as selected) sixteen hardware pixels for every "dot" when in a 64 by 64 resolution mode.

LINE

The LINE function generates the line connecting the pixel defined by the cursor to the pixel requested. Both endpoints are included in the line. Therefore, a line of zero length is logically equivalent to a call to DOT. Care must be exercised when erasing or otherwise changing the color of a line, since the pixels in a line from pixel A to pixel B may differ from those used when the line is drawn from pixel B to pixel A. When lines are drawn in lower resolution modes, the pixels used are the size made by the DOT function at that resolution.

CHAR

The CHAR function provides the capability to display alphanumeric as well as graphical data. In addition, control characters provide limited cursor positioning and control over display mode and current color as shown in table 1. Control characters that are not recognized are ignored. Note that form feed positions the cursor only—it does not erase the screen.

Characters are positioned so that the cursor defines the

lower left corner of a normal character (characters with descenders will extend below the cursor position). The cursor is left at the next character position. No check is made to detect characters off the edge of the screen. Parity is ignored. Lowercase characters, if not supported, are converted to uppercase.

ANIMAT

The function ANIMAT provides for flicker-free changes in the display by permitting the user to load one refresh buffer while displaying another. Each call to ANIMAT displays the buffer which is being filled, and opens another buffer for filling. This buffer exchange is performed at the start of the next vertical blanking period. Those displays without the ability to utilize multiple buffers but which *do* allow the erasing of individual pixels (such as the Matrox ALT-256*2) will just delay until the start of the next vertical blanking period. In either case, no changes are made to either buffer, and the cursor position is maintained. The ANIMAT function does nothing on those displays which support neither double buffering nor selective erase. To return to normal mode where updates are displayed in real time, it is necessary to reinitialize with INITG.

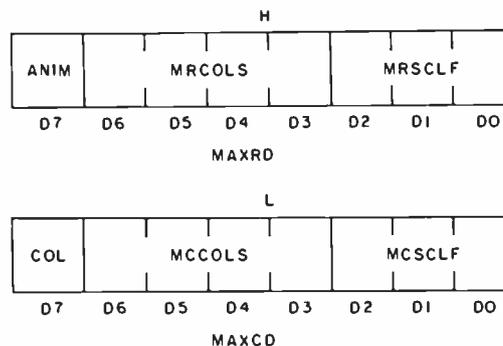
Standard Calling Sequences

To encourage maximum software interchange, two standard programming language protocols are currently defined. The first protocol is for 8080 and Z80 assembly language users, the second is for BASIC programs. By following one of these protocols, a program written for one display will work with any other display of sufficient resolution and color flexibility. The standard display and function definitions described previously are common to both protocols.

8080 Assembler Protocol

The 8080 assembly language interface is loaded into hexadecimal memory locations 0104 to 04FF. This provides a standard location for the package, regardless of memory size. To avoid conflict with programs requiring use of the restart (RST) instruction and most popular 8080 monitors, a lower starting address is not used. The first 21 bytes (hexadecimal 0104 to 0118) are the entry points to the different routines, as indicated in table 2. All arguments are passed to the called routine in register pair HL, except for the CHAR routine, which uses register A. The contents of all registers and flags are preserved, except for the INITG routine.

Routine INITG is called with the address of the first unused memory location above the program, to indicate



- ANIM = 0 - Delay to start of vertical blanking.
1 - Double buffered animation supported.
- COL = 1 - Display is in color.
0 - Display is black and white.
- MRCOLS - Colors (grey shades) in MAXR mode.
- MCCOLS - Colors (grey shades) in MAXC mode.
- MRSCLF - $\frac{256}{\text{Display resolution}}$ in MAXR mode.
- MCSCLF - $\frac{256}{\text{Display resolution}}$ in MAXC mode.

Figure 2: 8080 assembly language standard display parameter fields.

available space for refresh buffers. While some displays do not require this information, it should always be included for compatibility. The address in HL is replaced by INITG with a 2-byte description of the display being used (all other registers and flags are left undisturbed). The format for these bytes is given in figure 2. The colors and scale factor fields which are available in register H describe the display when maximum resolution is selected; the same fields in register L describe the maximum color selection mode.

The available colors field gives the number of colors, other than white, to which a point can be written. If the field is zero, it means that the way to erase what has been written is to page the display. The scale factor field indicates the physical size of display points in standard coordinates. If the X and Y scale factors differ, the larger of the two is used. For example, if the display had 64 lines with 100 points on each, the scale factor would be four, based on the Y axis resolution.

The animation and color fields apply to all display modes. If the animation field is one, the display supports double buffered animation. If this field is zero, it is impossible to build one display scene while another is displaying. In this case the ANIMAT routine is a delay until the start of vertical blanking. The color/black and white field is self-explanatory: if it is one, the display is in color; otherwise it is black, grey, and white. Note that this field has no real meaning if the number of available colors is zero or one.

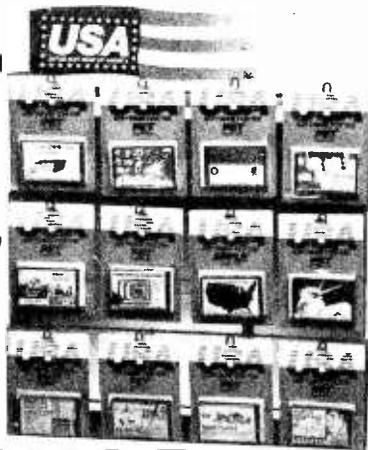
BASIC Protocol

For maximum flexibility and machine independence, a BASIC language usage protocol is also defined. Table 3 summarizes the commands and their arguments. Display initialization (IGR command) sets the variables A1

Routine	Vector Address (hexadecimal)	Parameters
INITG	104	HL = first free address
PAGE	107	Returns display description in HL
CURSOR	10A	None
DOT	10D	H = X coordinate; L = Y coordinate
LINE	110	None
CHAR	113	H = X end coordinate; L = Y end coordinate
ANIMAT	116	A = ASCII value of character
		None

Table 2: 8080 assembly language standard vector addresses.

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Mnemonic	Function	Arguments
IGR	INITG	None
PAG	PAGE	None
CUR	CURSOR	< X >, < Y >
DOT	DOT	None
LIN	LINE	< X >, < Y >
CHA	CHAR	< numeric ASCII value >
ANM	ANIMAT	None
TXT	PRINT	Equivalent to print except on display

Variable Name	Display Parameter
A1	X scale factor, high-resolution mode
A2	Y scale factor, high-resolution mode
A3	Available colors, high-resolution mode
A4	X scale factor, maximum color mode
A5	Y scale factor, maximum color mode
A6	Available colors, maximum color mode
A7	Animation support
A8	Grey scale

Table 3: BASIC standard protocols.

through A8 to reflect the display parameters. The scale factors A1, A2, A4, and A5, normally given exactly, are permitted to be rounded off to the nearest integer. These variables are ordinary BASIC variables and may be used and set as desired by the program.

The additional command TXT provides the user with the full flexibility of the BASIC PRINT command. Text and variables are displayed using the formats requested in the TXT statement starting at any location on the screen by using CUR to position the cursor. All characters are displayed using the current color.

Function Algorithms

To facilitate development of this standard, the algorithms used to produce the Matrox ALT-256**2 and the Cromemco Dazzler implementations of the 8080 assembly language standard are provided here. Of particular interest to most readers will be the line and character generation algorithms, which are independent of the hardware configuration of the display used.

For those readers not familiar with Nassi-Schneiderman design charts, a brief explanation is in order. More detailed information can be found in the original article published in the *SIGPLAN Notices* (August 1973). The Nassi-Schneiderman chart is a stylized flowchart for structured programming. By supporting only standard structured programming constructs (see figure 3) and not GOTOs and off page connectors, the chart forces the software designer to avoid the convolutions and obscurities in logic which make programs excruciating to debug and impossible to maintain.

The INITG and DOT routines are the only routines which normally require extensive adaptation to suit different displays. Since the Matrox ALT-256**2 is the only currently available low-cost display which is not direct memory access (DMA) refreshed from program memory and an enhanced 8080 assembly language package that is compatible with this standard is available from Matrox, the special considerations required to program I/O port driven displays are not included in this article. For direct memory access displays, the only other adaptations normally required are the refresh memory size parameter in

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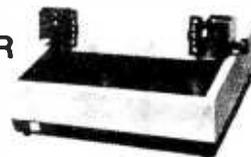
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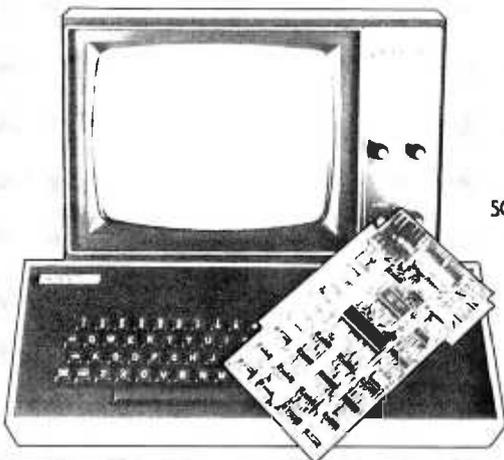
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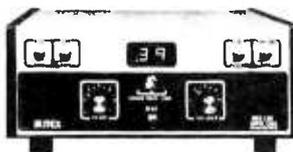
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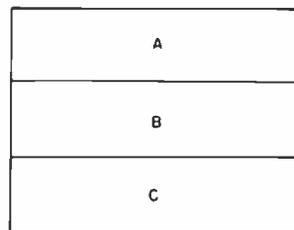
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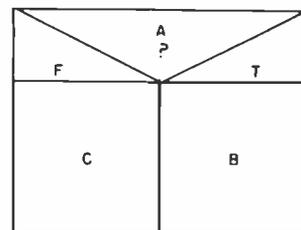
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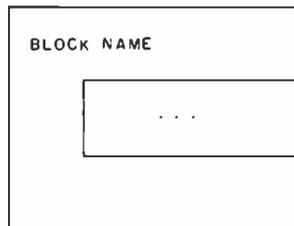
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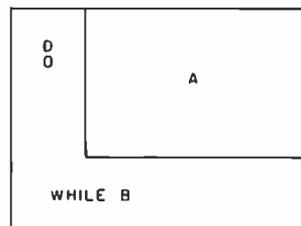
SEQUENTIAL EXECUTION



IF A THEN B ELSE C
(F = FALSE, T = TRUE)



BEGIN... END



DO A WHILE B

Figure 3: Nassi-Schneiderman charts, a system of stylized flowcharts which are designed for use with structured programming techniques. Each of the charts physically resembles the program section it emulates. The charts are read from top to bottom.

PAGE, the color and mode select controls in CHAR, and the scale factors used by the internal subroutine SCALE.

INITG Logic

Initialization is normally required for both hardware and software (see figure 4). The first step is to establish the refresh buffer. This requires taking the address which defines the top of the user program and moving up to the first address legal for refresh buffers. This address is needed by other routines, as well as for starting the display hardware. The different variables and flags are then set to the required values, and the page routine is called to clear the screen. The appropriate display

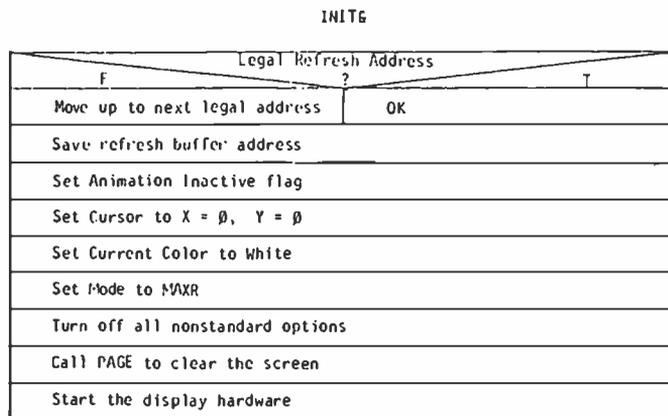


Figure 4: The INITG function. INITG serves three purposes as an aid to the user: it initializes the system, performs any initialization functions required by the display software, and sets the display description variables to the appropriate values.

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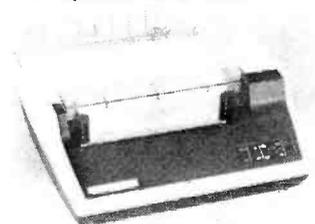
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ADR = Refresh buffer address	
CNT = Refresh buffer length	
D 0	Set [ADR] to zero (black)
	ADR = ADR + 1
	CNT = CNT - 1
UNTIL CNT equals 0	

Figure 5: The PAGE function. PAGE is used to clear the display screen.

CURSOR

Call SCALE to interpret coordinates
Set the software cursor to the scaled values.

Figure 6: The CURSOR function which sets the display cursor to a particular pixel on the screen.

description is generated, and control is returned to the calling program.

PAGE Logic

The PAGE command clears all the memory used for display refresh (see figure 5). The most general algorithm, and the one that is charted, is clear byte, increment address, decrement byte count, and test for done. In machines with indexed addressing, the byte count can

double as an index register. In machines with a memory-to-memory block transfer instruction, it is usually possible to clear one byte and transfer it to all of the display refresh memory.

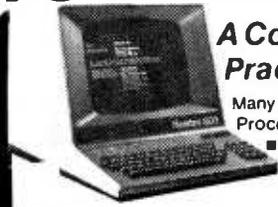
CURSOR Logic

The CURSOR routine must convert from standard coordinates to software coordinates (see figure 6). Software coordinates are required by the LINE and CHAR algorithms to have a one-to-one correspondence with the actual display pixels being used. CHAR further requires X coordinates to increase to the right and Y coordinates to increase to the top. Since LINE must also scale its arguments, CURSOR and LINE can usually share the same internal scaling routine for efficiency.

DOT Logic

DOT is the only routine (other than PAGE) which actually modifies the refresh memory (see figure 7). Both LINE and CHAR use it to modify the desired pixels in the display. This routine is extremely hardware-dependent. Indeed, one of the primary reasons for defining this protocol was protection from differing display idiosyncracies. The DOT routine must translate the coordinates in the software cursor to the actual corresponding bits in memory. Remember that the software cursor is scaled so that a unit change in a coordinate is equivalent to the adjacent pixel. The logic presented here assumes a linear scan through refresh memory to generate the entire display, a line at a time, with the top line displayed first. Note that this algorithm is not adequate for the Dazzler, nor is it suitable for self-refreshed displays like the

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DOT

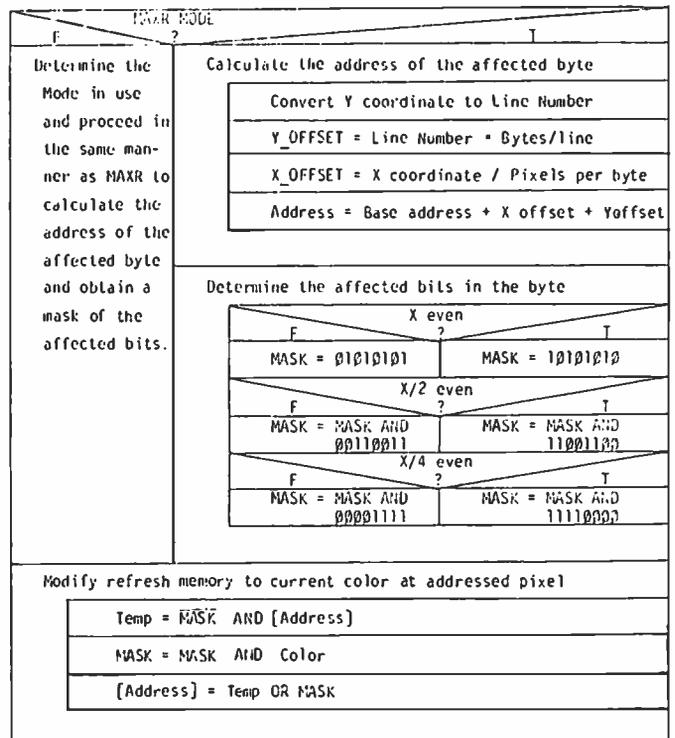


Figure 7: The DOT function which sets the display pixel indicated by the cursor to the currently selected color.

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LINE

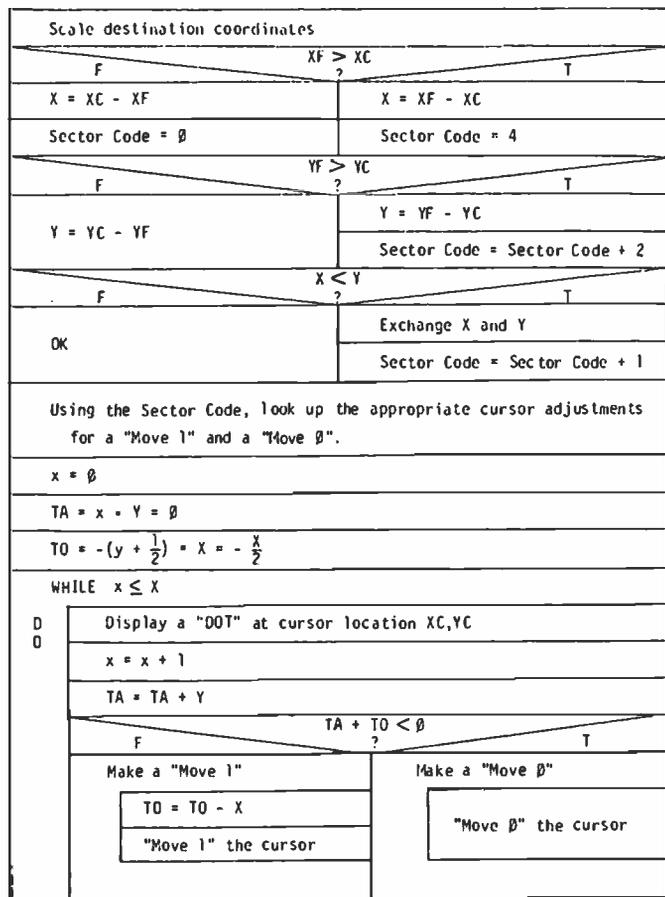


Figure 8: The LINE function which generates the line connecting the pixel defined by the cursor to the pixel requested.

Matrox ALT-256**2. The former divides the display into four quadrants, each in its own block of memory with every byte describing points on more than one line. The modifications to the algorithm are explained in the sample implementation, and need not concern the non-Dazzler owner. The Matrox's refresh memory is directly addressed by X,Y coordinates and no conversion is required.

The first step is to determine the address of the byte which contains the requested point. The cursor Y coordinate is converted to a display line number which, when multiplied by the number of bytes per line, gives the offset into the refresh buffer of the first byte on the line. The X coordinate corresponds directly to the desired point along the line. Dividing the X coordinate by the number of points in each byte gives the offset from the first byte in the line. Taking the base address of the refresh buffer (set up by INITG) and adding the offsets to the desired line in the buffer and the desired point on the line yields the address of the byte which requires modification.

The second step is to determine which bits in the byte correspond to the desired pixel. The hypothetical display depicted by the Nassi-Schneiderman chart has eight pixels in each byte. The selected bits are then changed to match the current color, and the refresh memory is updated to reflect the revised point. An effective procedure is to generate a mask which contains ones at bit positions

corresponding to the addressed point, and zeros elsewhere in the byte. The byte of refresh memory is ANDed with the complement of the mask to delete the old contents. The mask itself is then ANDed with the bit pattern for a byte with every pixel. The current color and the result are Ored into the cleaned up byte of refresh memory.

LINE Logic

Perhaps the most crucial facet of any graphics system is its line generator (see figure 8). Before introducing the actual algorithm used, it may prove beneficial to discuss its theoretical development.

We wish to generate an arbitrary line from a point (XC, YC) to a point (XF, YF) (see figure 9). The goal is to determine those discrete points (xn, yn) which best approximate the desired line.

To simplify the derivation, we will only consider generating a line from point (0,0) to point (X,Y), where X is greater than or equal to Y and both are greater than or equal to 0 (figure 10). (This situation is general because any arbitrary line may be rotated and translated to match the proposed conditions.) Under these conditions, there is a point along the line for every value of x (0 ≤ x ≤ X), and for every value of x there is only one value of y. Closer examination reveals that for any value of x, the y value for the following point (x + 1) will either remain unchanged or increase by 1. No other value of y is possible. Furthermore, it can be shown that the decision to increment y for the next x is based solely on whether the point (x + 1, y + 1/2) lies above or below the line. If it lies above the line, y remains unchanged. If it lies below the line, y is incremented. In the event (x + 1, y + 1/2) is exactly on the line, either option is correct. For convenience, "on the line" is arbitrarily treated as equivalent to "above the line."

Assuming that we have a method to determine the position of the point (x + 1, y + 1/2) relative to the desired line, we can generate an optimal approximation of the line from (0,0) to (X,Y), where X ≥ Y ≥ 0, using the following algorithm:

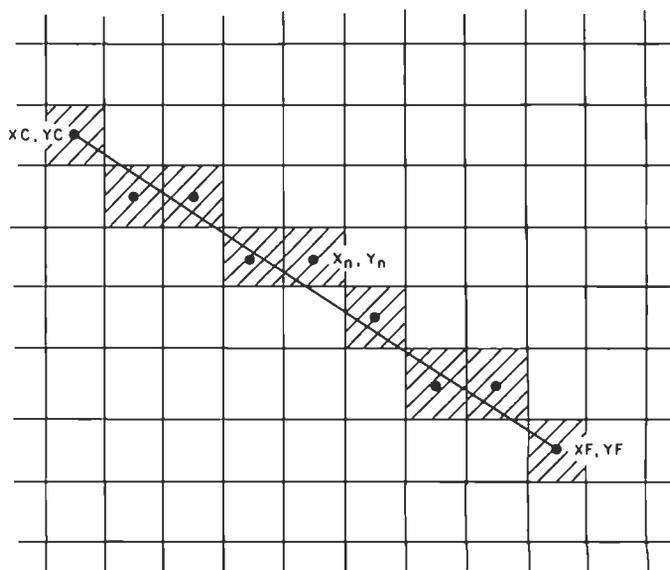


Figure 9: Generating an arbitrary line.

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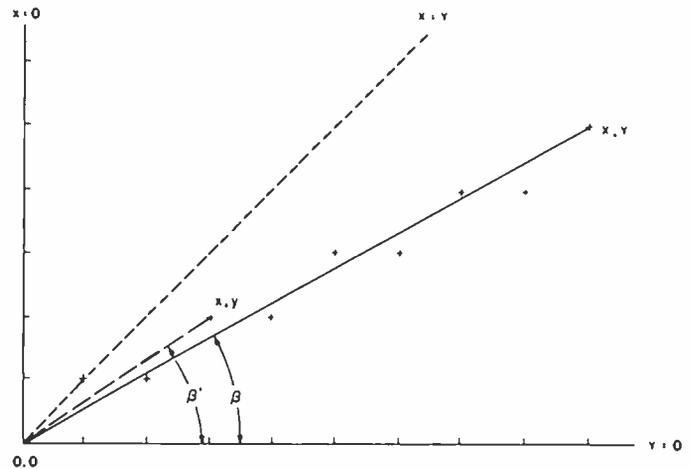


Figure 10: Simplified line generation.

- 1) Initialize $x \leftarrow 0$, $y \leftarrow 0$.
- 2) Display the point (x,y) .
- 3) Test for done: $x = X$?
- 4) Calculate the position of the point $(x + 1, y + \frac{1}{2})$ relative to the desired line.
- 5) Set dy to 1 if below the line; 0 if on or above.
- 6) Calculate the next point:
 $x \leftarrow x + 1$
 $y \leftarrow y + dy$
- 7) Go to step 2.

There are only two obstacles to overcome before implementing this algorithm: step 4 and the restrictive initial conditions. Let us examine each in turn.

A brief excursion into trigonometry is required to evaluate step 4. Referring to figure 10, if we call the angle between the desired line and the X axis θ , and the angle formed by the current point (x,y) the origin and the X axis θ' , then if (x,y) lies above the desired line, $\theta < \theta'$. Conversely, if (x,y) lies below the desired line, $\theta > \theta'$. Of course, if the two coincide, $\theta = \theta'$. We know from trigonometry that for angles in the first quadrant, the greater the angle, the greater its tangent. We also know that the tangent of θ is $\frac{Y}{X}$, while that of θ' is $\frac{y}{x}$. Therefore, we can easily determine the position of any point relative to the desired line by comparing the quotients $\frac{Y}{X}$ and $\frac{y}{x}$.

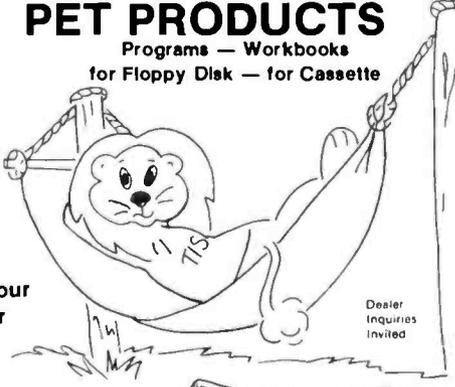
Unfortunately, performing division on microcomputers is a time-consuming process. Using the properties of inequalities to eliminate the divisions, we can build a decision table (see table 4) which requires only multiplication. Returning to our original algorithm, we set dy to 1 if:

$$(x + 1) \times Y > X \times (y + \frac{1}{2})$$

and to 0 if it is not. Further advantage can be gained by realizing that at each iteration the product on the left side of the inequality increases by Y , while the right either remains the same or increases by X . By remembering the

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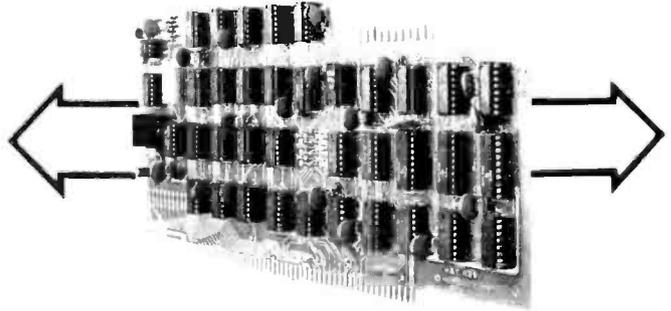
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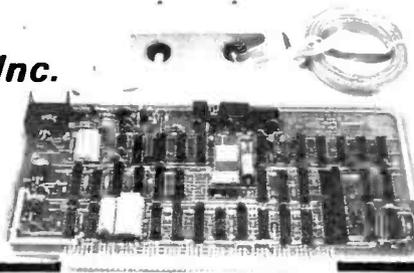
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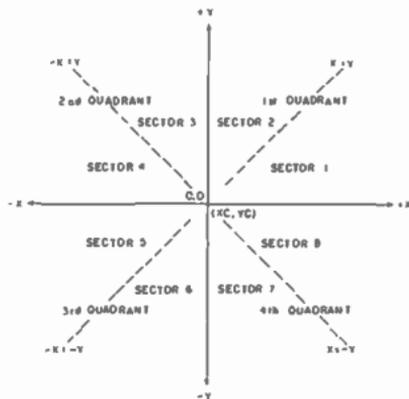


Figure 11: Quadrant and sector definition.

products from the previous iteration, and whether or not y is incremented, the multiplication can be reduced to addition. For maximum efficiency, the right-hand product can be maintained negated so that the comparison can be made with a single addition.

The restriction that the line runs from the $(0,0)$ to a point (X,Y) with $X \geq Y \geq 0$ requires the use of coordinate translations, rotations, and reflections. The first step is to translate the line so that it starts at $(0,0)$. Since the line originates at the cursor, we would traditionally subtract the cursor from the other endpoint to obtain its relative position. However, because a 256 by 256 display does not give us room for a sign-bit in an 8-bit byte, it is first necessary to rotate the line to the first quadrant and then calculate the magnitude of the endpoint displacements from the cursor.

While all these coordinate transformations may seem complicated, the actual implementation is quite simple. Consider the command to generate the line from the current cursor position (XC,YC) to a final point (XF,YF) . The first step is to compare XF to XC . If $XF \geq XC$ then we are in the first or fourth quadrant (see figure 11); otherwise, we are in the second or third. Similarly, if $YF \geq YC$, we are in the first or second quadrant; otherwise, the third or fourth quadrant. By combining the two results, the quadrant is uniquely determined, and we can proceed to determine the magnitude of the X and Y displacements, XM and YM , as shown in table 5. Finally XM and YM are compared to determine the exact sector.

The easiest technique for remembering this multiple logical decision is to weight the results of each decision and check the sum. Each sector is then assigned an equivalent weight, and the sector parameter table is reordered accordingly. Column 2 of table 6 applies a weight of 4 to $(XF > XC)$, 2 to $(YF > YC)$ and 1 to $(YF > XF)$.

Once the sector is determined, we have all the information required to construct any arbitrary line. Referring to

	Above	On	Below
Angle Relationship	$\theta < \theta'$	$\theta = \theta'$	$\theta > \theta'$
Tangent Relationship	$\frac{Y}{X} < \frac{Y'}{X'}$	$\frac{Y}{X} = \frac{Y'}{X'}$	$\frac{Y}{X} > \frac{Y'}{X'}$
Relationship after Multiplying through by $X \cdot X'$	$xY < Xy$	$xY = Xy$	$xY > Xy$
Result of $xY \cdot Xy$	Negative	Zero	Positive

Table 4: Point position relative to a line.

Quadrant	XM	YM
1	$XF - XC$	$YF - YC$
2	$XC - XF$	$YF - YC$
3	$XC - XF$	$YC - YF$
4	$XF - XC$	$YC - YF$

Table 5: Component magnitudes in the four quadrants.

Sector	Sector Weight	X	Y	Move 0		Move 1	
				x Incr	y Incr	x Incr	y Incr
1	6	XM	YM	+1	0	+1	+1
2	7	YM	XM	0	+1	+1	+1
3	3	YM	XM	0	+1	-1	+1
4	2	XM	YM	-1	0	-1	+1
5	0	XM	YM	-1	0	-1	-1
6	1	YM	XM	0	-1	-1	-1
7	5	YM	XM	0	-1	+1	-1
8	4	XM	YM	+1	0	+1	-1

Table 6: Coordinate equivalents for each sector.

step 5 of the fundamental sector 1 algorithm, we call setting dy to 0 "move 0," setting dy to 1 "move 1," and generate the equivalence chart in table 6. As the algorithm steps along in transformed coordinates, it uses the "move 0" and "move 1" to modify the cursor position using X and Y increments appropriate for the sector the line is actually in.

CHAR Logic

One of the most common formats for displaying characters is the 5 by 7 matrix of points (see figure 12). However, not many people realize why 5 by 7 is the smallest common size. The limiting width is, of course, the minimum number of points capable of displaying the three separate parallel lines required for the letters M and W. This sets the minimum possible width to 5, but why must 7 be the minimum height? The answer is, it need not be! However, human engineering studies have indicated that the average person finds it easier to read characters which are proportioned the same as in standard printing. Ratios of width to height far removed from the "normal" 0.75 increase fatigue and error rates.

To generate easily read lowercase characters, even larger matrices are required. This is a result of the greater complexity and finer detail of the lowercase characters. The full ASCII character set can be generated with a 7 by 9 matrix if provision is made for characters with descenders (g, j, p, etc). This requires the use of an extra

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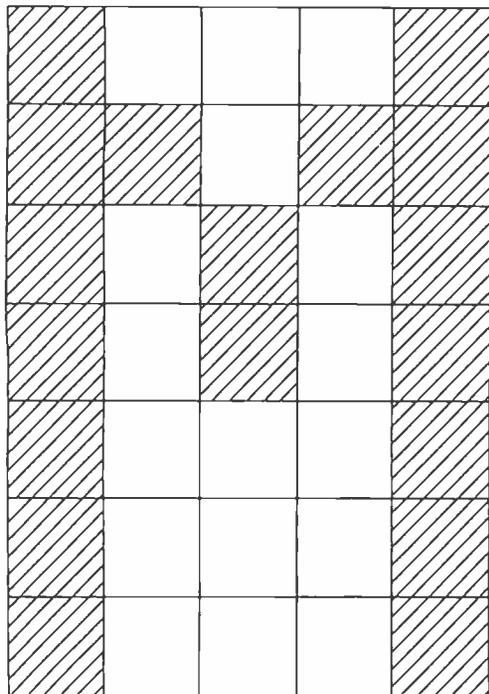


Figure 12: Typical character generation.

Char Size	LC	Char/Line (256 by 256)	Lines/Page (256 by 256)	Memory For Tables (bytes)
9 x 11	Y	25	18	1200
7 x 9	Y	32	21	864
5 x 7	N	42	32	320
4 x 5*	N	64	32	192

*See text

Table 7: Effects of differently sized character matrices.

bit to determine if the matrix is displayed normally or shifted down two positions. As far as the display is concerned, the character uses a 7 by 11 matrix of display points. Larger display matrices can be used for greater legibility and varying character fonts, but even a 7 by 11 character matrix severely restricts the total number of characters that will fit on the low-resolution displays for which this standard is designed. If even one row of blank points is left between adjacent characters, then only sixteen 7 by 9 characters will fit across a 128-wide display. Memory requirements for large matrix character pattern storage are also severe. The table space required is directly proportional to the area of the matrix (see table 7).

A character matrix size less than the "absolute minimum" 5 by 7 was desirable, since even 5 by 7 characters require 320 bytes for their lookup table. Readable versions of 58 of the 64 uppercase printing ASCII characters can be generated within a 4 by 5 matrix. The remaining 6 characters (#, \$, &, %, M, and W) fit in a 5 by 5 matrix. Since these are normally considered wide characters, their unity width-to-height ratio is not objectionable.

To simplify table lookups and the special handling of 5 wide characters, 3 bytes are used for each character. Twenty bits are used for the 4 by 5 display matrix; the four extra bits are used as flags to define the specific parameters for each character. Two flag-bits are used to indicate the width of the character. Proportional spacing also fits the maximum number of characters into any given space. The third flag-bit is used by 5 wide characters to indicate whether the first column is all ones (M and W), or must be retrieved from an auxiliary lookup table (#, \$, %, and &). The remaining flag is used to indicate descending characters (, ; and _). These characters are displayed two positions lower than their matrices indicate. Each character is therefore displayed in an n by 7 display area, where n ranges from 2 to 5.

The basic character generation algorithm (figure 13) is applicable to any size character matrix, whether the character is stored by column (more efficient for 5 by 7 and 6 by 8 matrix characters), or by row (more efficient for variable 4 by 5, 7 by 9, and 8 by 11). If the character set being used does not include lowercase, it is necessary to shift lowercase characters to their uppercase equivalents. Comparing the ASCII value of the character to 32 separates control characters for special handling.

The character table is ordered by ASCII value and lookup is done by indexing on the ASCII value requested. Since the first 32 ASCII characters are control characters,

CHAR	
Remove parity bit from character	
Control Character	
F	T
Lower case	HUL ?
F	T
OK	Convert to upper case
OK	MODE = MAXR
Determine Char. table entry	
F	SOH ?
F	T
OK	Retrieve byte with flags
OK	MODE = MAXC
Calculate next chr position	
F	STX ?
F	T
Five wide	OK
F	MODE = R128
F	M or W ?
F	ETX ?
F	T
OK	Look up 1st Pretend col. in the retrieved Aux. Table all ones
OK	MODE = R64
OK	Put up a "DOT" in the first column for each one in the entry
OK	Adjust cursor Y = Y - 8
OK	Move cursor right 1 col
OK	Adjust cursor X = 0, Y = -6
OK	Set width to 4 columns
OK	CR ?
OK	Adjust cursor X = 0
OK	Descender ?
OK	DLE ?
OK	Move down 2 rows
OK	OK
OK	COLOR = black
OK	DC1 ?
OK	COLOR = red
OK	Do the same for the 2nd row
OK	Do the same for the 3rd row
OK	DC2 thru ETB ?
OK	Set COLOR as requested
OK	Do the same for the 4th row
OK	Do the same for the Top row
OK	Similarly check for and act on any optional control char to be implemented
OK	Set cursor to next char. pos.

Figure 13: The CHAR function which provides the capability to display alphanumeric as well as graphical data.

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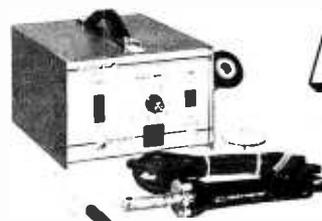
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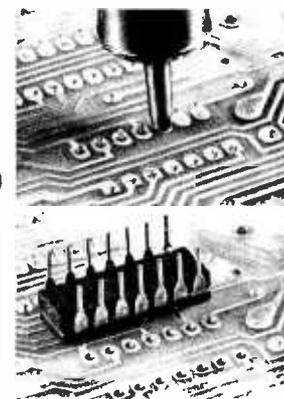
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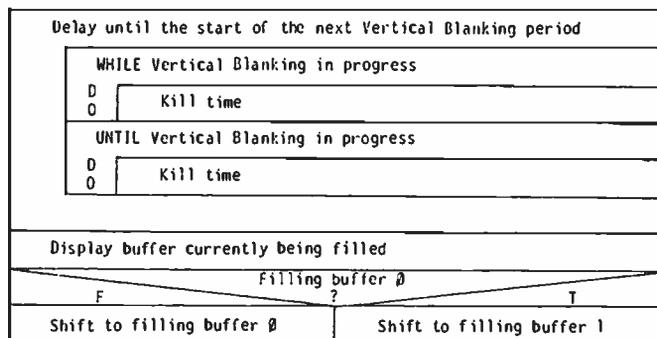


Figure 14: The ANIMAT function which provides for flicker-free changes in the display by permitting the user to load one refresh buffer while displaying another.

the physical contents of the table start with character 32 (blank). To index into the table, the ASCII value of the first table entry is subtracted from the value requested. This index value is then multiplied by the number of bytes per character, and the product is added to the address of the first character in the table in order to obtain the address of the first byte of the character desired. The cursor is then sequenced through the character matrix, turning on the points indicated. Only the points actually making up the character are affected, so background data is not erased and an overprint results.

Control characters are handled separately. Mode and color changes will depend on the DOT routine. Since these will be overly hardware-dependent, their implementation is left as an exercise to the reader. Carriage control characters modify the cursor position without otherwise affecting the display. Any unrecognized characters should be ignored.

ANIMAT Logic

The first requirement of the ANIMAT logic is to wait for vertical blanking to start (see figure 14). Most displays provide an input port with a status-bit which indicates when vertical blanking is in progress. By delaying until the status-bit indicates normal scan, then delaying until it indicates vertical blanking in progress, we are assured of a full vertical blanking period being available. If the display being programmed does not support changing the location of the refresh buffer by software controls, the routine is finished.

Displays in which refresh buffer locations can be changed are programmed to provide double buffering. After waiting for the vertical blanking period, the refresh buffer currently being filled is put on display. The alternate buffer is then opened for filling. Note that this algorithm is valid whether the buffer being filled is displayed (first call to ANIMAT after an INITG) or is being filled while another buffer is being displayed (all subsequent calls to ANIMAT).

In part 2 we will present an implementation of the 8080 assembly language protocol for the proposed graphics software standard, plus a series of demonstration programs. ■

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Book Reviews

8080/8085: Assembly Language Programming

Lance R Leventhal
Osborne and Associates Inc
Berkeley, California 1978
467 pages softcover
\$9.50

8080/8085: Assembly Language Programming is another in the series of Osborne and Associates' books on microcomputers. Those who are familiar with earlier works published by this company know that, in its contents, the entire series is comprehensive. Unfortunately, these books have been extremely difficult to read due to the use of bold

and regular type and the appearance of obscure abbreviations in their diagrams. I am pleased to say that this new book upholds the reputation for completeness, and it is also quite readable.

Chapter 1 defines and justifies assembly language programming. I doubt that anyone who purchases this book needs this chapter, but it is reassuring to us assembly language enthusiasts.

Chapter 2 describes how an assembler works and gives a very complete view of all the available features. As with all this publisher's books, it is not merely an overview. This chapter will greatly assist you in choosing among the available assemblers.

Chapter 3 is technical writing at its finest. Each assembly language instruction given is elaborated upon with diagrams the reader has become acquainted with in the earlier books—minus the incomprehensible abbreviations. Bold type is used only where it should be—for titles.

Chapters 4 thru 13 give sample programs ranging from very simple to extraordinarily complex. The early examples are slightly beyond the information given in chapter 3, but they progress through arithmetic and tables to I/O (input/output) routines and interrupts. Each chapter ends with self-testing examples where the answers, but not

the methods, are given. These self-tests are well-thought-out variations of earlier examples and, therefore, double the learning experience.

The final chapters give detailed advice on programming. These are mandatory if one expects his programs to be useful to anyone else. Leventhal repeatedly emphasizes that commercial programs must be written for the program buyer, not the writer.

In summary, this is an excellent encyclopedia of assembly language programming. If you understand all of this book and have it for reference, you will have few problems.

Bruce R Evans MD
16 Marwin Rd
Pickering Ontario
CANADA
L1V 2N7

Technical Aspects of Data Communication

John E McNamara
Digital Press
Digital Equipment Corp,
Educational Services Dept
12 Crosby Dr
Bedford MA 07130
\$19.95

Technical Aspects of Data Communication by John E McNamara is the book I was looking for five years ago. It could have saved me hundreds of hours of searching and reading. The last paragraph of the introduction states why: "This book will not teach anyone everything about data communication. Knowledge of data communication is acquired by a bootstrapping process in which one learns enough to read the next book or explore the next problem, from which one learns enough to go on further. This book is intended to fill

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a place in that process."

This book deals with the real nitty-gritty of data communications from "what is a stop bit?" all the way through an explanation of packet switching. All the information is presented in practical terms rather than through math and theory. A glossary in the back of the book defines all the terms used. Various accompanying tables list character codes, pin connections, and usable line lengths. If you need to know what a UART is and how it works, there is an appendix devoted entirely to UARTs.

If you need to know about asynchronous or synchronous communication, common protocols and what they are suited for, how telephones work, the characteristics of different modems, and what types of automatic-calling units are available and how to write a program to talk to them, you can find it in this book. If you only need to know what pin 8 on the 25-pin connector on your terminal is used for, you can also find that information in this book.

There are about 400 pages of good reference information with readable explanations for anyone who must deal with data communications hardware or software. *Technical Aspects of Data Communication* is well worth the price. ■

Phil Hughes
POB 2847
Olympia WA 98507



Broken Text

Several readers have brought to our attention that line 1790 of the Quest program on page 181 of the July 1979 BYTE is difficult to read. The line should read 1790 ON A1 GOTO 1000, 9999, 1760. ■

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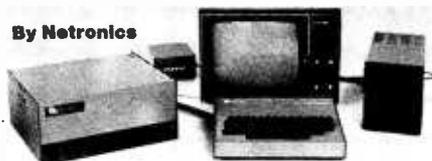
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Frank DeCaro
103 Spit Brook Rd, Apt C-2
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A digital-logic probe is a convenient device for examining signals. A typical probe has one or more light emitting diodes (LEDs) to indicate logic states. The LED lights to indicate a high (1) logic state, and turns off to indicate a low (0) logic state. It is not possible, however, to compare these signals with the state of the system clock. The system clock is the square wave source from which all other signals are derived.

The digital oscilloscope presented here allows comparison of selected signals with the system clock. The schematic diagram is given in figure 1. The digital oscilloscope converts a serial digital signal into a visible display on 16 LEDs. Each LED corresponds to $\frac{1}{2}$ of a clock cycle. Figure 2 shows some typical waveform traces and their corresponding displays on the digital oscilloscope. Figure 3 shows a typical method of connection for displaying serial waveforms. One limitation of the 16 LED display is that it cannot completely show a signal which is derived from the clock signal by dividing by more than 8.

A block diagram of the digital oscilloscope is shown in figure 4. The major sections are:

- data and enable sequencer
- enable strobe
- data strobe
- latch
- display

The clock is fed into a circuit which divides the frequency by 8. These 2 signals comprise the data and enable sequencer. Eight clock cycles are required for the sequencer to complete 16 transitions. The 16 address inputs

Text continued on page 226

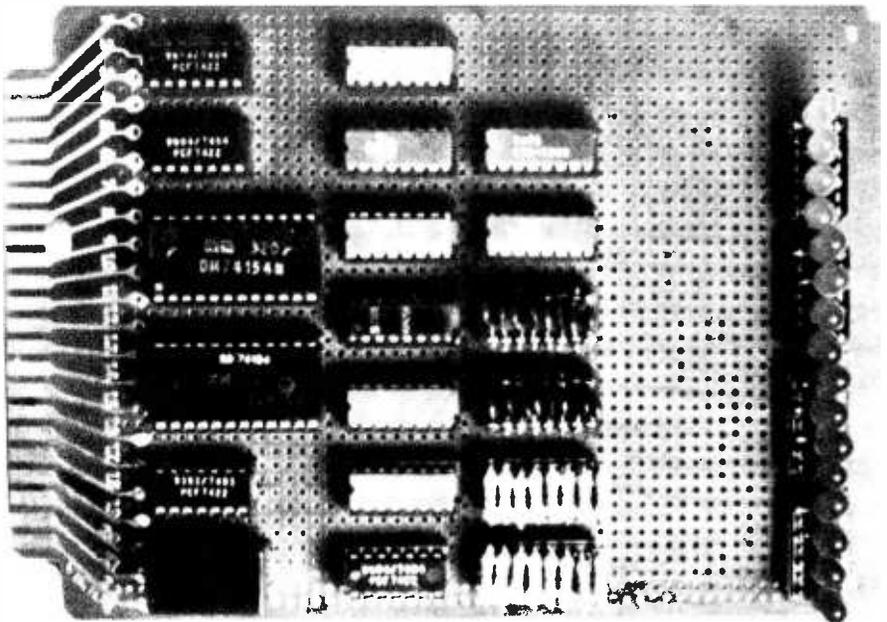


Photo 1: Digital oscilloscope as constructed on a project board. The photo shows the original design (the schematic diagram in figure 1 shows an updated version which eliminates all capacitors on the output lines).

Device	Type	+ 5 V	GND
IC1	74154	24	12
IC2	7404	14	7
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IC7	7474	14	7
IC8	7474	14	7
IC9	7474	14	7
IC10	7474	14	7
IC11	7474	14	7
IC12	7474	14	7
IC13	74154	24	12
IC14	7493	5	10

Table 1: Power and ground connections for integrated circuits in figure 1 schematic diagram.

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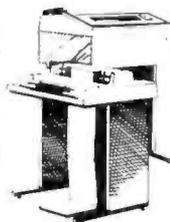
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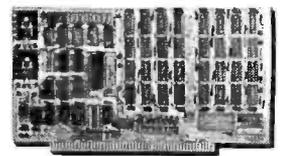
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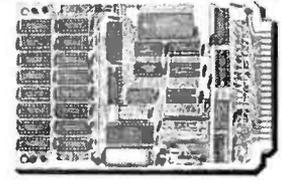
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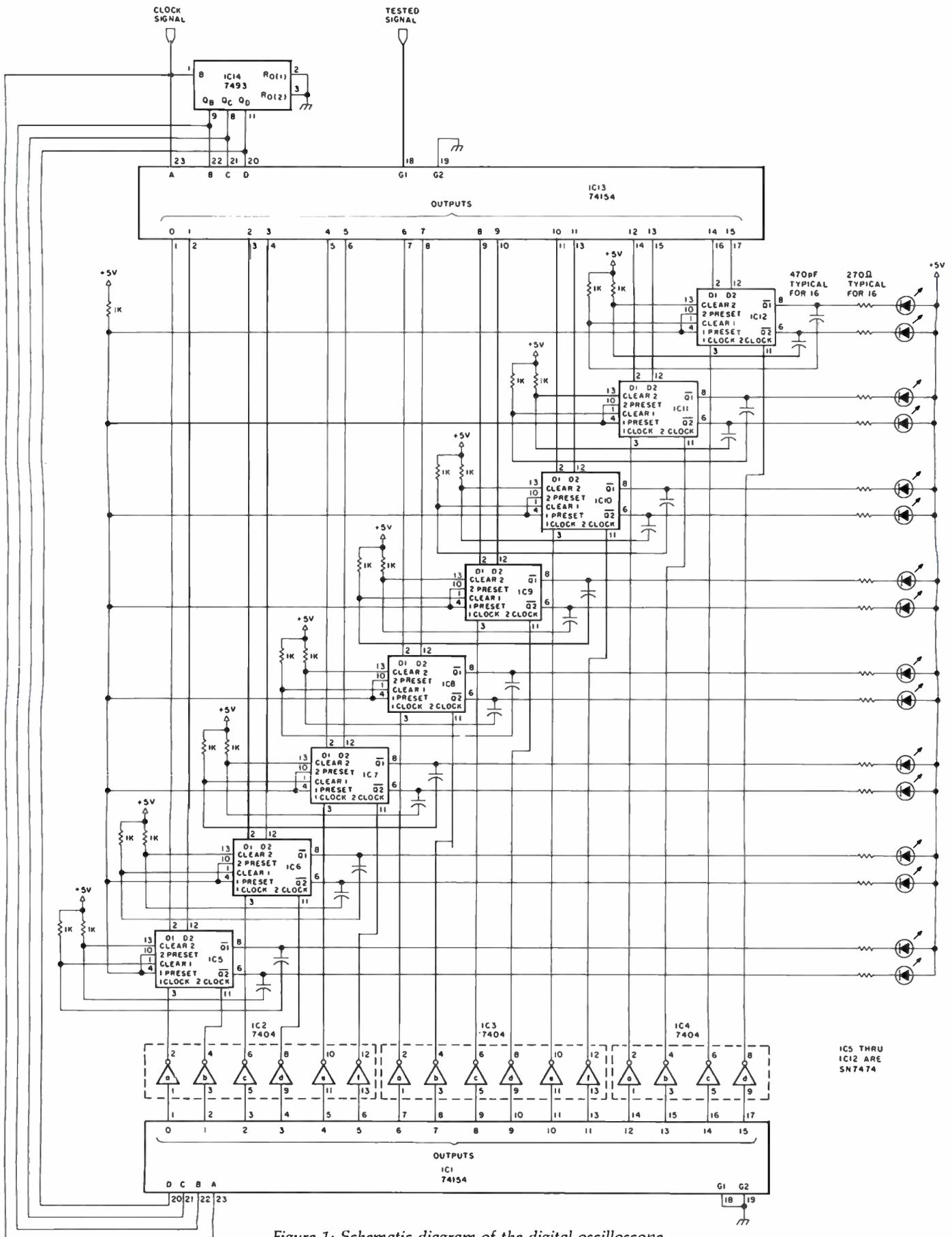


Figure 1: Schematic diagram of the digital oscilloscope.

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DUAL RACE Dual Race is a very exciting fast paced and challenging auto race game for two players. (> 16k) \$14.95

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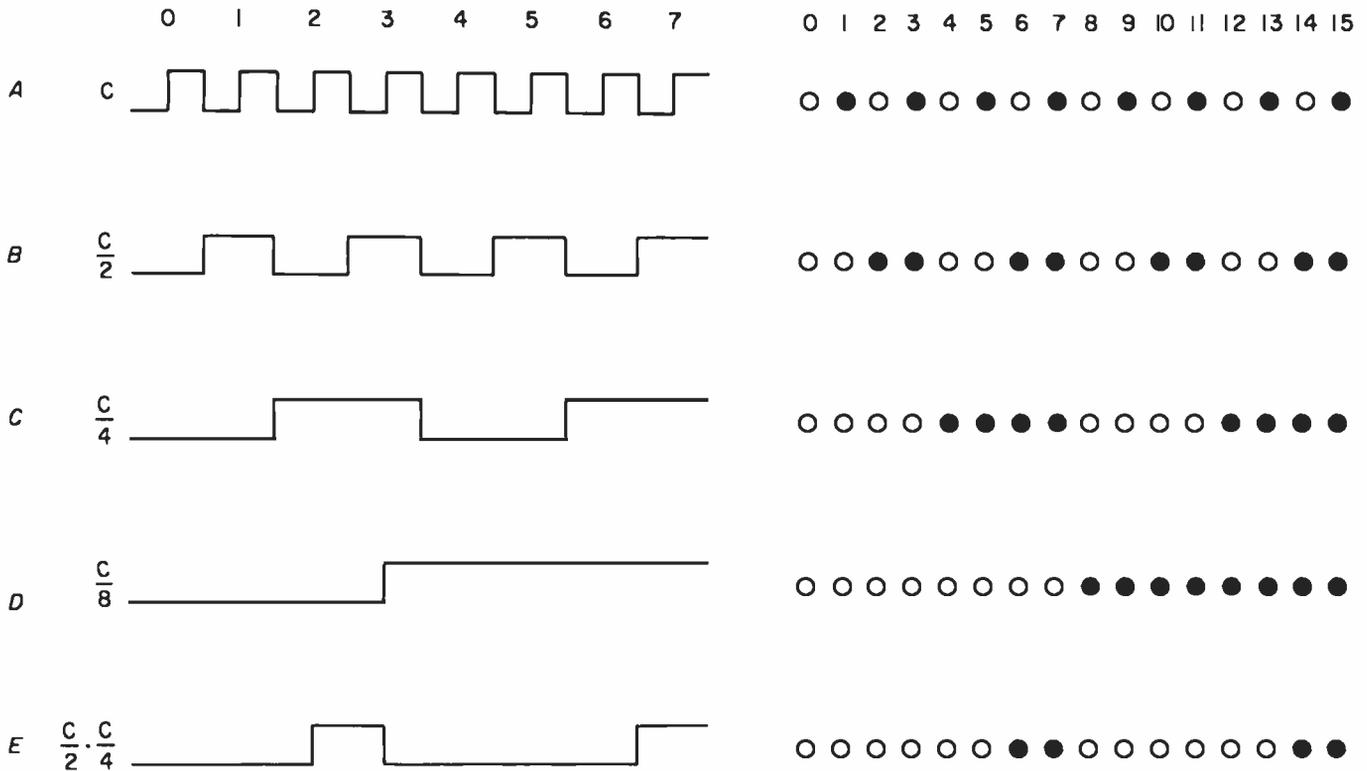


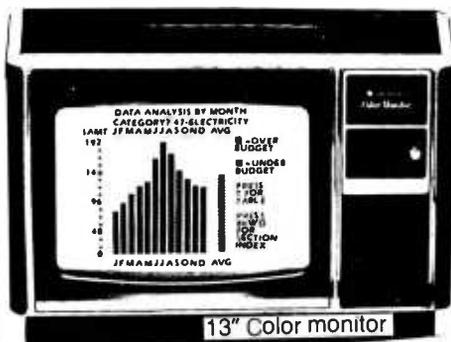
Figure 2: Comparison of waveforms as they might be displayed on an analog oscilloscope, and as they are displayed on the digital oscilloscope. The dark circles indicate lighted light emitting diodes (LEDs). The open circles show unlighted LEDs.

Text continued:
of the enable and data strobes are sequentially scanned.

The data and enable strobe signals are sent to latches. The data strobe provides the information to be stored when the enable strobe of the same latch goes low. The latches are updated every 8 clock cycles. The output of each latch is used to drive an LED. The LED will glow if the output of the latch is low (a 0 state). In this manner, the serial digital signal is mapped onto the array of 16 LEDs.

The digital oscilloscope is also useful as a logic design and analysis aid. It can generate a truth table for a combinational logic network of up to 4 inputs. To accomplish this, simply connect the clock signal, the clock divided by 2, the clock divided by 4, and the clock divided by 8 to the inputs of the logic network (pins 23, 22, 21, and 20 of IC1.) Connect the output of the logic network to the signal input of the digital oscilloscope. Figure 5 illustrates how to make these connections to a logic network. ■

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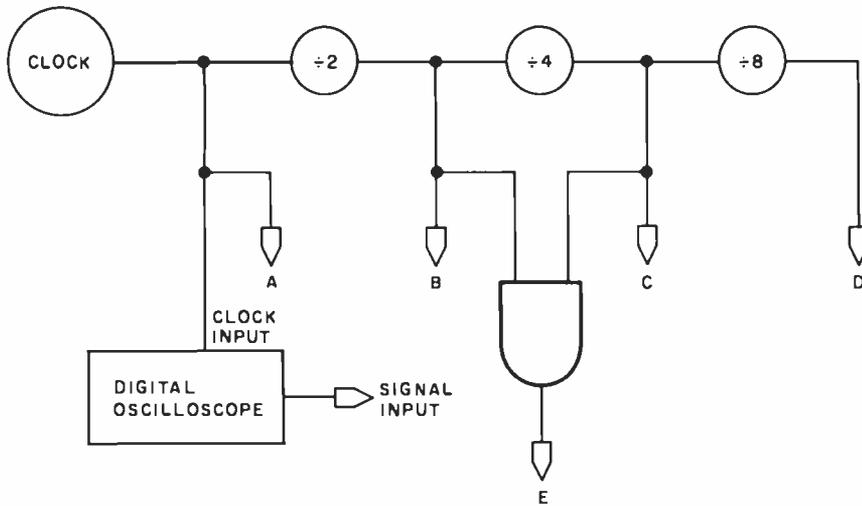


Figure 3: Typical method of connection for displaying serial waveforms.

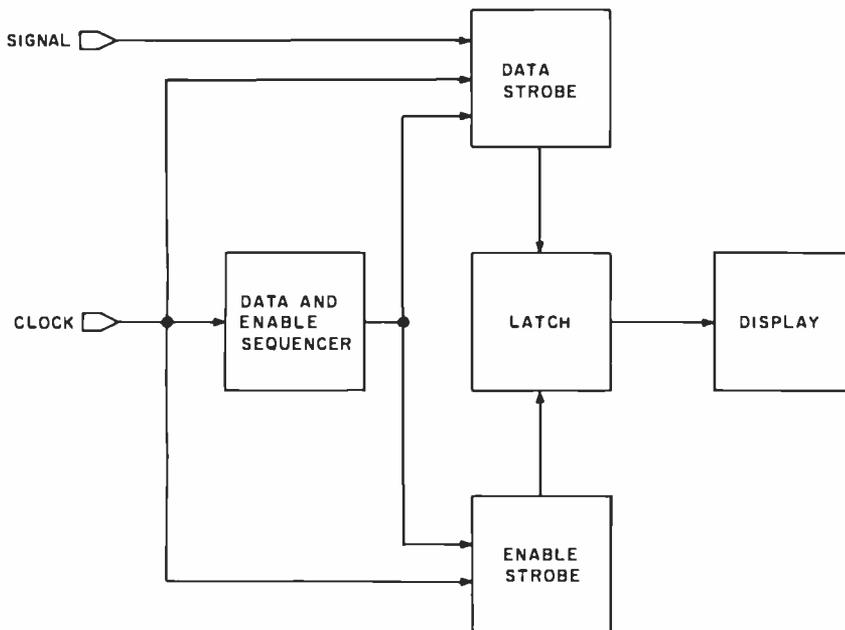


Figure 4: Block diagram of digital oscilloscope function.

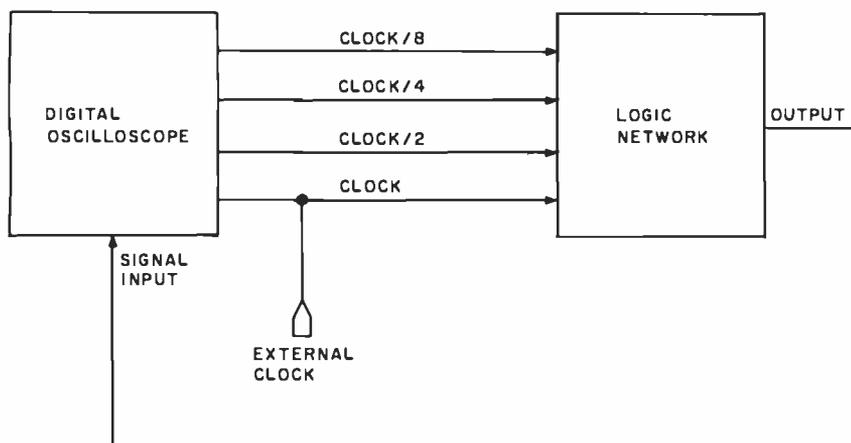
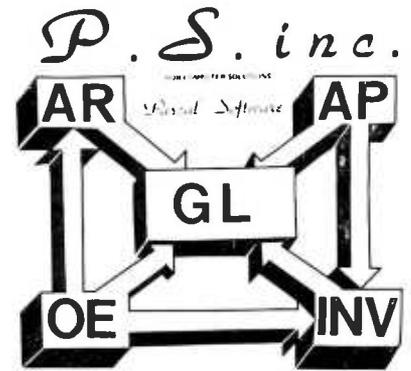


Figure 5: Connections to determine truth table for a logic network.



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NOVEMBER 1979

November 1

Invitational Computer Conference, Cherry Hill NJ. This conference is directed to the quantity buyer and will feature the newest developments in computer and peripheral technology. Contact B J Johnson and Associates, 2503 Eastbluff Dr, Suite 203, Newport Beach CA 92660.

November 5-7

Thirteenth Asilomar Conference on Circuits, Systems and Computers, Asilomar Hotel and Conference Grounds, Pacific Grove CA. Contact Roger C Wood,

Electrical and Computer Engineering Dept, University of California, Santa Barbara CA 93106.

November 5-8

Electronics Production Engineering Show, Kosami Exhibition Center, Seoul Korea. This international industrial exposition will be devoted to the needs of manufacturers of electronic products in Korea. Contact Expoconsul, Clapp and Poliak International Sales Division, 420 Lexington Ave, New York NY 10017.

November 6-8

IEEE Third International Conference on Computer Software and Applications, The Palmer House, Chicago IL. Contact IEEE Computer Society, POB 639, Silver Spring MD 20901.

November 6-8

Midcon/79 Show and Convention, O'Hare Exposition Center and Hyatt Regency O'Hare, Chicago IL. Contact Electronic Conventions Inc, 999 N Sepulveda Blvd, El Segundo CA 90245.

November 6-8

New England Printed Circuits and Micro-Electronics Exposition, Northeast Trade Center, Woburn MA. This show is devoted to the equipment, materials, tools, supplies, and test instruments needed to manufacture electronic and microelectronic circuits, components, and systems. The show is sponsored by the International Electronics Packaging Society. Contact Industrial and Scientific Conference Management Inc, 222 W Adams St, Chicago IL 60606

November 6-8

Third Digital Avionics Systems Conference, Ft Worth TX. This conference will probe the expectations and challenges of the digital revolution in avionics systems. Contact John C Ruth, Technical Program Chairman, POB 12628, Ft Worth TX 76116.

November 8-10

Entering a Decade of Experience - Where Are We and Where Are We Going?, Atlanta Hilton, Atlanta GA. Sponsored by the Society for Computer Medicine, this conference will cover microprocessing in medicine, computers and medical records, automated ill-patient monitoring and other related topics. Contact the Society for Computer Medicine, Suite 602, 1901 N Ft Myer Dr, Arlington VA 22209.

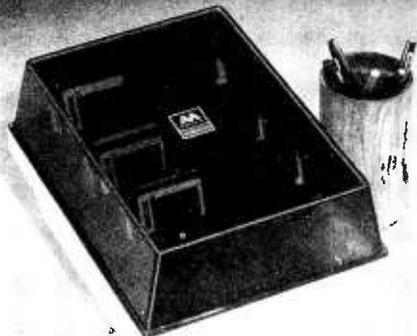
November 12-14

Computer Cryptography, The George Washington University, Washington DC. The objective of this course is to provide each participant with a working knowledge of the use of

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cryptography in computer applications. Contact Continuing Education, George Washington University, Washington DC 20052.

November 12-16

Communications Satellite Antenna Technology, University of Southern California, Los Angeles CA. This course is for engineers engaged in the design of military or commercial satellite communication systems, spacecraft antenna and ground stations. Multiple beams, frequency reuse,

polarization control, the new generation of satellites, and other topics will be discussed. For more information, call (213) 741-2410.

November 13-15

DPMA Education Foundation Sponsors Systems Conversion Symposium, Washington DC. The theme of the three-day meeting is "Converting Today's Systems to Tomorrow's Technology." Hardware and software aspects of computer conversion, strategies and techniques, and transi-

tion to a distributed data base system will be discussed. Contact Ken Burroughs, DBD Systems Inc, 1500 N Beauregard St, Alexandria VA 22311.

November 14-16

Advanced Programming Techniques Using Pascal, Allentown PA. This class will teach Pascal programmers how to build a comprehensive and effective Pascal-based software development environment. Emphasis will be on programming exercises with

group and individual instruction. Contact Software Consulting Services, 901 Whittier Dr, Allentown PA 18103.

November 14-16

1979 International Micro and Minicomputer Conference, Astro Village, Houston TX. This conference concerns micro and minicomputer systems, a survey of the range of current applications, and exploration of potential areas for future development. Emphasis will be

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November 15

Invitational Computer Conference, Southfield MI. See November 1 for details.

November 15-19

White House Conference on Library and Information Services, Washington DC. This conference has been called to help shape policies on public access and dissemination of information in this country. Two issues to be covered are the libraries' ability to help stop functional illiteracy and the use of computers, cable television, audio and video systems as alternative routes of information delivery. Contact Susanne

Roschwalb, (202) 466-7800 or Vera Hirschberg, (202) 653-6252.

November 27-29

Sixth Datacomm, Pacific Grove CA. This symposium is sponsored by the IEEE Computer Society, the IEEE Communications Society, and the Association for Computing Machinery. Some of the subjects of the eleven sessions are electronic fund transfer, protocols, routing and flow control, new data network services in Europe, and local networks.

For more information, contact Sixth Datacomm, POB 639, Silver Spring MD 20901.

November 28-30

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November 29-30

Metric Management Workshop, Dallas North Park Inn, Dallas TX. The workshop is designed to help personnel at all levels plan and implement a cost-effective transition to metric in their company. The sessions will cover establishing a metric plan and strategy, assigning responsibility for the transition within the existing organizational structure, and developing a sensible approach to controlling conversion costs. Contact Len Boselovic, ANMC, 1625 Massachusetts Ave NW, Washington DC 20036.

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December 3-5

Implementing Cryptography in Data Processing and Communications Systems, New York NY. Going beyond an introduction to cryptographic systems, the seminar will stress implementation of the DES and address public key implementation considerations. Contact Ms Jansen, Cryptotech, 12 State Rd, Bellport NY 11713.

DECEMBER 1979

December 2-6

MUSE North American Annual Meeting, Bahia Mar Hotel and Yachting Center, Ft Lauderdale FL. This conference of Modcomp Users Exchange (MUSE) will feature technical sessions, workshops and user/manufacturer interface sessions on the use of Modcomp computers and their related software. Contact Kathy Black, MUSE, 4620 W Commercial Blvd, Suite 6C, Tamarac FL 33319.

December 3-5

The Application of Computer Technology to Accounting Systems, Washington DC. The theme of the conference is "Information Systems as a Management Tool for the Financial Executive." It is sponsored by the Association of Government Accountants (AGA). Contact Ken Burroughs, DBD Systems Inc, 1500 N Beauregard St, Alexandria VA 22311.

December 3-5

COMDEX '79, MGM Grand Hotel, Las Vegas NV. This conference and exposition

December 8-9

Data Processing for Businesspeople, Cherry Hill Inn, Cherry Hill NJ. Management Information Corporation presents this seminar to meet the needs of company management in understanding computers. The seminar includes basic concepts of data processing alternatives (service bureaus, timesharing), small business computer systems, program packages availability and selection, managing the computer system, and the future of data processing. Contact Management Information Corporation,

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STAR TREK III \$14.00 Travel through the galaxy on the Enterprise and destroy klingons. New updated version.	NEWDOOS \$49.00 Same as above without utilities.	INVENTORY II \$99.00 activity listing, complete listing, selected listing, minimum quantity search, 1000 items per disk
AIR RAID \$14.00 Real time shooting gallery.	SYSTEM INTEGRATION TEST tests memory, disk drives, and printer. \$29.00	ALL ABOVE PROGRAMS BY SBBG
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December 10-11

Mini and Microcomputers in Control, Galt Ocean Mile Hotel, Ft Lauderdale FL. This symposium will cover computer architecture and hardware for control, languages for control, algorithms for control, hierarchical control, methodology, and other topics. Contact The Secretary, Computers in Control Symposium, POB 2481, Anaheim CA 92804.

December 10-12

Project Management for Computer Systems, Chicago IL. This seminar will illustrate techniques for planning, implementing, installing, and controlling projects. Contact The University of Chicago, 1307 E 60th St, Chicago IL 60637.

December 10-13

1979 Fall DECUS US Mini/Midi Symposium, San Diego CA. This symposium is an opportunity for Digital Equipment Computer users to participate in a technical exchange. Contact DECUS, One Iron Way, MR2-3, Marlboro MA 01752.

December 10-14

IEEE Computer Society's Tutorial Week 79, Hotel Del Coronado, San Diego CA. Fifteen different one-day seminars will be offered throughout the week. Contact IEEE Computer Society, POB 639, Silver Spring MD 20901.

JANUARY 1980

January 3-4

Hawaii International Conference on System Sciences, Honolulu HI. The conference will cover developments in theory or practice in software and hardware, and advanced computer systems applications in selected areas with emphasis on medical infor-

mation processing and computer-based decision support systems for upper-level managers in organizations. For more information, contact Perry G Patten, Office of Management Programs, University of Hawaii, 2404 Maile Way, Honolulu HI 96822.

January 23-26

International Microcomputers Minicomputers Microprocessors (IMMM), Harumi Exhibition Centre, Tokyo Japan. This is a show for manufacturers, commercial and financial establishments, service industries and institutions, and design engineers interested in buying computer systems, components and services. For more information, contact Industrial and Scientific Conference Management Inc, 222 W Adams St, Chicago IL 60606.

January 28-30

Principles of Programming Languages, Las Vegas NV. This symposium concerns practical and theoretical aspects of principles and innovations in the design, definition, and implementation of programming languages. Some topics are algorithms and complexity bounds for language processing tasks, specification languages, error detection and recovery, and unusual or special-purpose languages that raise issues of principle. Contact Professor John Werth, Department of Mathematical Sciences, University of Nevada, Las Vegas NV 89154.

January 30-February 1

MIMI '80 Asilomar, Asilomar Conference Grounds, Pacific Grove, CA. This symposium covers all aspects of mini and microcomputers including technology, hardware, software engineering, languages, education and more. Contact The Secretary, MIMI '80 Asilomar, POB 2481, Anaheim CA 92804. ■

The Formation of a New Personal Computer Society

Do personal computer owners need a national organization? A personal computer user named Abby Gelles would answer in the affirmative. She was interacting with a number of the attendees of the National Computer Conference Personal Computer Festival last June when the usual pro and con arguments were raised in her conversations. She is convinced there is a need.

So, with some kindred spirits in New York City, Abby has formed the *Personal Computer Society*. You can find out about what she is proposing by writing her at: Ms Abby Gelles, Executive Director,

Personal Computer Society, POB 147, Village Sta, New York NY 10014.

ICS Announces New Courses

Integrated Computer Systems Inc (ICS), 3304 Pico Blvd, POB 5339, Santa Monica CA 90405, has announced the fall and winter schedule for their Short Course series. Courses on computer graphics, digital signal processing, troubleshooting microprocessor systems, and other topics, will be covered. The courses will be held in cities around the United States from November through February. These courses are structured for technical and managerial personnel. ■

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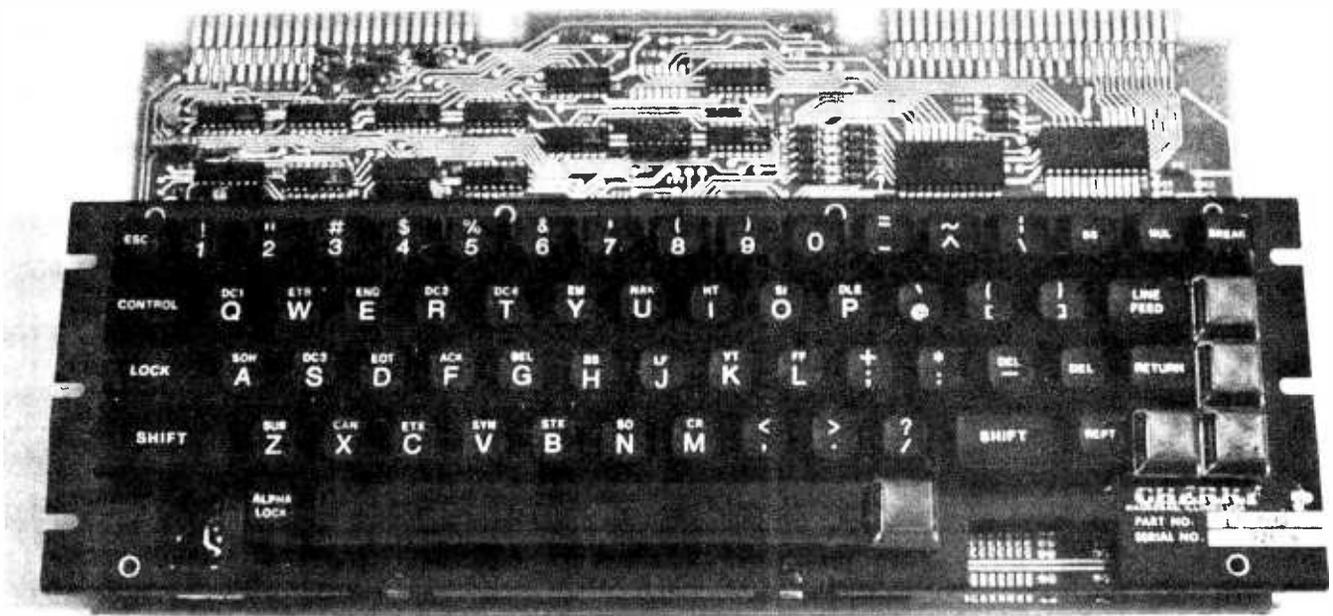
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ER-12 Power Etch bubble pump unit*	7.25

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In the few short years since the birth of the personal computer, the list of peripheral devices has grown tremendously: printers, video displays, mass storage devices, and keyboards. At first, many of these items were overruns from original manufacturers, or were removed from used business or military systems. Documentation was scarce and complete schematics were often nonexistent. Keyboards were available in a myriad of styles, but not with all the features of a professional unit. If they were encoded at all, it was often in half ASCII (upper case ASCII only, as available on the Teletype Model 33).

About the Author

Dan S Parker is presently completing work on a PhD degree in Physics at the University of California at Davis. His area of research is magnetic properties of rare earth crystals in solid state, low temperature physics. He is also actively developing a data acquisition and cryogenic control microcomputer for his research equipment.

No more! Enter the PRO, Cherry's new entry into the personal computer keyboard market (Cherry model B70-05AB). Aptly named, it is indeed a professional keyboard that comes fully assembled, tested, and ready for installation in your computer system. Its features rival those of keyboards found in expensive terminals.

General Features

The PRO features the full 128 ASCII character set of upper case, lower case, and control characters. A total of 67 gold contact keys, engraved in white on durable matte black injection molded plastic, are easy on the eyes. The shift, shift lock, control, linefeed, and return keys are oversize for easier operation (see photo 1). Cherry lists the operating force of the keys at 2.5 ounces. They feel solid, positive, and very smooth. The keys are wave soldered to 1/16 inch glass epoxy circuit board material and anchored to a 1/16 inch black anodized aluminum cover subplate. No wobble in those keys or flexing of the circuit board when a key is pressed.

Five of the keys are unassigned and

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available for user defined functions. They can be relabeled (clear plastic covers to put labels under) and are all momentary contact. The operation and customizing manual is easy to read and has the full set of diagrams including schematics.

Electrical Specifications

The PRO operates from a single +5 V power supply and draws 325 mA maximum current as listed in the operator's manual. I measured it and found that it draws considerably less: 200 mA nominal. Outputs are via one of two 22 pin edge connectors and are TTL and DTL (transistor-transistor logic and diode-transistor logic) compatible. Pinouts include the seven ASCII bits, optional parity, +5 V, ground, strobe and inverted strobe, shift, break, repeat, control, and keyboard lockout. Cherry has conveniently placed these contacts so that only one side of a 22 pin edge connector (not supplied) is needed. Thus a single readout 22 pin connector may be used. The other pins are available with solder pads for customizing.

A second 22 pin edge connector (the one in the upper right of photo 1) is designed for piggybacking a numeric keypad onto the PRO. The matrix scanning technique employed makes it easy to modify key assignments and generate custom output codes.

The strobe pulse is generated 2.5 μ s after a key is pressed to insure data stability and is nominally 100 μ s wide. This seems to be ideal for both the Dajen SCI and Processor Technology 3P+S that I've used the keyboard with. The manual describes how to modify this timing.

Customizing

The keyboard is truly designed for the experimenter; Cherry is to be commended for making the keyboard user adaptable with a minimum of effort. As shipped, the keyboard is ready to use for most applications. As an example of the ease of modification, two of the integrated circuits are provided in sockets. Changing these two circuits to other integrated circuits (not provided but standard parts) and making no other changes converts the board to negative logic. Yet a different exchange of these two circuits results in a positive logic 3 state output so that two or more PRO keyboards can be wired in parallel. Still a fourth choice of circuits gives high voltage CMOS drive compatibility.

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All schematic reference points, integrated circuit designations, and modification points are marked on the circuit board. All of the keys are equipped with dual plated-through holes so that the link connecting them can be cut to isolate the keyswitch. This makes it easy to add custom features. A large number of solder pads and a spare integrated circuit pad have also been provided.

A provision has been made for the addition of an automatic repeat key by installing a 74123 monostable multivibrator in a provided integrated circuit pad along with appropriate timing capacitors and resistors. The manual's suggested timing components made this very easy to implement. My only complaint is that the holes on the empty pad are filled with solder which has to be removed (eg: the board is wave soldered).

The repeat function has two modes. In the first mode, holding down any key for more than 1/2 second causes that character to repeat at about nine characters per second. In the second mode, simultaneously holding down the repeat and character keys causes the automatic repeat.

A few of the other documented changes that can be made include the generation of odd or even parity, latched output, and a shift control mode in which, by depressing

both the shift and control keys, additional 8 bit codes can be generated.

Alpha Lock versus Shift Lock

Shift lock and alpha lock are not the same thing, and a lot of confusion among experimenters and dealers seems to exist about this point. Put simply, alpha lock (often called caps lock or teletypewriter lock) simply locks out the lower case characters so that the keyboard generates only numbers and upper case letters. In this mode the shift key still operates and gives the shifted mode characters above the numbers such as ") (*&%\$#. The advantage of this mode is that much software, like most BASICs and assemblers, accepts only upper case letters and numbers.

In the second mode, with the alpha lock not engaged, the keyboard generates upper and lower case just like a typewriter, such as might be needed for text editing. In both modes the shift and shift lock keys are active. The alpha lock key is shown in photo 1 just to the left of the space bar and is an alternate action key, as is the shift lock key. My preference would have been to position the alpha lock key a bit further from the main section of the keyboard.

Enclosures

The PRO comes without an enclosure but is provided with mounting wings. A recommended panel cutout diagram is included with the manual for custom cutting if you so desire. Fortunately, the cutout is simplified by a minimum of contour "stair step" cuts. Dimensions of the keyboard are 14 by 7 1/4 by 7/8 inches (34.6 by 18.4 by 0.9 cm). The thickness is measured from bottom of the printed circuit board to top of aluminum cover plate. Hence the keyboard can be mounted extremely low profile either flat or tilted. At present, the only custom precut keyboard enclosures available commercially, I believe, are offered by Electrolabs (POB 6721, Stanford CA 94305) and Ironman (POB 1260D, Southgate CA 90280). A number of firms offer blank enclosures which also appear to be suitable for use with the PRO. Better yet, make your own.

Concluding Remarks

The PRO is priced at \$135 in single quantities. For two to four pieces, the price is \$107 each, directly from Cherry. The price plummets to \$94.50 for five or more keyboards. Delivery takes two or three weeks.

For more information, contact Cherry Electrical Products Corp, 3600 Sunset Av, Waukegan IL 60085. ■



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ACM Special Interest Group Publishes Newsletters

The Special Interest Group on Language Analysis and Studies in the Humanities' *SIGLASH Newsletter* is published in March, June, September and December by the Association for Computing Machinery (ACM). The newsletter contains unrefereed papers, reviews of books and articles, abstracts of members' work, a "rap" section for short communications, announcements of general interest, and letters to the editor. Membership in this special interest group, which includes the newsletter, is \$4 a year for ACM members and \$10 for non-ACM members. Contact

ACM Inc, POB 12105, Church St Station, New York NY 10249.

Tri-State Computer Club

The Tri-State Computer Club is a newly established hobbyist group serving the river cities in the Ohio, West Virginia and Kentucky areas. They have over 40 members representing 6800s, TRS-80s, Digital Equipment Corporation (DEC) and Heath equipment. The meetings are held on the second Saturday of the month at 3:30 PM in the Lawrence County OH public library. Meetings are open and the public is invited to attend. Contact Douglas

Troughton, 508 Colony Dr, Wheelersburg OH 45694.

Apple Computer Users Group in Honolulu HI

Honolulu HI now has its own Apple Computer Users Group. The Honolulu Apple Users Society (HAUS) supports a newsletter containing the latest up-to-date information concerning the Apple, including program tips and techniques, listings, reviews, etc. Meetings are held the first Monday of each month at the Computerland store in Honolulu. The president is Bob McDowell, and Randy Brumback is vice-president. The club holds weekly sessions on programming, BASIC, hi-res graphics, etc. Annual dues are \$10 which include a newsletter. Additionally, the group is interested in exchanging information and software with other clubs. Contact Bill Mark, 98-1451-A Kaahumanu St, Aiea HI 96701 or phone (808) 488-2026.

PPC Journal for Hewlett-Packard Programmable Calculator Users

The *PPC Journal* is the monthly publication of the Personal Programmers Club (PPC) which is a volunteer, nonprofit, loosely organized, world-wide group of Hewlett-Packard programmable calculator users. The purpose of the publication is to disseminate user information related to the selection, evaluation, care and application of all Hewlett-Packard programmable calculators. The journal is available through membership in PPC. Inter-

ested individuals should write to PPC, 2541 W Camden Pl, Santa Ana CA 92704. A sample issue of the *PPC Journal* and other information materials may be obtained by sending a self-addressed 9 by 12 inch envelope with 2 ounces of first class US postage attached.

Non-Mikbug 6800 Series System User Group

According to a letter received from Mark Siebart, he is attempting to set up a users group and newsletter for non-MIKBUG 6800 series systems with emphasis on the Capitol Radio Engineering Institute (CREI) and National Radio Institute (NRI) machines. These are based on a J-Bug compatible monitor using the MEK format. Anyone interested in such a group should write to Mark at 2599 Caulfield, San Diego CA 92154.

Bulletin for TRS-80 tiny-c and Assembler

The TRS-80 *tiny-c and Assembler Programming Bulletin* specializes in programs and techniques for Radio Shack's editor and assembler and *tiny-c* associates' *tiny-c* interpreter for the TRS-80. An annual subscription (4 issues) costs \$8.50 and a single issue is priced at \$2.50. Contact Rob Varty, 2193 Haygate Cr, Mississauga, Ontario CANADA L5K 1L7.

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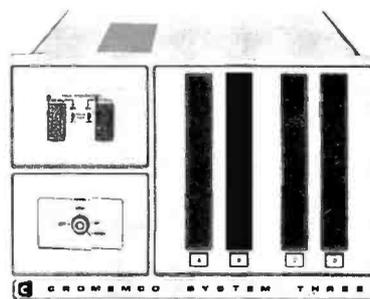
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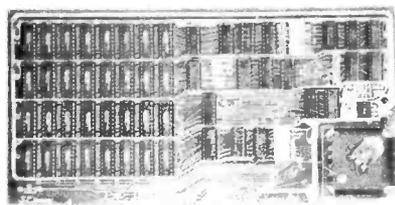
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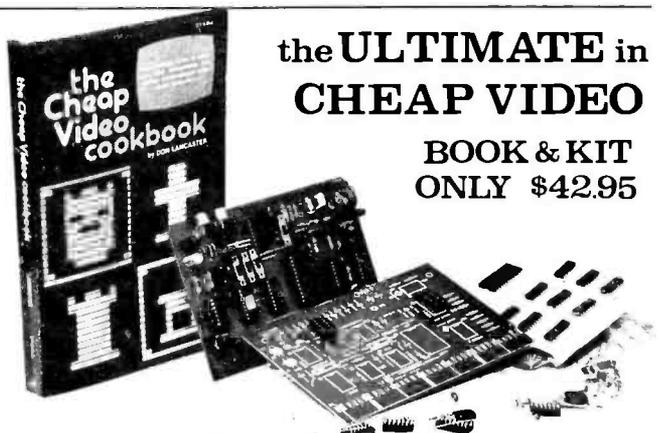
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meetings are at 7:30 PM on the third Wednesday of every month. For a copy of the current WAKE newsletter, send a stamped, self-addressed envelope to WAKE, c/o Ted Beach, 5112 Williamsburg Blvd, Arlington VA 22207 or phone (703) 538-2303.

Microcomputer
Investors
Association

The most recent issue of the MicroComputer Investors Association journal contains 200 pages with 20 articles that deal with utilizing microcomputers to make and manage investments. Practical computer programs accompany half of the articles. The Association is a nonprofit group which was formed 3 years ago to enable members to share data and information. An information packet is

available for \$1. Contact Jack Williams, MCIA, 902 Anderson Dr, Fredericksburg VA 22401.

Free Newsletter
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Hands On! is a free newsletter published 3 times a year by the Technical Education Research Centers (TERC), 575 Technology Sq, Cambridge MA 02139. TERC is a nonprofit curriculum research and development corporation. Billed as a forum for science and technology educators, the latest issue of the newsletter contains articles such as *A Biased Introduction to the World of the 6502 Microprocessor: Toward Affordable Computers: Networking and Graphics; Microcomputers in Instru-*

ment and Control and much more. To be added to TERC's mailing list, contact the company at the above address.

Computer Club
in Venezuela

The Cuatro Computer Club, Los Pinos Ave, EDF Airosa 5, La Florida, Caracas VENEZUELA, has a monthly newsletter entitled *Micronews*. The newsletter includes short programs on computer graphic art and game programs, as well as future conferences and events, and anecdotes.

The Delmarva
Computer Club

The Delmarva Computer Club has been formed to create a community awareness of microcomputer uses for business and pleasure. The club meets at

Arcadia High School in Oak Hill VA at 7:30 PM on the first and third Wednesday of each month. Beginners are able to get hands-on programming instruction in BASIC, and advanced members work on community projects and software development and exchange. Contact Jean Trafford, POB 36, Wallops Island VA 23337.

Albany-
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Microcomputer
Society

Capital Area Microcomputer Society (CAMS) is a newly organized group interested in information exchange among members, solving software and hardware problems, and presentation of programs of general interest. Presently there are about 30 members and meetings are held at various locations around the Capital District on the second Wednesday of each month. Contact Stanley L Mathes, Box 348 Ridge Rd, RD#1, Scotia NY 12302, (518) 372-3767.

Electronotes for
Musicians

Electronotes 99 is a newsletter for knowledgeable designers, technicians and hobbyists in the music synthesizer field. There are projects, diagrams, items for sale and articles of general interest to sound engineers and designers. For more information, contact *Electronotes 99*, 1 Pheasant Ln, Ithaca NY 14850.

Utah Computer
Association

The Utah Computer Association (UCA) meets every second Thursday of the month at 7 PM at Murray High School, 5440 S State St, Salt Lake City UT. The club also has special interest groups that meet at different times to review new products and exchange

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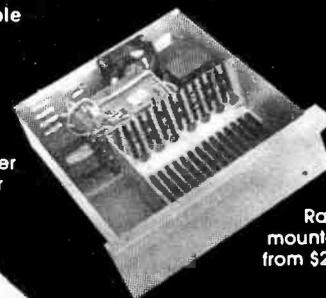
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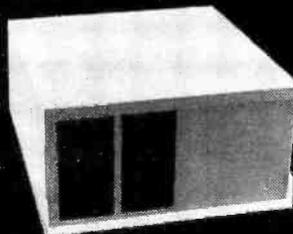
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information on programs. Their newsletter, *Bits*, is published monthly and includes articles concerning club meetings, programs and instructions for microcomputers, advertisements, and general information for computer users. Membership in the club is \$7.50 per year which includes subscription to *UCA Bits*. For more information, contact UCA, 378 E 9800 S, Sandy UT 84070.

Chicago Area Computer Hobbyist Exchange

The Chicago Area Computer Hobbyist Exchange (CACHE) meets at 1 PM on the third Sunday of the month at the Northern Illinois Gas Building, Golf and Shermer, Glenview IL. Annual dues are \$10 which includes the monthly newsletter, the *CACHE Register*. For further information, call the club's hotline at (312) 849-1132 or write to CACHE, POB 52, S Holland IL 60473.

Computer Club in Tucson

The Pima Community College Computer Club has been formed at the East Side campus at 7830 E Broadway and meets the second Friday of each month at 7:30 PM. Most of the members have already purchased systems, but those still searching for the best buy are welcome, as are nonstudents. Contact Mike Blicharz (602) 749-9157 or Saul Levy (602) 793-0670.

Institute for Computers in Jewish Life (ICJL)

The ICJL recently sponsored a conference on the use of the microprocessor in Jewish education. The conference was open to all educators interested in the application of computers in education. The *Use of Microprocessors in Jewish Education* newsletter covers programs used for teaching

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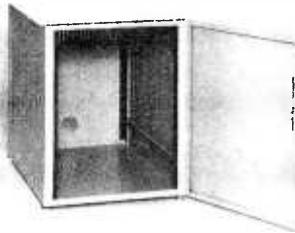
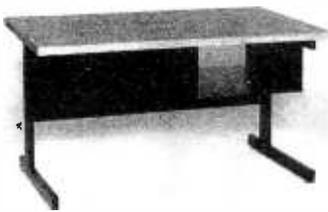
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The Eastern Iowa Computer Club

This group meets on the last Sunday of each month. Their newsletter deals with the events of the meeting and future activities of the club. They have printed game programs in the report and are currently working on a software contest. The club invites inquiries from other computer groups and users. For more information, contact the Eastern Iowa Computer Club, POB 164, Hiawatha IA 52233.

The Homebrew Computer Club

The Homebrew Computer Club, POB 626, Mountain View CA 94042, meets at the Fairchild Auditorium in the Stanford Medical Center on the third Wednesday of each month from 7 to 10 PM. The group exchanges programs, works out bugs and tries out new microcomputer systems. Their newsletter covers new products, conferences, and has a section of used computers for sale.

The Popular Computing Newsletter

This is a newsletter for TRS-80 users. It includes programming tips, various programs for home and business, reviews of books and programs, and one edition has programs for two games and a program for add-on interest comparison. It is available from Popular Computing Inc, POB 16875, FT Lauderdale FL 33318, at \$24 for one year, \$36 for two years, and \$48 for three years. ■

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After entering the program (see listing 1), press E. Subroutine E clears the memories, sets the program pointers, and repartitions the memory space to give the

Listing 1: TI-58 program for multiplying two numbers with an answer totaling up to 90 digits long.

```

TI 58
NUMBER PUNCHING 017 11 A 049 13 C
018 72 ST+ 049 97 DSC
019 01 01 050 06 06
LABEL . ST 020 69 DP 051 01 01
021 21 21 052 31 31
022 69 DP 053 73 RC#
001 15 E 023 22 22 054 05 05
017 11 A 024 92 RTN 055 65 %
006 12 B 025 76 LBL 056 73 RC+
048 13 C 026 12 B 057 03 03
002 14 D 027 72 ST+ 058 54 )
028 01 01 059 74 SN+
PROGRAM LIST 029 97 DSC 060 01 01
030 00 00 061 73 RC+
031 00 00 062 01 01
001 15 E 032 38 38 063 69 DP
002 47 CMS 033 69 DP 064 33 33
003 01 1 034 21 21 065 55 -
004 00 0 035 69 DP 066 01 1
005 42 STD 036 24 24 067 52 EE
006 01 01 037 92 RTN 068 06 6
007 02 2 038 43 RCL 069 54 )
008 42 STD 039 01 01 070 59 INT
009 00 00 040 42 STD 071 69 DP
010 42 STD 041 03 03 072 21 21
011 06 06 042 69 DP 073 74 SN#
012 04 4 043 33 33 074 01 01
013 69 DP 044 61 GTD 075 65 %
014 17 17 045 00 00 076 01 1
015 92 RTN 046 33 33 077 52 EE
016 76 LBL 047 76 LBL 078 06 6
    
```

Listing continued on opposite page

Listing 1 continued:

079	22	INV	104	29	29	129	61	GTD
080	52	EE	105	43	RCL	130	14	D
081	54)	106	09	09	131	43	RCL
082	69	DP	107	42	STD	132	02	02
083	31	31	108	01	01	133	42	STD
084	22	INV	109	97	DSZ	134	07	07
085	74	SM*	110	04	04	135	43	RCL
086	01	01	111	00	00	136	04	04
087	69	DP	112	49	49	137	42	STD
088	21	21	113	43	RCL	138	00	00
089	97	DSZ	114	02	02	139	43	RCL
090	07	07	115	75	-	140	01	01
091	00	00	116	01	1	141	42	STD
092	49	49	117	54)	142	05	05
093	69	DP	118	44	SUM	143	42	STD
094	35	35	119	01	01	144	09	09
095	43	RCL	120	92	RTN	145	69	DP
096	02	02	121	76	LBL	146	35	35
097	42	STD	122	14	D	147	43	RCL
098	07	07	123	73	RC*	148	03	03
099	43	RCL	124	01	01	149	42	STD
100	08	08	125	99	PRT	150	08	08
101	42	STD	126	69	DP	151	61	GTD
102	03	03	127	31	31	152	00	00
103	69	DP	128	91	R/S	153	53	53
						154	00	0
						155	00	0

greatest possible capacity. The partition will be displayed. Now you can enter the multiplications, 6 digits at a time, pressing A after each 6 digits of the first multiplicand, reading from left to right.

Each multiplicand is divided into groups of 6 digits from right to left, then the numbers are entered from left to right. If the number of digits in a multiplicand is not exactly divisible by 6, the first group of digits of that multiplicand will have less than 6 digits. When the first multiplicand has been entered, the second multiplicand may be entered in the same manner by pressing B after each group of 6 digits.

For example, 6,853,233,214,307,635,533,673. × 5,822,756,618,783,644,505,626,130. must be entered in the following manner:

6853	A
233214	A
307635	A
533673	A
5	B
822756	B
618783	B
644505	B
626130	B

When the multiplicands have been entered, press C to calculate the result and enter it into computer memory. It may take 5 seconds for each 6 digits of the multiplicands entered to perform this step. When the calculation is completed, a meaningless number is displayed. The result can be extracted from memory by pressing D several times. Pressing D causes the result to be read from left to

right. In this case, the result is on the order of 4×10^{46} , so it will be necessary to press D 8 times to recall the entire result. If D is pressed one too many times, the last entered group of digits from the second multiplicand will be displayed. Each time D is pressed 6 more digits of the result are displayed.

D	0
D	39904
D	709058
D	677695
D	645793
D	103475
D	894028
D	753563
D	675490

It appears at first that the TI-58 uses the 10-digit display value in its calculations. In reality, all calculations are done using a 13-digit internal register or accumulator which allows it to multiply two 6-digit numbers and retain all eleven or twelve digits.

The algorithm used in this program is very similar to the old method of pencil and paper multiplication, where you multiplied one digit of one multiplicand by one digit of the other multiplicand at a time, carrying the tens digit to be added to the next multiplication. The main difference is that instead of multiplying and carrying one digit at a time, the computer does 6 digits at a time, greatly speeding up the calculation. ■

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LINE	CODE			
00			0.1° ADDED TO	R ₀ TRUE COURSE (DEGREES)
01	2401	RCL 1	WIND DIRECTION	
02	2400	RCL 0	TAKES CARE OF	
03	41	—	TAIL AND HEAD	R ₁ WIND DIRECTION + 0.1°(DEGREES)
04	2407	RCL 7	WINDS	
05	41	—		R ₂ AIR SPEED MILES/HR.
06	2304	STO 4		
07	2407	RCL 7		
08	51	+		R ₃ WIND SPEED MILES/HR.
09	1551	8 ≥ 0		
10	1313	GTO 13		
11	1312	GTO 12		R ₄ AIR SPEED θ
12	2304	STO 4		
13	2404	RCL 4		
14	1541	8 × < 0		R ₅ WIND SPEED θ
15	1320	GTO 20		
16	09	9		
17	00	0		R ₆ 180°
18	51	+		
19	2304	STO 4		
20	1404	f SIN		R ₇ 360°
21	2403	RCL 3		
22	61	x		
23	2402	RCL 2		
24	71	+		
25	1504	8 SIN -1		
26	2305	STO 5		
27	2404	RCL 4		
28	2406	RCL 6		
29	51	+		
30	1551	8 ≥ 0		
31	32	CHS		
32	2405	RCL 5		
33	1551	8 ≥ 0		
34	32	CHS		
35	51	+		
36	2406	RCL 6		
37	51	+		
38	1404	f SIN		
39	2403	RCL 3		
40	61	x		
41	2405	RCL 5		
42	1404	f SIN		
43	71	+		
44	1541	8 × < 0		
45	32	CHS		
46	74	RS	GROUND SPEED	
47	2400	RCL 0		
48	2405	RCL 5		
49	51	+	TRUE HEADING	

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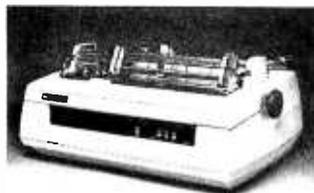
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SNOBOL Commentary

Jonathan Sachs, 6713 Richmond Ave,
Richmond View CA 94805

As a long-time SNOBOL addict, I enjoyed Bruce Burns' "SNOBOL Conquers All?" (June 1979 BYTE, page 220), but I want to protest two things he said.

First, that "opponents to the language say they feel that the language's power invites unstructured programming..." I think we are basically in agreement on this one, but uncareful readers may get the idea that if you understand what you are doing, unstructured programming in SNOBOL is OK. Make no mistake: when the full power of SNOBOL4 is applied to a problem, it is beyond the power of a human to understand the resulting program without extensive documentation *and* thorough study. It is wise to use the language below its capabilities 99% of the time, and end up with readable code.

While I am on the subject of structure, I will add that SNOBOL's lack of strong structure (WHILE/DO, IF/THEN/ELSE) is its single intolerable vice. I object, not because it allows fools to write bad code, but because it

prevents *me* from writing *good* code unless I sweat blood. Because of this, I am planning to modify my SNOBOL compiler (FASBOL II on the DECsystem-10) to support the above constructs. I would like to hear from anyone else who has tried this.

Now, for my second objection. It concerns the one-line code segment to put the characters of a string in lexical order. The one-liner works, but it is horribly inefficient for long strings. When it finds characters N and N+1 are out of order it transposes them, then *returns to the beginning of the string*, even though we know characters 0 through N-1 are ordered.

Gross inefficiency is not a sin, but there is no justification for it unless it buys some overbalancing benefit such as storage economy or generality. Here, the only benefit we get is a one-liner. I think that is a poor demonstration of elegance. I wish Mr Burns had come up with a one-liner (if he had to use one at all) that someone might want to use in a real program.

Incidentally, the following "3-liner" benchmarks almost 4 times faster on my system, for the string 'THE QUICK BROWN FOX JUMPS OVER THE LAZY DOG':

```
P = 0
LEXORD  S TAB(*P) $ A @Q LEN(1) $ B @P LEN(1) $ C
+          *LGT(B,C) = A C B          :(ORDERED)
P = ?GT(Q) Q - 1          :(LEXORD)
ORDERED  ....
```

But these are minor complaints. Mr Burns' crusade to implement SNOBOL on microcomputers is a worthy one, and if there is anything I can do to support it, I will.

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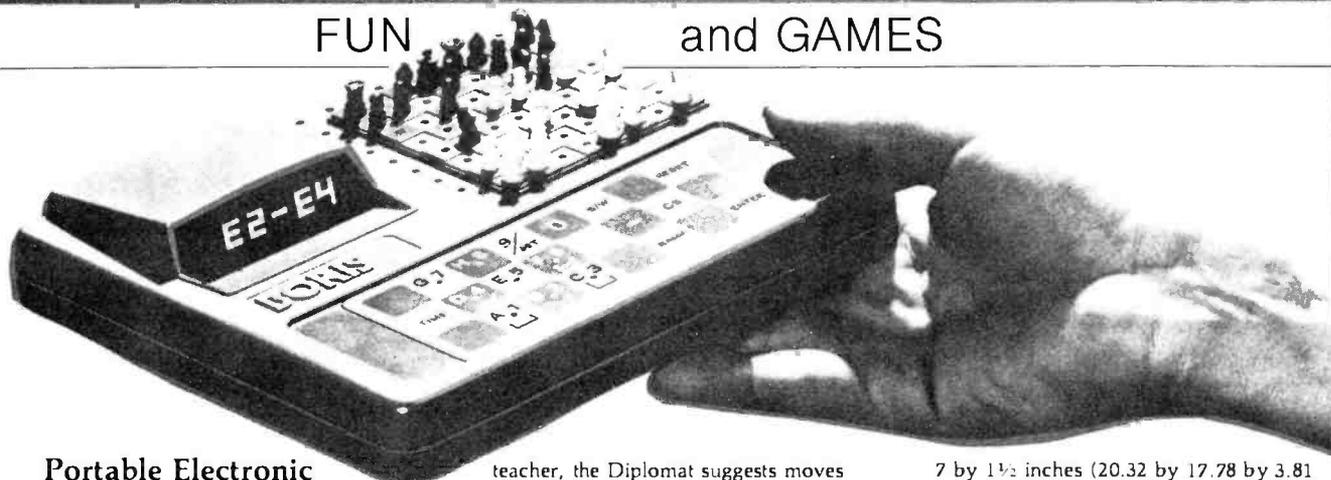
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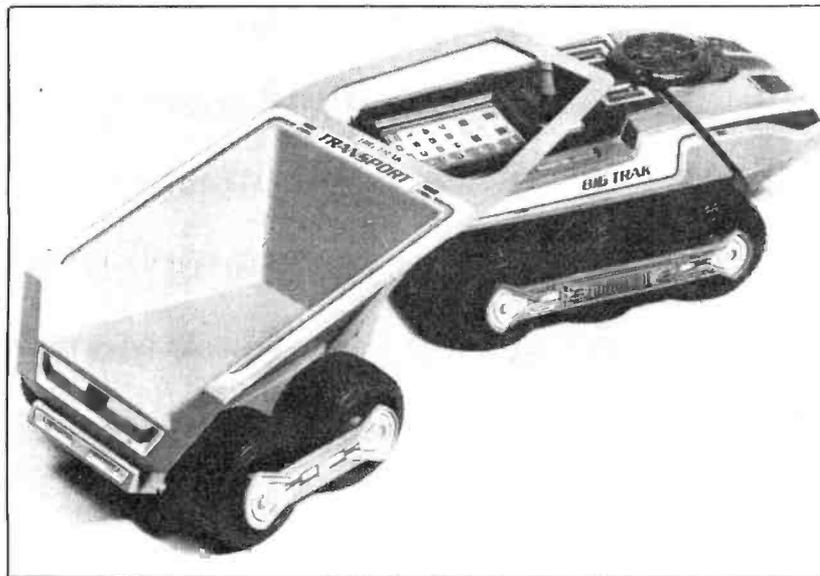
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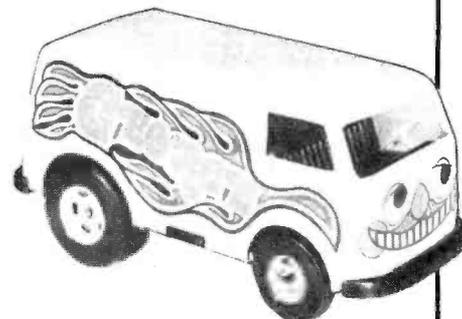


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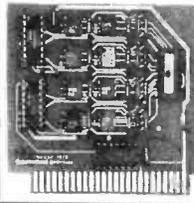
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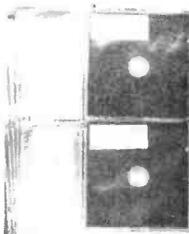
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Made from heavy duty .0095 matte plastic with reinforced grommets. The mini-diskette version holds two 5-1/4 inch diskettes and will fit any standard three ring binder. The pockets to the left of the diskette can be used for listing the contents of the disk. Please order only in multiples of ten. \$9.95/10 Pack.



VIDEO TERMINAL

16 lines, 64 columns • Upper and lower case • 5x7 dot matrix • RS-232 in • RS-232 out with TTL parallel keyboard input • On board baud rate generator 75, 110, 150, 300, 600, & 1200 jumper selectable • Memory 1024 characters (7-21L02) • Video processor chip SFF96364 by Neculonic • Control characters (CR, LF, ...), non destructive cursor, CS, home, CL • White characters on black background or vice-versa • With the addition of a keyboard, video monitor or TV set with TV interface (part no. 107A) and power supply this is a complete stand alone terminal • also S-100 compatible • requires +16, & -16 VDC at 100mA, and BVDC at 1A. Part no. 1000A \$199.95 kit.

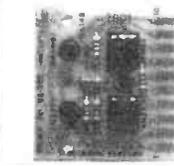


INTERNATIONAL MICROPROCESSOR DICTIONARY

English, French, Danish, German, Italian, Hungarian, Norwegian, Polish, Spanish, Swedish. 10 languages, 28 pp. SYBEX. Ref. IMD. \$4.95

RS-232/20mA INTERFACE

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



COMPUCOLOR II

Model 3, 8K \$13.95, Model 4, 16K \$15.95, Model 5, 32K \$18.95. Prices include color monitor, computer, and one disk drive.



PET COMPUTER

With 32K & monitor - \$1195. Dual Disk Drive - \$1195.



APPLE II PLUS

16K - \$995, 32K - \$1059, 48K - \$1123. Disk & cont. \$589



6502 APPLICATIONS BOOK Z80 APPLICATIONS BOOK

This book will teach you how to connect a board to the outside world and implement practical applications for the 6502. (or Z80). Applications range from home control (a complete alarm system, including heat sensor), to industrial applications. You will learn techniques ranging from simulated traffic control to analog-digital conversion. All experiments can be realized with a minimum of external (low-cost) components. They are directly applicable to any 6502-based board such as SYM, KIM, AIM 65. This book also studies in detail input-output techniques and components, and is the logical continuation of C202 (or C280). By Rodney Zaks. SYBEX. 6502: Ref. D302; Z80: Ref. D380. Each \$12.95

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



PARALLEL TRIAC OUTPUT BOARD FOR APPLE II

This board has 8 triacs capable of switching 110 volt 6 amp loads (660 watts per channel) or a total of 5280 watts. Board only \$15.00 Part No. 210, with parts \$119.95 Part No. 210A.

To Order: Mention part no., description, and price. In USA shipping paid by us for orders accompanied by check or money order. We accept C.O.D. orders in the U.S. only, or a VISA or Master Charge no., expiration date, signature, phone no., shipping charges will be added. CA residents add 6.5% for tax. Outside USA add 10% for air mail postage and handling. Payment must be in U.S. dollars. Dealer inquiries invited. 24 hour order line (408) 448-0800

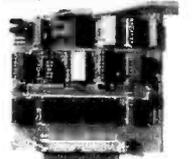


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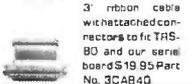
ELECTRONIC SYSTEMS Dept. B, P. O. Box 21638, San Jose, CA USA 95151

TRS-80 E.S. SERIAL I/O

- Can input into basic
- Can use LLIST and LPRINT to output, or output continuously
- RS-232 compatible
- Can be used with or without the expansion bus
- On board switch selectable baud rates of 110, 150, 300, 600, 1200, 2400, parity or no parity odd or even, 5 to 8 data bits, and 1 or 2 stop bits. D.T.R. line
- Requires +5, -12 VDC
- Board only \$19.95 Part No. 8010, with parts \$59.95 Part No. 8010A, assembled \$79.95 Part No. 8010C. No connectors provided, see below.



EIA/RS-232 connector Part No. 0825PS8.00, with 9: 8 conductor cable \$10.95 Part No. 0825PS9



3 ribbon cable with attached connectors for TRS-80 and our serial board \$19.95 Part No. 3CAB4Q

MODEM

- Type 103
- Full or half duplex
- Works up to 300 baud
- Originate or Answer
- No coils, only low cost components
- TTL input and output-serial
- Connect B Ω speaker and crystal mic. directly to board
- Uses XR FSK demodulator
- Requires +5 volts
- Board only \$7.60 Part No. 109, with parts \$27.50 Part No. 109A



DISKETTES



Box of 10, 5" B" \$29.95, B" \$39.95
Plastic box, holds 10 diskettes, 5" - \$4.50, B" - \$6.50.

APPLE II[®] SERIAL I/O INTERFACE



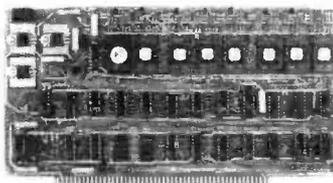
Baud rate is continuously adjustable from 0 to 30,000

- Plugs into any peripheral connector
- Low current drain. RS-232 input and output
- On board switch selectable 5 to 8 data bits, 1 or 2 stop bits, and parity or no parity either odd or even
- Jumper selectable address
- SOFTWARE
- Input and Output routine from monitor or BASIC to teletype or other serial printer
- Program for using an Apple II for a video or an intelligent terminal.
- Also can output in correspondence code to interface with some electrics.
- Also watches DTR
- Board only \$15.00 Part No. 2, with parts \$42.00 Part No. 2A, assembled \$62.00 Part No. 2C

8K EPROM PIICEON

Saves programs on PROM permanently (until erased via UV light) up to 8K bytes. Programs may be directly run from the program saver such as fixed routines or assemblers.

- S-100 bus compatible
- Room for 8K bytes of EPROM non-volatile memory (2708's).
- On-board PROM programming
- Address relocation of each 4K of memory to any 4K boundary within 64K
- Power on jump and reset jump option for "turnkey" systems and computers without a front panel
- Program saver software available
- Solder mask both sides
- Full silkscreen for easy assembly.
- Program saver software in 1 2708 EPROM \$25. Bare board \$35 including custom coil, board with parts but no EPROMS \$139, with 4 EPROMS \$179, with 8 EPROMS \$219.



WAMECO PRODUCTS WITH

ELECTRONIC SYSTEMS PARTS

- FDC-1 FLOPPY CONTROLLER BOARD** will drive shugart, pertek, remex 5" & 8" drives up to 8 drives, on board PROM with power boot up, will operate with CPM (not included) PCBD \$42.95
- FPB-1 Front Panel** (Finally) IMSAI size hex displays Byte or instruction single step. PCBD \$42.95
- MEM-1A** 8Kx8 Fully buffered, S-100, uses 2102 type RAMS. PCBD \$24.95, \$168 Kit \$34.95
- QMB-12 MOTHER BOARD**, 13 slot, terminated, S-100 board only \$89.95 Kit \$89.95
- CPU-1 BOBOA Processor board** S-100 with B level vector interrupt PCBD \$25.95 \$89.95 Kit
- RTC-1 Realtime clock board**. Two independent interrupts. Software programmable. PCBD \$25.95, \$60.95 Kit
- EPM-1** 1702A 4K EPROM card PCBD \$25.95 \$49.95 with parts less EPROMS
- EPM-2** 2708/2716 16K/32K EPROM card PCBD \$24.95 \$49.95 with parts less EPROMS
- QMB-9 MOTHER BOARD**. Short Version of QMB-12. 9 Slots PCBD \$30.95 \$67.95 Kit
- MEM-2** 16Kx8 Fully Buffered 2114 Board PCBD \$25.95, \$269.95 Kit

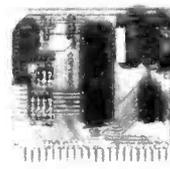
T.V. TYPEWRITER

- Stand alone TVT
- 32 char/line, 16 lines, modifications for 64 char/line included
- Parallel ASCII (TTL) input
- Video output
- 1K on board memory
- Output for computer controlled cursor
- Auto scroll
- Non-destructive cursor
- Cursor inputs: up, down, left, right, home, EOL, EOS
- Scroll up, down
- Requires +5 volts at 1.5 amps, and -12 volts at 30 mA
- All 7400, TTL chips
- Char. gen. 2513
- Upper case only
- Board only \$39.00 Part No. 106, with parts \$145.00 Part No. 106A



UART & BAUD RATE GENERATOR

- Converts serial to parallel and parallel to serial
- Low cost on board baud rate generator
- Baud rates: 110, 150, 300, 600, 1200, and 2400
- Low power drain +5 volts and -12 volts required
- TTL compatible
- All characters contain a start bit, 5 to 8 data bits, 1 or 2 stop bits, and either odd or even parity.
- All connections go to a 44 pin gold plated edge connector
- Board only \$12.00 Part No. 101, with parts \$35.00 Part No. 101A, 44 pin edge connector \$4.00 Part No. 44P



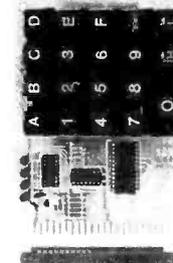
TAPE INTERFACE

- Play and record Kansas City Standard tapes
- 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 \$27.50 Part No. 111A



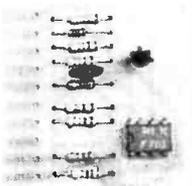
HEX ENCODED KEYBOARD E.S.

This HEX keyboard has 19 keys, 16 encoded with 3 user definable. The encoded TTL outputs, B-4-2-1 and STROBE are debounced and available in true and complement form. Four onboard LEOs 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.



RS-232/ TTL INTERFACE

- Converts TTL to RS-232, and converts RS-232 to TTL
- Two separate circuits
- Requires -12 and +12 volts
- All connections go to a 10 pin gold plated edge connector
- Board only \$4.50 Part No. 232, with parts \$7.00 Part No. 232A 10 Pin edge connector \$3.00 Part No. 10P



RS-232/TTY INTERFACE

This board has two active circuits, one converts RS-232 to 20mA, and the other converts 20mA to RS-232. Requires +12 and -12 volts. Board only \$4.50 Part No. 600, with parts \$7.00 Part No. 600A.



S-100 BUS ACTIVE TERMINATOR

Board only \$14.95 Part No. 900, with parts \$24.95 Part No. 900A



DC POWER SUPPLY

- 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. 60B5, with parts excluding transformers \$42.50 Part No. 60B5A



To Order: Mention part no. description, and price. In USA shipping paid by us for orders accompanied by check or money order. We accept C.D.D. orders in the U.S. only, or a VISA or Master Charge no., expiration date, signature, phone no., shipping charges will be added. CA residents add 6.5% for tax. Outside USA add 10% for air mail postage and handling. Payment must be in U.S. dollars. Dealer inquiries invited. 24 hour order line (408) 448-0800



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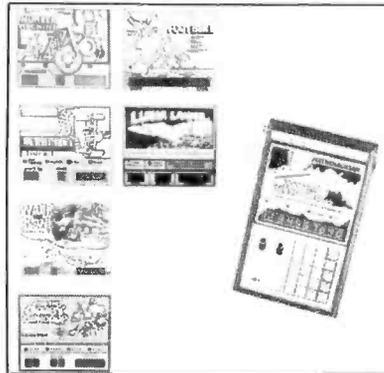
What's New?

FUN and GAMES

Game Playing Device Is Also a Teaching Calculator

Mathemagician is a teaching calculator and game-playing device for adults and children of all ages. It can teach children arithmetic operations: multiplication tables, division tables, addition and subtraction. Children and adults can play any of six different games, which are: Number Machine, Counting On, Walk the Plank, Goopy Gumdrops, Football, and Lunar Lander. Mathemagician's games can be played by one or two people. All functions let the user know at the end of each problem if he or she has given the correct answer, and if not, will then display the correct answer.

Mathemagician sells for \$29.95. For

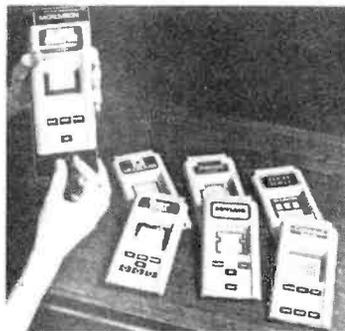


further information, contact APF Electronics Inc, 444 Madison Ave, New York NY 10022.

Circle 627 on inquiry card.

Microvision Features Seven Different Game Cartridges

Milton Bradley's Microvision is a hand-held mini "video" game with its own screen. The electronically operated Microvision comes equipped with the game Blockbuster; moreover, six additional game cartridges may be purchased, including Bowling, Pinball, Connect 4, Star Trek Phaser Strike, Vegas Slots, and Mindbuster. Microvision is priced at \$51.25. Game cartridges



Game Software for the TRS-80

The Software Association has announced a new line of entertainment programs for the TRS-80. All programs are written in machine language and provide fast response times. The initial offerings include:

Z-Chess — a full-featured chess opponent providing seven levels of difficulty, from Blitz to Expert. Six moves of look-ahead are possible, and Z-Chess can solve mate-in-two problems quickly. Numbered squares and a board setup mode are provided for ease of play.

Back-40 — a backgammon challenger with an unrivaled graphic board display. Doubling is permitted, and every feature of a regulation backgammon match is provided including the score.

Dr Chips — a fascinating program based on Doctor and Eliza programs. Machine language allows Dr Chips to analyze sentences and talk back instantly.

All programs require a 16 K byte Level II machine. Z-Chess is priced at \$17.95, Back-40 and Dr Chips are \$14.95 each. For further information, contact The Software Association, POB 58365 Houston TX 77058.

Circle 628 on inquiry card.

Electronic Robot Promises Preschool Fun

Alphie is an electronic toy robot offering action, lights, sounds, music and games for children 3 to 8 years old. Preschoolers will enjoy Alphie's Question and Answer games. Once the child makes a decision, Alphie lights up the correct answer. If the child has made the right selection, Alphie plays a rendition of Sousa's "Stars and Stripes Forever." If the child's answer does not match, Alphie gives a good-natured "razzberry." Alphie also plays other tunes, and there is a choice of five popular children's songs.

Slightly older children will enjoy playing Robot Land. In this color matching game, the child tries to beat Alphie or a friend by being the first to move a miniature Alphie piece along the path from the Robot Factory to Spaceship XK-3. In the Lunar Landing game, children count the tones Alphie makes in order to be first to assemble an Alphie puzzle on the lunar game board.

Alphie is priced at approximately \$28. For further information, contact Playskool Inc, 4501 W Augusta Blvd, Chicago IL 60651.

Circle 630 on inquiry card.



range in price from \$16.50 to \$18. Contact Milton Bradley Co, Springfield MA 01101.

Circle 629 on inquiry card.

The DATA-TRANS 1000

A completely refurbished
IBM Selectric Terminal with
built-in ASCII Interface.

\$1395

Features:

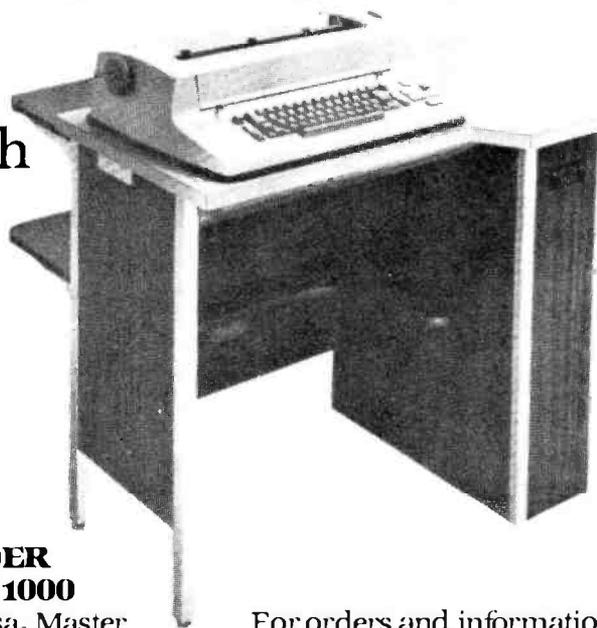
- 300 Baud
- 14.9 characters per second printout
- Reliable heavy duty Selectric mechanism
- RS-232C Interface
- Documentation included
- 60 day warranty - parts and labor
- High quality Selectric printing
- Off-line use as typewriter
- Optional tractor feed available
- 15 inch carriage width

HOW TO ORDER DATA-TRANS 1000

1. We accept Visa, Master Charge. Make cashiers checks or personal check payable to:

DATA-TRANS

2. All orders are shipped F.O.B. San Jose, CA
3. Deliveries are immediate



For orders and information
DATA-TRANS
2154 O'Toole St.
Unit E
San Jose, CA 95131
Phone: (408) 263-9246

MICRO-PROCESSORS: FROM CHIPS TO SYSTEMS

This book covers all aspects of microprocessors, from the basic concepts to advanced interfacing techniques, in a progressive presentation. It is independent from any manufacturer, and presents uniform **standard** principles and design techniques, including the interconnect of a **standard** system, as well as specific components. It introduces the MPU, how it works internally, the system components (ROM, RAM, UART, PID, others), the system interconnect, applications, programming, and the problems and techniques of system development. By R. Zaks. SYBEX. Ref. C201. \$9.95

MICRO-PROCESSOR INTERFACING TECHNIQUES

Microprocessor interfacing is no longer an art. It is a set of techniques, and in some cases just a set of components. This comprehensive book introduces the basic interfacing concepts and techniques, then presents in detail the implementation details, from hardware to software. It covers all the essential peripherals, from keyboard to floppy disk, as well as the standard buses (S100 to IEEE 488) and introduces the basic troubleshooting techniques. (2nd Expanded Edition). By Austin Lesea and R. Zaks. Ref. C207 SYBEX. \$11.95

PROGRAMMING THE 6502 PROGRAMMING THE Z80 PROGRAMMING THE 8080*

It covers all essential aspects of programming, as well as the advantages and disadvantages of the 6502 and should bring the reader to the point where he can start writing complete applications programs. For the reader who wishes more, a companion volume is available: The 6502 Applications Book. By R. Zaks. 6502: Ref. C202; Z80: Ref. C280; 8080: Ref. C208. SYBEX. Each \$10.95



44 BUS MOTHER BOARD

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.



AN INTRODUCTION TO PERSONAL AND BUSINESS COMPUTING

No computer background is required. The book is designed to educate the reader in all the aspects of a system, from the selection of the microcomputer to the required peripherals. By Rodney Zaks. Ref. C200. SYBEX \$6.95

TVT COOKBOOK

Bk 1064 — by Don Lancaster. Describes the use of a standard television receiver as a microprocessor CRT terminal. Explains and describes character generation, cursor control and interface information in typical, easy-to-understand Lancascaster style. \$9.95

COMPUTER PROGRAMMING HANDBOOK

A complete guide to computer programming & data processing. Includes many worked-out examples. By Peter Staak. TAB \$9.95

DIGITAL CASSETTE

5 min. each side. Box of 10 \$9.95. Part No. C-5.



To Order: Mention part no., description, and price. In USA shipping paid by us for orders accompanied by check or money order. We accept C.O.D. orders in the U.S. only, or a VISA or Master Charge no., expiration date, signature, phone no., shipping charges will be added. CA residents add 6.5% for tax. Outside USA add 10% for air mail postage and handling. Payment must be in U.S. dollars. Dealer inquiries invited. 24 hour order line (408) 448-0800



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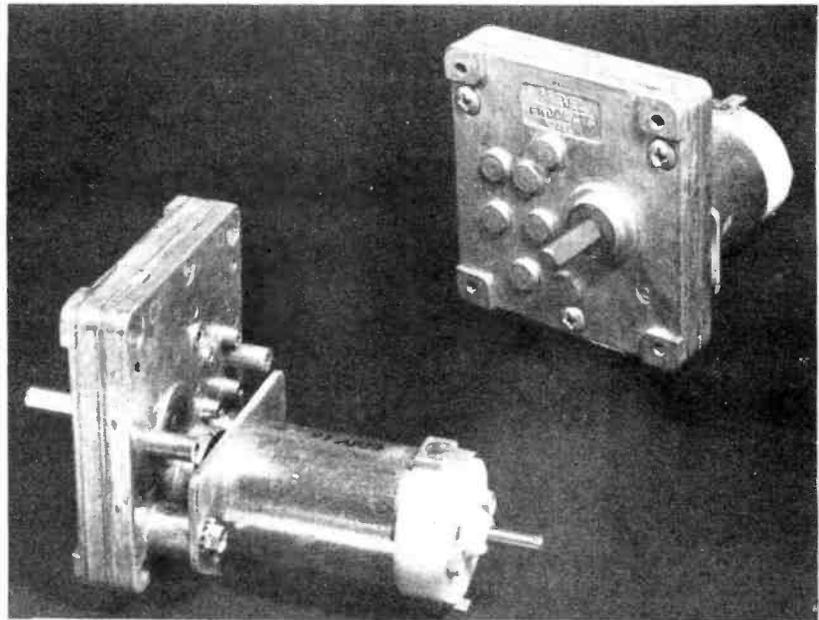
What's New?

of INTEREST to DESIGNERS

Muscles for Robots

This 12 V DC, 17 RPM, reversible gearmotor has been designed for robotic applications. The motor produces 11 inch-pounds of torque and operates on 750 mA full load current. The motor is priced at \$18. Contact Gledhill Electronics, POB 1644, Marysville CA 95901.

Circle 634 on inquiry card.



Pascal Processor for the S-100 Bus

The Pascal-100 processor is a 16-bit central processor board for the S-100 bus, especially designed for use with the Pascal programming language. The processor directly executes p-code instructions generated by the Pascal compiler written at the University of California, San Diego (UCSD Pascal). It runs the latest version of the entire UCSD Pascal operating system, including the Pascal compiler, screen editor, filing system, BASIC compiler, graphics package, games library, computer-based learning system, and utilities and cross-assemblers for other micro and minicomputers.

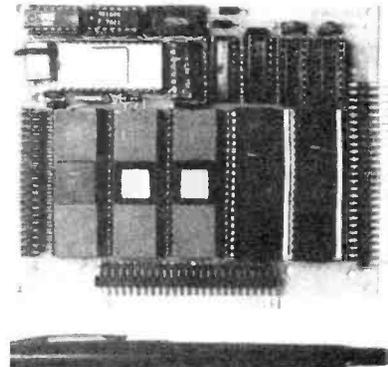
Other features of the Pascal-100 processor include support of up to 128 K bytes of directly addressed main memory, 16-bit data bus transfers, vectored interrupts and floating point operations. The processor complies with the Institute of Electrical and Electronic Engineers standard for the S-100 bus, and will also operate with most peripheral and memory boards designed prior to the standard.

The Pascal-100 processor is priced at \$995. For further information, contact David Lewis, DigiComp Research Corp, Terrace Hill, Ithaca NY 14850.

Circle 635 on inquiry card.

Microprocessor Controller Card

The System A process control board utilizes an 8085 microprocessor and can interface to 76 I/O (input/output) lines. The board contains 4 K bytes of erasable read-only memory and up to 4.6 K bytes of programmable memory. It also has RS-232 teletypewriter control and 14-bit binary counter and timers. The board can be purchased with a resident program that allows the user to program interface requirements and data rates from an external source. Minimal configuration boards may also be purchased. The board dimensions are 4 by 5 inches (10.16 by 12.20 cm). The System A board starts at \$295. For further information, contact FH and M

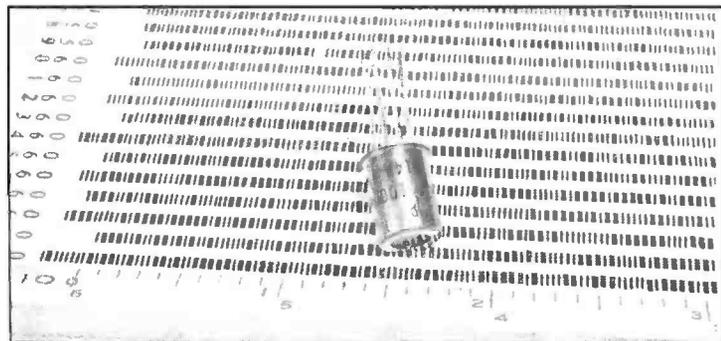


Enterprises Inc, 1850 Gravers Rd, Norristown PA 19401.

Circle 636 on inquiry card.

Hewlett-Packard Introduces High-Resolution Optical Reflective Sensor

The HEDS-1000 is a fully integrated module designed for optical reflective sensing. The module contains a 0.007 inch (0.178 mm) diameter light-emitting diode (emitting visible 700nm wavelength light) and a matched integrated circuit photodetector. A bifurcated aspheric lens is used to direct the active areas of the light-emitter and the detector to a single image spot 0.171 inch (4.34 mm) in front of the package. The reflected signal can be sensed directly from the photodiode or through an internal transistor that can be configured as a high-gain amplifier. Applications



include pattern recognition, object sizing, optical limit switching, tachometry, defect detection, dimensional monitoring, line locating, mark and bar code scanning, and paper edge detection.

For further information, contact Hewlett-Packard, Optoelectronics Division, 640 Page Mill Rd, Palo Alto CA 94304.

Circle 637 on Inquiry card.

B&K PRECISION Transistor Testers



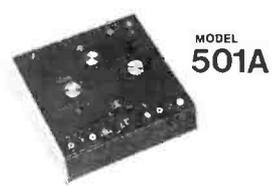
MODEL 520B
Industrial Transistor Tester

- Now with HI LO Drive
- Works in-circuit when others won't
- Identifies all in-circuit transistor leads
- Random lead connection
- Audible and visually indicate GOOD transistor
- Automatic NPN/PNP determination
- Positive Si/Ga identification
- Tests diodes, SCR's, FET's, and Darlingtons
- CSA approved version available



MODEL 510
Portable Transistor Tester

- Fast GND/GD in-circuit transistor testing
- Fast in-circuit GND/GD and in-circuit testing
- Tests FET's and SCR's in-circuit
- Connects in-circuit to in-circuit
- Gives positive emitter-base code identification in in-circuit
- Light emitting diodes indicate NPN, OK or PNP, OK
- Power up - Over 100 hours of testing from single set of AA cells
- Digital display - no adjustments, nothing to go out of calibration
- Includes carrying case and leads



MODEL 501A
Semiconductor Curve Tracer

- Displays characteristic curves for all semiconductor devices on your scope
- Measures breakdown voltage non-destructively
- Identify unknown devices
- Complete with FP-5 Probe



MODEL 530
Lab-Quality Semiconductor Tester...

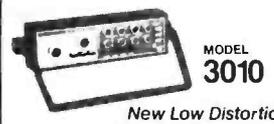
- Measures I of bipolar transistors up to 1500 MHz
- Nondestructive testing of transistors and diode breakdown voltages
- Measures transistor beta of FET's
- Measures all transistor breakdown and leakage parameters
- Fast testing of transistors, FET's, and SCR's - in or out of circuit
- Base diagrams are not required
- No biasing information required
- Identifies all leads of transistors and SCR's
- Automatic identification of PNP/NPN types and N- or P-channel FET's

New from B&K ... Before you buy, check our prices...



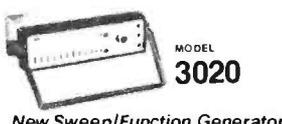
MODEL 820
New Portable Digital Capacitance Meter

- Measures capacitance from 0.1pF to 100µF
- Resolves to 0.1pF
- 10 ranges for accuracy and resolution
- 4 digit easy-to-read LED display
- 0.5% accuracy
- Special lead insertion jacks or banana jacks
- Fuse protected
- Uses either rechargeable or disposable batteries
- Overrange indication



MODEL 3010
New Low Distortion Function Generator

- Generates sine, square and triangle waveforms
- Variable amplitude and fixed TTL square-wave outputs
- 0.1 Hz to 10 MHz sine ranges
- Push button range and function selection
- Typical sine wave distortion under 0.5% from 0.1 Hz to 100 kHz
- Variable DC offset for engineering applications
- VCO external input for sweep-frequency tests



MODEL 3020
New Sweep/Function Generator

- Four instruments in one package - sweep generator, function generator, pulse generator, tone-burst generator
- Covers 0.02Hz-20MHz
- 1000:1 tuning range
- Low-distortion high-accuracy outputs
- Three-step attenuator for pulse sweep control
- Internal linear and analog sweeps
- Tone-burst output is front-panel or externally programmable



MODEL DP-50
50MHz Digital Probe

- Multi-family compatible with TTL, DTL, RTL, HTL, CMOS, MOS and NMOS
- Displays DC to 50MHz
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- Memory mode to "freeze" pulse display
- Pulse mode "stretches" short pulses
- 2 megohm input impedance
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- Multi-family - Compatible with TTL, DTL, RTL, HTL, NMOS, MOS and CMOS
- High current drive will pull shorted logic outputs high or low
- Short duty cycle pulse will not damage circuitry under test
- Fully overload protected
- Companion to DP-50 digital probe



MODEL 2815
New 3 1/2-Digit DMM with LCD Readout

- 0.1% DC accuracy
- 0.5% LCD display for high readability
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 \$52.95

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 Model 2800 \$269.95

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 Model MS 15 Reg. \$318.00 \$269.95

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 Reg. \$1050 \$889.95

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 Reg. \$139.00 \$69.50

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 Model MC 10A \$49.50

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 Model MC 412A Reg. \$120.00 \$59.95

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 Reg. \$120.00 \$59.95

ES CONTINENTAL SPECIALTIES 100 MHz 8-Digit Counter
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 \$52.95

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 Model 4400 Reg. \$39.95 \$29.95

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 C-777 \$52.50

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 \$45.00

FREE 1979 Catalog

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What's New?

MASS STORAGE

Intelligent Disk System for S-100 Computers

A 10 M byte intelligent rigid disk system has been introduced by Corvus Systems, 900 S Winchester Blvd, San Jose CA 95128. Plug compatible with the Radio Shack TRS-80, Apple and all S-100 bus-type computers, the system adds cost-effective mass storage to these computers, while maintaining total compatibility with existing hardware and software.

The disk system

consists of a compact IM1 7710 disk drive employing Winchester technology with two 8-inch rigid disks; a Corvus Z80 intelligent disk controller with comprehensive disk diagnostics; and an intelligent personality module and associated software for each form of computer. Each drive has a capacity of 10 M bytes of formatted storage. Up to four drives can be supported in a simple daisy chain.

The price

of the system is \$5350, including disk drive, controller, and personality module. Add-on disk drives are priced at \$2900.

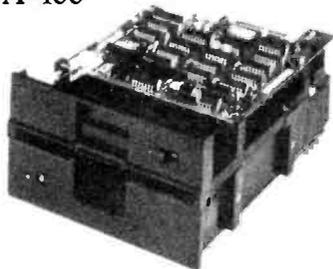
Circle 631 on inquiry card.



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.

5-Inch Disk Drive Is Compatible with Shugart SA-400



The Teac FD-50A 5-inch disk drive moves its data-transfer head directly to the selected track, giving the drive a track-to-track access time of 25 ms and an average access time of 298 ms. A precision built stepper motor ensures accurate head positioning while an improved head configuration is used for precise erasing. In its basic 35-track configuration, the capacity of the FD-50A is 109.4 K bytes (unformatted). This may be extended if desired by addressing an additional 5 tracks. Recording on a total of 40 tracks expands the capacity to 125 K bytes. Up to four FD-50A 5-inch disk drives can be daisy-chained to a single controller. The FD-50A is fully plug-to-plug and disk-compatible with the Shugart SA-400.

For further information, contact Teac Corp, 3-7-3, Naka-cho, Musashino, Tokyo, JAPAN.

Circle 632 on inquiry card.

5-Inch Double Density Disk Drive for TRS-80

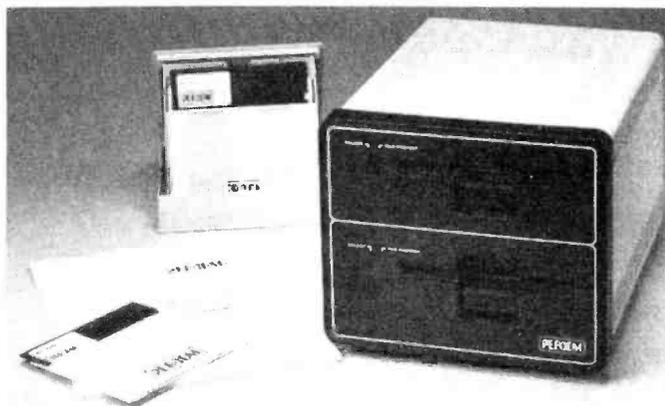
Percom Data Company has expanded its TFD line of add-on 5-inch disk systems for the Radio Shack TRS-80 computer to include a dual drive unit featuring double-density storage. Designated the TFD-1000, the unit provides 800 K bytes of on-line storage. Two systems (four drives) may be used with a TRS-80 to provide 1.6 M bytes on line.

The TFD-1000 is supplied complete with an interconnecting cable (which accommodates either one or two units), a Peripheral Adapter Module (PAM) printed circuit card, Percom's MICRODOS operating system, and support documentation. The PAM card replaces the RS-232C card in the TRS-80

expansion interface and includes RS-232C circuitry so that serial interfacing capability is retained. The MICRODOS operating system, which replaces TRSDOS, was developed especially for business and professional applications. It provides full random-access capability, is faster than TRSDOS and requires less than 7 K bytes of programmable memory. It is supplied on a system disk that includes BASIC program examples and a menu of the programs. The menu is activated on power-up or reset.

The TFD-1000 complete with cable, operating system, PAM card and documentation costs \$2495. Two TFD-1000 units (four drives) cost \$4950. For further information contact the company at 211 N Kirby, Garland TX 75042.

Circle 633 on inquiry card.



ProComp/New England Super Christmas Sale

Prices marked with * good thru Dec 31. Mail and phone orders welcome. Prices FOB Boston, MA. Shipping costs billed COD. Mass residents add 5% sales tax.

TRS-80 MEGABYTES and MORE !

The MEGABOX includes provision to add 32K of RAM and a UART with the RS-232 interface, so the MEGABOX can be used with the TRS-80 alone to provide a complete 48K system, capable of supporting a printer. (By MICROMATION, of course!)

One MByte Storage.....	\$2295	CP/M + TRS-80	
Two MByte Storage.....	\$3095	Software Patch.....	\$249 *
		Microsoft FORTRAN...	\$199 *

[TRS-80 TM Tandy Corp.]

Add Capacity and Power to your S-100 System.

--- DISK STORAGE ---

Micromation ' Doubler ' (2D / Disk Controller) \$449.00

One MByte Disk Sub-System (Two REMEX 8" RFD-2000) (Controller / Housing & CP/M)..... \$2,295

Two MByte Disk Sub-System (Two REMEX 8" RFD-4000 dual head) (Controller / Housing & CP/M)..... \$2,595 *

--- MEMORY BOARDS ---

Measurement Systems & Controls 48K Dynamic (DM-4800)..... \$549.00 *

Seattle Computer Products '16K Plus' Static (250ns)..... \$325.00 *

.... Add a PRINTER

◦ COMPRINT (Parallel).....	\$589	◦ Epson TX-80 (Parallel).....	\$739
(Serial).....	\$549	(Serial).....	\$769
◦ Sanders Technology MEDIA 12/7.....	\$3589 *	◦ TI-825 (RO).....	\$1749

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Take your pick of Operating Systems [CDOS /or/ CP/M]

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What's New?

PUBLICATIONS

Predict Object Motion With Your Programmable Calculator

Countdown, a book by Robert Eisberg and Wendell Hyde, will show the reader how to use a programmable calculator to accurately predict the motion of a variety of interesting objects. Using only basic math and physics, the book explains how to calculate the motion of skydivers, single and multistage rockets, Earth satellites, planets, and alpha particles. The book is written without the assumption that the reader has any familiarity with a programmable calculator. This 114 page paperback book is priced at \$6.95. For further information contact Dilithium Press, POB 92, Forest Grove OR 91776.

Circle 598 on inquiry card.



Publications on Business Computing

BusinessComputing Press has announced a series of publications informing businessmen and professionals about the effective utilization of low-cost microcomputers in business. The bi-monthly journal, *BusinessComputing Review*, provides research reporting on business computers and applications software. The information is presented in a concise review format that simplifies the selection of systems based on business requirements. Related articles and commentary compliment the reviews.

The report, *Evaluating Small Business Software*, details the characteristics that any quality software package must possess in order to be used successfully. Specific evaluation criteria are provided for General Ledger, Accounts Receivable, Accounts Payable, Payroll, and Inventory Control packages.

BusinessComputing Newsletter, published 6 times annually, presents newsworthy information about the use of microcomputers in business. The newsletter contains tutorials on business computing and abstracts of new products. The newsletter is sent to subscribers of *BusinessComputing Review*.

BusinessComputing Review is available for an annual subscription rate of \$25. The report, *Evaluating Small Business Software*, is \$15 per copy. Contact Business Computing Press, POB 55056, Valencia CA 91355.

Circle 599 on inquiry card.

TM990 Series Microcomputer Module Selection Guide Available from Texas Instruments



A 20-page product selection guide and catalog covering the TM990 Series of 16-bit microcomputer modules is available free from Texas Instruments Inc, POB 1443, MS-6404, Houston TX 77001. It provides engineers with a con-

venient reference to TI's line of TM990 Series microcomputer modules and other TM990 Series software, firmware, and hardware products. The publication, CL 377A, covers TM990 Series microcomputer modules; memory expansion modules; I/O (input/output) expansion modules; industrial AC and DC I/O modules; analog-to-digital and digital-to-analog interface modules; university educational module; and software development module. Product descriptions include key specifications and features.

Also included in CL 377A are descriptions, key features and specifications for TI's data entry and display Microterminal; firmware support, including TIBUG Monitor and line-by-line assembler; software, including Power BASIC high-level language and TIPMX Executive Library, a collection of assembly language programs available for users of TI's TMS9900 family of microprocessors; TM990 transportable cross support; Advanced Microprocessor Prototyping Lab (AMPL); and TM990 Series accessories.

Circle 600 on inquiry card.

Computers for Business People

DDC Publications has announced the publication of a new book for people planning to buy a business computer system. The book, entitled *Winning the Computer Game* by Chris Kloek, presents a business computer guide to the layman or professional. The book recommends when a company should computerize, when it should not, how to buy systems and services, and how to live happily with them. *Winning the Computer Game* goes into detail on such subjects as custom versus packaged software, contract negotiation, installation management, and financing alternatives. Appropriate cautions are also provided.

The 178 page guide costs \$12.95 and is available from DDC Publications, 5386 Hollister Ave, Santa Barbara CA 93111.

Circle 602 on inquiry card.

Free Technical Catalog

The 1979 edition of *Engineering Guide: AC/DC and DC/DC Power Sources* contains 44 pages and includes 10 pages of design, applications, and selection information for both linear and switch mode regulated power sources. Designed to help the engineer select the most cost effective power source for an application, this reference includes complete specifications, dimension drawings

and extended pricing information for 23 product families ranging from dual-in-line packaged single and dual output DC/DC converters to high-efficiency 76 W multioutput open frame power supplies. The Guide presents a variety of new products and lists price reductions for certain existing product groups. For further information, contact Semiconductor Circuits Inc, 218 River St, Haverhill MA 01830.

Circle 601 on inquiry card.

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TO ORDER CALL (212) 687-5001

SUPERBRAIN™

INTERTEC DATA SYSTEMS

32K ONLY \$2995
64K \$3245



More than an intelligent terminal, the SuperBrain outperforms many other systems costing three to five times as much. Endowed with a hefty amount of available software (BASIC, FORTRAN, COBOL), the SuperBrain is ready to take on your toughest assignment. You name it! General Ledger, Accounts Receivable, Payroll, Inventory or Word Processing... the SuperBrain handles all of them with ease.

Features Include:

- Two dual-density minifloppies with 320K bytes of disk storage
- 32K of RAM to handle even the most sophisticated programs
- a CPM Disk Operating System with a high-powered text editor, assembler and debugger.

NEW! MINIMAX



The Minimax Series Computer is an integrated compact unit containing the CPU, Disk Storage, 12 inch CRT, and Full Style Keyboard.

- Features Include:
- 2 Megahertz 6502 CPU
 - 108K System RAM
 - High Res. Graphics (240x512)
 - Switchable 110 or 220V Operation
 - Choice of Book or 2.4 Megabyte Disks
 - Business Packages Available
 - Serial and Parallel I/O
- MINIMAX I - 8 Megabyte on line minifloppy storage \$4495
MINIMAX II - 2.4 Megabyte on line 8" floppy storage \$5995

Commodore Computer

These low cost Commodore PET Business Computers have virtually unlimited business capabilities. Accounts Receivable, Inventory Records, Payroll, and other accounting functions.

- PET 16N & 32N COMPUTERS**
- Full size keyboard
 - 16 or 32,000 Bytes Memory
 - Level III Operating System
 - Full Screen Editor
 - Upper/lower case & 64 graphic characters



- PET DUAL FLOPPY DISK**
- Stores 360,000 Bytes on-line
 - Microprocessor controlled
 - Uses single or dual sided floppies



- HI-SPEED PRINTER**
- 150 characters per second • Up to 4 copies 8 1/2" wide
 - Microprocessor Controlled • Prints All Graphics
 - Full Formatting Capability

PERIPHERALS FOR PET

- 24K Memory Expansion \$499
- 16K Memory Expansion 399
- PET to RS232 Serial 169
- 2 Way Serial/Communication 229
- Modem Board for PET 375
- Analog to Digital Board for 16 Devices 275
- Second Cassette Drive 95
- Parallel Printer Interface 169



NEW!



APPLE II PLUS ONLY \$1195

A complete self-contained computer system with APPLESOFT floating point BASIC in ROM, full ASCII keyboard in a light weight molded carrying case.

Features Include:

- auto-start ROM • Hi-Res graphics and 15 color video output.
- Expandable to 48K.

Disk	\$595	Programmer's Aid	50
Add-on Disk	485	Speechlab	229
Pascal Card	485	Lightpen	250
Business Software	625	Communication Card	225
Monitor	149	Modem	200
Printer Card	160	EPR0M Programmer	100

NEW D. C. Hayes MICROMODEM II

- Combines the capabilities of a communications card and acoustic coupler.
 - Plugs directly into Apple slot and modular telephone jack.
 - Auto dial/receiver • FCC approved
- only \$379

NEW Mountain Hardware SUPERTALKER

- Digitized speech recording and playback
 - Foreign language teaching pack available
 - Must be heard to be believed
 - Software compatible.
- only \$279



- 16-bit microprocessor
- 16K RAM
- 13" color monitor (24 lines of 32 chrs.)
- 26K ROM operating system (includes 14K BASIC)
- Sound - 3 tones, 5 octaves
- 16 colors: 192 x 256 res.
- Large TI library of ROM programs available.

FINALLY TEXAS INSTRUMENTS TI-99/4 Home Computer

only \$1150 Includes 13" Color Monitor!

Many Peripherals. Coming soon!

Over 1000 software tapes, books, disks on display. Come in and browse.

NEW!

CENTRONICS 704

- 180 cps Bi-Directional
- Upper/Lower Case
- 9 x 9 Matrix
- Tractor Feed
- Up to 15" Paper Width
- RS-252 Serial Interface



CENTRONICS 753

- New Word Processing Dot Matrix Printer
- 130-150 cps • Proportional Spacing
- Tractor Feed • 9 x 9 Matrix

Call for Special prices

\$1495 Complete!

- 16K Model add \$200
- 32K Model add \$500



CENTRONICS 730

Parallel \$995
Serial \$1045

- 50 CPS • MICROPROCESSOR CONTROLLED!
- Tractor & Friction Feed • Uses Single Sheets, Roll, Fanfold • Upper & Lower Case • Light Weight

CompuColor II

COMPUCOLOR II Disk-Based Model 3 Advanced hardware and software technology gives you:

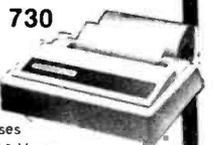
- 13" Color Display
- Advanced Color Graphics
- 51K Disk Built-In
- 16K ROM Operating System
- 8K RAM User Memory
- 4K RAM Refresh
- 8080A Microcomputer
- RS-232 I/O

ANDERSON JACOBSON

841 I/O Terminal

Ideal for word processing and small businesses.

- ASC II Code
- 15 cps Printout
- High Quality Selective Printing
- Use Keyboard for PET
- Reliable heavy duty Mechanism
- Completely Refurbished by A.J.
- Service in 15 Major Cities
- Plus \$35 Freight-In Charge



DATA GENERAL micro NOVA

The ultimate in small Business Computers

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minicomputer. Software:

Accounts Receivable/Payable,

Inventory Control/ Order Entry,

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from \$12,140 for 64K computer

with cabinet, printer terminal, video terminal

dual disk and multi-user operating system!



Data General

10 Megabyte System \$17,040

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What's New?

SOFTWARE

Add-on Graphics for Apple II Software

Superchip is a 16 K bit read-only memory designed to be plugged into the Apple II computer. The device provides an alternate set of I/O (input/output) service routines. The output routine can display, within the window concept, the full American Standard Code for Information Interchange (ASCII) character set (lowercase included), along with 32 new characters. User defined characters and character sets are also supported. Text is available in reverse video and may be freely mixed with high-resolution graphics. Characters can be rotated in 90 degree steps to achieve vertical and upside down printing. The new input routine permits the generation of all the new characters from the standard keyboard. An enhanced full screen editor is also provided with full cursor motion, character insertion and deletion, and several other features to increase the speed of editing. The Character Edit Program, which is available on cassette, permits one to construct or modify a character pattern by working with a magnified grid. Superchip was designed to be transparent to existing Apple software, and most programs run under it with no modification.

Superchip supports printing through either the communications or printer

Full Standard PILOT on PET

Commodore PET owners can get full standard PILOT on a minimum size PET with the PETPILOT language processor and editor which is suitable for preparing long programs of up to 80,000 characters. The product features full BASIC in compute statements as well as two new keywords designed to make PILOT programming easier and faster. All language features of the most recent PILOT standard are implemented. Only the tape drive supplied with the PET is required to run any PILOT program. While simple PILOT programs can be created on a single drive PET, authors writing long programs will need the second cassette drive offered by Commodore.

The package offered by the PET-PILOT project contains both programs, a sample PILOT program, a teacher's manual, a quick reference card, and licenses to run the programs on a single PET. The basic package costs \$25. Specify the PET serial number to be licensed when ordering. Contact Dave Gomberg, 7 Gateview Ct, San Francisco CA 94116.

Circle 640 on inquiry card.

How can your APPLE do this?
(Turn over for answer)

mix text

VERTICAL

with graphics

HORIZONTAL

Reverse Video

Display the usual:
!"#\$%&'()*+,-./
0123456789:;<=>?
@ABCDEFGHIJKLMNO
PQRSTUVWXYZ[\]^_

Plus the desired:
'abcdefghijklmnopq
rstuvwxyz(:)~%

Plus the new:
^_!@#%&'()*+,-./
:;<=>?@ABCDEFGHIJKLMNO
PQRSTUVWXYZ[\]^_

Even add your own:
Q q R r S s T t U u V v W w X x Y y Z z

(ANS: Just Plus in SUPERCHIP)

interface board and requires a 16 K byte system to operate. The Applesoft board is also supported. Superchip is priced at \$99.95, and the Character Edit Program is \$19.95. A disk interface is available

for \$19.95, and a word processing package costs \$19.95. For further information, contact Eclectic Rentals Inc, 2830 Walnut Hill Ln, Dallas TX 75229.

Circle 638 on inquiry card.

User-Oriented Database Management System

Global is a comprehensive and versatile user-oriented database management system for database creation and list maintenance. Global runs under CP/M and CBASIC2 on a microcomputer system in 40 K bytes of programable memory. This general-purpose tool can be used for diverse applications such as inventory systems, mail lists, indexing collections, history reports, payroll files, accounting files, price lists, client lists, etc.

Some features include completely user-defined file structure with sequential, random, and linked file maintenance; user-defined number of fields; data transfer between records;

automatic high-speed search algorithms with global search function, built-in indexed sequential-access method, etc; fast sort and merge utility; record-selectable output that can be formatted and printed on various forms; links to CP/M commands or programs with automatic return to Global; status reports on disk, data file and hardware environment; and disk used as extended memory.

Global is supplied on standard 8-inch IBM-compatible disks and comes complete with a BASIC subroutine library supplied in source code, and a comprehensive manual for \$295. The manual alone is \$35. For further information, contact Global Parameters, 1505 Ocean Ave, Brooklyn NY 11230.

Circle 639 on inquiry card.

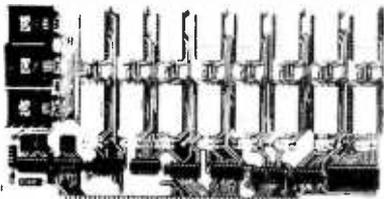
Educational Software for Apple and TRS-80

Mind-Memory Improvement (Course Steps 1 and 2) has been designed for the Apple and the TRS-80 (Level I and II). It combines the advantages of the home computer with a teaching manual and audio cassettes. The Mind course teaches a system for memorizing lists of items easily. In addition, the course

develops memorizing skills for more difficult material as well as teaching a system for listening and remembering. Emphasis is placed on remembering people's names and faces. The price for Mind-Step 1 is \$24.95 and Mind-Step 2 is priced at \$29.95. Both courses are available for \$49.90. For further information, contact TYC Software, 40 Stuyvesant Manor, Geneseo NY 14454.

Circle 641 on inquiry card.

16K EPROM CARD-S 100 BUSS



\$59.95
KIT

OUR
BEST
SELLING
KIT!

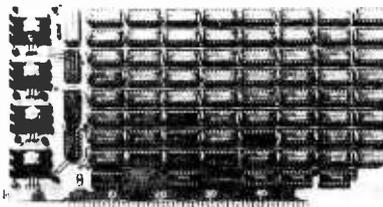
USES 2708's!

Thousands of personal and business systems around the world use this board with complete satisfaction. Puts 16K of software on line at **ALL TIMES!** Kit features a top quality soldermasked and silk-screened PC board and first run parts and sockets. All parts (except 2708's) are included. Any number of EPROM locations may be disabled to avoid any memory conflicts. Fully buffered and has WAIT STATE capabilities.

OUR 450NS 2708'S
ARE \$8.95 EA. WITH
PURCHASE OF KIT

ASSEMBLED
AND FULLY TESTED
ADD \$25

8K LOW POWER RAM KIT-S 100 BUSS SALE



PRICE
CUT!

\$119.50
KIT

(450 NS RAMS!)

Thousands of computer systems rely on this rugged, work horse, RAM board. Designed for error-free, NO HASSLE, systems use.

KIT FEATURES:

1. Doubled sided PC Board with solder mask and silk screen layout. Gold plated contact fingers.
2. All sockets included.
3. Fully buffered on all address and data lines.
4. Phantom is jumper selectable to pin 67.
5. FOUR 7805 regulators are provided on card.

Blank PC Board w/Documentation \$29.95
Low Profile Socket Set...13.50
Support IC's (TTL & Regulators) \$9.75
Bypass CAP's (Disc & Tantalums) \$4.50

ASSEMBLED AND FULLY
BURNED IN ADD \$30

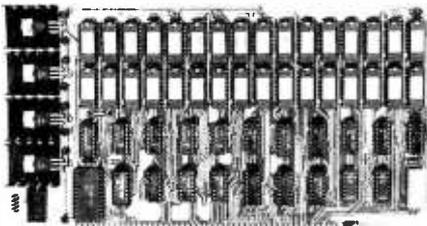
16K STATIC RAM KIT-S 100 BUSS

PRICE CUT!

\$279 KIT

FOR 250NS
ADD \$10

FULLY
STATIC, AT
DYNAMIC PRICES



WHY THE 2114 RAM CHIP?

We feel the 2114 will be the next industry standard RAM chip (like the 2102 was) This means price, availability, and quality will all be good! Next, the 2114 is FULLY STATIC! We feel this is the ONLY way to go on the S-100 Bus! We've all heard the HORROR stories about some Dynamic Ram Boards having trouble with DMA and FLOPPY DISC DRIVES Who needs those kinds of problems? And finally, even among other 4K Static RAM's the 2114 stands out! Not all 4K static RAMs are created equal! Some of the other 4K's have clocked chip enable lines and various timing windows just as critical as Dynamic RAM's. Some of our competitor's 16K boards use these "tricky" devices. But not us! The 2114 is the ONLY logical choice for a trouble-free, straightforward design.

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 2 amps TYPICAL from the +8 Volt Bus
10. Blank PC Board can be populated as any multiple of 4K.

BLANK PC BOARD W/DATA—\$33

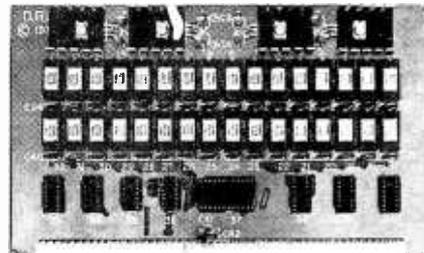
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- Plated thru holes
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- All S-100 BUS signals labeled and numbered
- Accommodates standard size IC sockets
- 4 top-220 regulator positions available
- Allows either positive or negative regulators
- Dense hole configuration

Cat No. 1600 \$ 27.00

Model 2501A S-100 Solder Board

- S-100 BUS compatible
- Double sided PC board
- Plated thru holes
- Perimeter ground
- All S-100 BUS signals labeled and numbered
- Accommodates standard size IC sockets
- 4 top-220 regulator positions available
- Allows either positive or negative regulators
- Dense hole configuration

Cat No. 1604 \$ 27.00

Model 2501A S-100 Mother Board

- 12 slot capability
- All 12 S-100 bus connectors included
- Low inductance inner-connect to reduce signal noise and crosstalk
- Active termination of all bus lines to further reduce signal noise and line reflections
- Distributed bypassing of all power lines
- Solder mask both sides of board
- Silkscreen of reference designations
- Simple strong board mounting
- Cross-cross BUS lines both sides of board
- All holes plated thru
- Solder plated circuit area

Cat No. 1616 Kit \$ 90.00
Cat No. 1615 A&T \$ 105.00

Model 2520A S-100 Extender/ Terminator

- Active and/or dynamic termination
- All power lines fused for protection
- All S-100 lines labeled and numbered
- Can be used as an extender and/or terminator
- Solder mask both sides of board
- Silkscreened reference designations
- Grid plated fingers

Cat No. 2520 Kit \$ 37.95

Model 7811A Apple II Arithmetic Processor

- Based on AMD AM9511 device
- Fixed point 16 and 32 bit operation
- Floating point 32 bit operation
- Binary data formats
- Add, subtract, multiply, and divide
- Trigonometric and inverse trigonometric functions
- Square roots, logarithms, exponentiation
- Float to fixed and fixed to float conversions
- Stack oriented operand storage
- Programmed I/O data transfer
- End signal selectable interrupt
- Supports interrupt daisy chain
- Allows DMA daisy chain
- Power down ROM
- 256 bytes firmware (ROM) or software (RAM) space available

Cat No. 1635 \$375.00

Model 7114A Apple II Prom Module

The 7114A PROM MODULE permits the addition or replacement of the Apple II firmware without the physical removal of the Apple II ROMS. This allows software/firmware replacement, change, and/or patch to be made on a ROM or BYTE BASIS. An on-board enable/disable toggle switch is also available.

- BYTE oriented program overlay
- Selectable prom overlay
- Power down of PROMS
- 14K PROM space available
- Uses +5 volt 2716 type proms
- Allows use of DMA/interrupt daisy chains

Cat No. 1631 A&T \$ 72.00
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Model 2016B S-100 16K Static Memory

- Fully static operation
- Uses 2114 type static ram's
- +8 VDC input at less than 2 amps
- Bank select available by bank part and bank byte
- Phantom line capability
- Addressable in 4K blocks in 4K increments
- 4K blocks can be located anywhere within 64K bank
- May be used as a 4K, 8K, 12K or 16K memory board
- Led indicators for board/bank active indication
- Solder mask on both sides of board
- Silk screen with part and reference designation
- Available fully assembled and tested, as a kit, or as a bare board

Cat No. 1601A Kit 450ms \$285.00
Cat No. 1601B Kit 200ms \$310.00
Cat No. 1602A A&T 450ms \$330.00
Cat No. 1602B A&T 200ms \$385.00

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The 7470 allows conversion of a DC voltage to a BCD number for computer monitoring and analysis. Typical inputs would be DC inputs from temperature or pressure transducers.

- Selectable interrupt at end of conversion
- 200µs per conversion
- 4 to +4 VDC full scale
- Plus or minus .05% nonlinearity
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- Calibration adjustment
- Input offset adjustment
- Floating inputs
- Overrange and sign indicators
- Input filters
- Power down ROM
- Supports interrupt daisy chain
- Allows DMA daisy chain
- 256 byte firmware (ROM) or software (RAM) space available

Cat No. 1621 Kit \$115.00
Cat No. 1622 A&T \$135.00

Model 2200A Mainframe

- S-100 compatible
- Industrial/commercial quality construction
- Flip-top cover
- Excellent cooling capability
- 12 slot capability (uses model 2501A)
- Input 105, 115, or 125 VAC
- Output +8 VDC, 20A + - 16 VDC 4A
- Active termination of all bus lines
- Fan and circuit breaker included
- Rugged construction
- All parts available separately

Cat No. 1612 Kit \$330.00
Cat No. 1614 A&T \$375.00

Model 7440A Apple II Programmable Timer Module

- Flexible external interface patch area for custom interface applications
- Selectable prescaler on timer
- 3 capable of 4MHz input
- Programmable interrupts
- Readable down counter indicates counts to go to time-out
- Selectable gating for frequency or pulse width comparison
- Three asynchronous external clock and gate/trigger inputs internally synchronized
- Three maskable outputs to patch area
- Power down ROM
- Supports interrupt daisy chain
- Allows DMA daisy chain
- 256 byte firmware (ROM) or software (RAM) space available

Cat No. 1617 Kit \$135.00
Cat No. 1618 A&T \$145.00

Apple II Model 7712A Synchronous Serial Interface

- Conforms to RS-232C (configuration A thru E)
- Supports half or full duplex operation
- DTE type configuration
- Failsafe RS-232C operation
- 14 STD CLK rates 50-19.2K BAUD plus EXT CLK
- BAUD rates dip switch selectable
- All BAUD rates crystal controlled
- Programmable interrupts from transmitter, receiver, and error detection logic
- Character SYNC by one or two SYNC codes
- Programmable SYNC code register
- Standard asynchronous signaling rate per RS-269/ANSI X3.1-1976
- Peripheral/modem control functions
- Three bytes of fifo buffering on both transmit and receive data
- 7, 8, or 9 bit transmission
- Optional odd, even, or no parity bit
- Parity, overrun, and overflow status checks
- Power down prom
- 256 bytes firmware (ROM) or software (RAM) space available
- Supports interrupt daisy chain
- Allows DMA daisy chain

Cat No. 1627 Kit \$ 90.00

Apple II Model 7710A Asynchronous Serial Interface

- Parity, overrun, and framing error check
- Optional divide by 16 clock mode
- False start bit detection
- Software programmable interrupts
- Data double buffered
- One or two stop bit operation
- Power down PROM
- 256 bytes firmware (ROM) or software (RAM) space available
- Supports interrupt daisy chain
- Allows DMA daisy chain
- 134.5 BAUD available for selective interface
- Conforms to RS-232C (configuration A thru E)
- Supports half or full duplex operation
- DCR type interface
- Failsafe RS-232C operation
- 14 STD CLK rates 50-19.2K BAUD plus EXT CLK
- BAUD rates dip switch selectable
- All BAUD rates crystal controlled except EXT
- 8 and 9 bit transmission
- Optional even, odd, and no parity bit
- Programmable control register

Cat No. 1624 A&T \$145.00
Cat No. 1623 Kit \$ 90.00

Model 7720A Apple II Parallel Interface

- Two bi-directional 8 bit buses for interface to peripherals
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- Two programmable data direction registers
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- Handshake control logic for input and output peripheral operation
- High impedance 3 state and direct transistor drive peripheral lines
- Programmable interrupts
- CMOS drive capability on side A peripheral lines
- 2 TTL drive capability on all A and B side buffers
- Power down ROM
- Supports interrupt daisy chain
- Allows DMA daisy chain
- 256 bytes firmware (ROM) or software (RAM) space available

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- Perimeter ground
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Model 7510A Apple II Solder Board

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Model 7590A Apple II Etch Board

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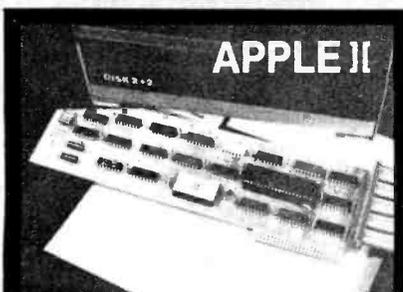
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3	1.08	3.22	5.65	7	1.66	5.63	10.37
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4	1.18	3.70	6.62	8	1.78	6.15	11.44
4.5	1.23	3.95	7.12	8.5	1.82	6.41	11.97
5	1.28	4.20	7.61	9	1.87	6.76	12.51
5.5	1.32	4.48	8.10	9.5	1.92	6.93	13.04
6	1.37	4.72	8.59	10	1.99	7.26	13.57

Kit #1 Less than 2.7¢/ft. (#30)	\$7.95	Kit #2 Less than 2¢/ft. (#30)	\$19.95	KIT #3 Less than 1.7¢/ft. (#30)	\$24.95	Kit #4 Less than 1.6¢/ft. (#30)	\$44.95	#30 Spools	1-4	5-9	10+
250 3" 100 4"		250 2½" 250 5"		500 2½" 500 4½"		1000 2½" 1000 4½"		50 ft.	1.75	1.60	1.40
250 3" 100 5"		500 3" 100 5½"		500 3" 500 5"		1000 3" 1000 5"		100 ft.	3.00	2.75	2.50
100 4" 100 6"		500 3½" 250 6"		500 3½" 500 5½"		1000 3½" 1000 5"		250 ft.	4.75	4.50	4.25
		500 4" 100 6½"		500 4" 500 6"		1000 4" 1000 6"		500 ft.	8.50	8.00	7.50
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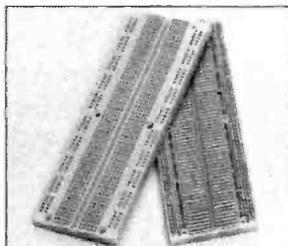
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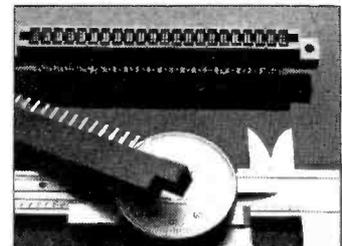
Dimensions: .33"h x 2.2"w x 6.5"l



TI Edge Card Connectors

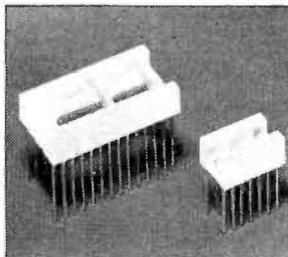
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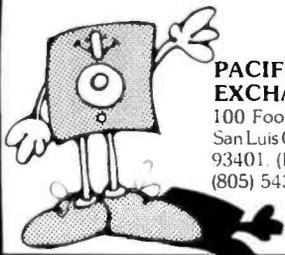
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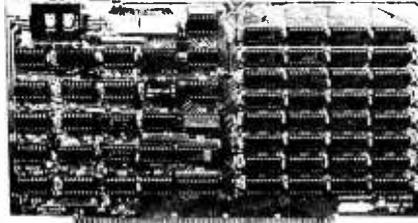
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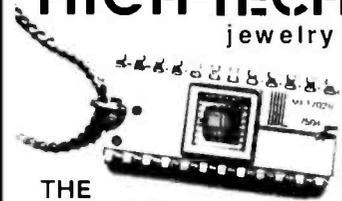
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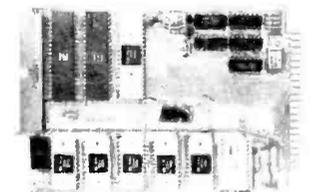
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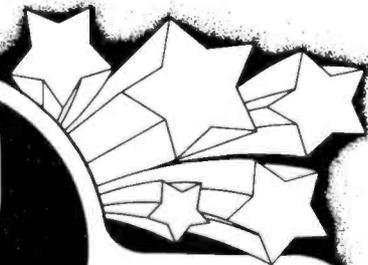
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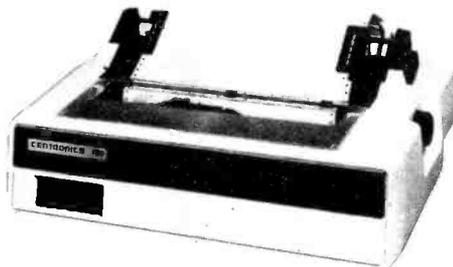
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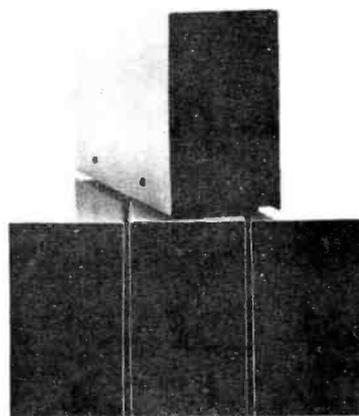
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This real-time audio spectrum analyzer is designed to fit inside the Commodore PET computer. The analyzer divides the audio spectrum from 20 Hz to 20 kHz into 31 one-third octave bands, and displays those bands, with their relative amplitudes, on the PET screen. The unit can be used for measuring sound and noise levels, for optimizing the equalization of a music or public address system, for checking the frequency response of audio components, and for speech and sound pattern recognition (useful for voice control systems).

Because of the capabilities of the Commodore PET, great flexibility in the manipulation of the analyzed data is permitted. The PET can store and recall spectral data, and make comparisons with past, future, or other channel data. There is a Peak Hold feature, which enables the unit to determine whether any preset levels have been exceeded. Programs to access the analyzer are

written in BASIC; accordingly, three programs are provided with the unit: interactive operation, self-test, and minimal operation.

The analyzer comprises a single circuit board, which installs in about 5 minutes inside the PET. It has 31 one-third octave filters, detectors, an analog-to-digital converter, a 1 K byte read-only memory which contains machine language routines, and the necessary peripheral circuitry for transferring data into the PET memory. The board draws its power from the PET transformer.

The cost of the analyzer is \$595. For further information, contact Eventide Clockworks Inc, 265 W 54th St, New York NY 10019.

Circle 642 on inquiry card.

features include full upper and lowercase 96-character set; adjustable form width; forms control with eight standard form lengths; both 80- and 132-column formats; choice of six or eight lines per inch vertical spacing; software-selectable character density; automatic multiline buffering; and both RS-232C serial and Centronics-compatible parallel interfaces. Multiple transmission rates from 110 to 1200 bits per second (bps) are also switch selectable. The new printer uses a stepper motor paper feed, and an automatic re-inking mechanism extends ribbon life. A variable character-size feature permits program controlled highlighting and formatting of copy.

The modular Paper Tiger uses a single printed circuit board that contains all printer electronics and uses a printhead rated at a life of over 100 M characters. An optional 2 K byte buffer and graphics package provides full dot-plotting graphics capability. The larger 2 K byte buffer holds the contents of a full video screen or 1920 characters. The Paper Tiger is priced at \$995.

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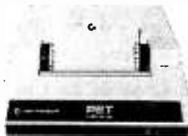
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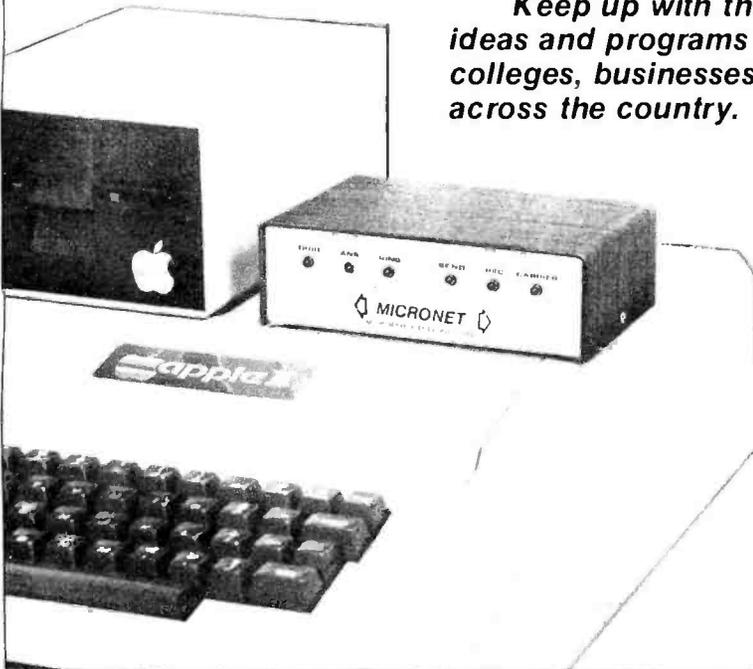
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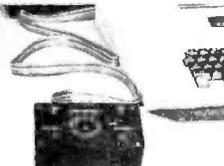
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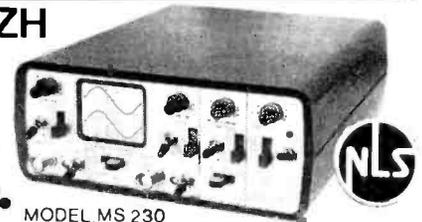
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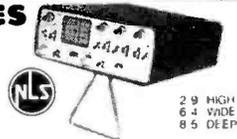
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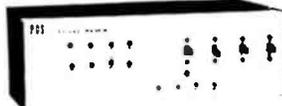
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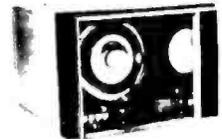
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- DIABLO HYTYPE I Model 1200 PRINTER MECHANISM: Used, complete and tested. Requires power supply, case & mCPU interface. Tested: \$750.00
6' Ribbon cable and connector \$ 10.00
for printer Main Logic PCB \$ 20.00
"As-is" spare printer PCB's for parts (Logic, Heat Sink, Control): each \$ 20.00
New Pin-lead Platen (14"): \$100.00
\$50 if bought w/printer; separately \$100.00

MODEMS



- POS 103/202 "MAX" or "MATCH" MODEM: BELL 103 and/or BELL 202 FREQUENCIES: Unique POS control design permits use in one housing of both Bell-compatible 103 (0-300 baud) and 202 (0-1200 baud) modem modules originally made by VADIC Corp. for a telephone company subsidiary. FEATURES: RS-232 serial interface, auto-answer, auto-dial, LED display, telephone line interface via acoustic coupler, manual DAA, or auto-answer DAA (sold separately). FULLY ADJUSTED; no special tools required. 3,000 mile range over standard dial-up telephone lines.
POS 103 MODEM \$179.95
POS 202 MODEM \$249.95
POS 202 MODEM (Auto-Answer) \$279.95
POS 103/202 MODEM \$399.95

TAPE DRIVES & CONTROLLERS



- POS-100 NRZ1 TAPE DRIVE CONTROLLER/FOR-MATTER: Designed as interface between S-100 bus mCPU and 9-track, 800 BPI, NRZ1 tape drive. Allows microcomputerist to read and write IBM-compatible 5/8" mag tapes. Software provided for 8080 or Z-80 systems. Requires modification for drives of various mfrs. Std. version: 2 MHz/8080/Z-80 CPU for use with 12"/sec. PIRTEC-style Tape Drive. Price: (Includes S-100 card, controller card, 10' cable, software listing) \$750.00
- NRZ1 TAPE DRIVE by CIPHER Data Products: Full size PIRTEC-style 800 BPI drive model 1008AX; 2400' Tape, 9 track, 25 to 37 ips, used, refurbished. Wt. approx. 120 lb. Price: \$1500.00
- CONVERT 15" IBM OFFICE SELECTRIC TO I/O TYPEWRITER: Kit includes assembled solenoids, switches, wire harness, magnet driver PCB plus instructions for installation and mCPU interface \$200.00
- DIGITAL CASSETTE DRIVE (from GTE/IS Terminal): 1800 baud, 6"/sec; AC motor; fwd/revnd circuitry plus tape head, no read/write electronics \$25.00
- FORMS TRACTORS, Moore Variable width 11" or 14" inch for print terminals:
a) Model 56SP for 15" Carriage
IBM Selectrics (used) \$75.00
b) Model K81 for QUAM or DIABLO
Hytype I or II printers (new) \$90.00
- POWER SUPPLIES for Disk Drive, mCPU, tested under load shown:
No. 5 19 w/Jan & AC cord) +5V reg.
+12V reg., +21V, @4A (10 lbs.) \$39.95

NO RISK!! 15 DAY APPROVAL ON ALL MAIL ORDERS

Full documentation included PLUS interface instructions where indicated. All equipment is shipped insured FOB Palo Alto within 14 days after check clears or COD order is received. Prices may change without notice. Call or write for details, quantity prices, catalog. 15 Day return privilege PLUS 90 day no charge replacement of defective parts. All orders shipped from stock. No back orders, no substitutions. Master Charge and VISA accepted.

10-DAY FREE TRIAL

Send for our
FREE Catalog



\$100 FREE ACCESSORIES WITH 16K or 32K PET

Buy our 16K or 32K PET and we'll give you your first \$100 worth of accessories. **FREE.** Just indicate on your order that you have reduced the cost of your accessories by \$100.

FREE Terminal Package with 8K PETs

SAVE \$69

4K - Keyboard C	\$ 595
8K - Keyboard C	\$ 795
16K - Keyboard B	\$ 995
16K - Keyboard N	\$ 995
32K - Keyboard C	\$1295
32K - Keyboard B	\$1295
32K - Keyboard N	\$1295
C — calculator keyboard (only version with tape deck)	
B — Large Keyboard (graphics not on keys)	
N — large keyboard with graphics symbols	
Used 8K PET with 90-day warranty	\$650



Hazeltine 1400

LIST SALE

~~\$850~~ ~~\$740~~

SUPER SALE PRICE TOO LOW TO ADVERTISE

Immediate Delivery — 2-Year Factory Warranty

You may have seen the Hazeltine advertised at \$850. You may have seen it sale prices at \$749 or even \$699 but our new price is so low that we can't even advertise it. Call us for a quote. Hurry, we have a limited quantity at this price. The 8048-based Hazeltine 1400 has a 12" screen, 24 x 80 display, TTY-style keyboard, addressable cursor, and RS-232 I/O from 110 to 9600 baud.

Hazeltine 1410 — \$835	Hazeltine 1510 — \$1195
Hazeltine 1500 — \$1069	Hazeltine 1520 — \$1499

PET ACCESSORIES

Commodore Dual Floppy Disk Drive	\$100 SALE! \$995.00
Commodore Printer (tractor feed)	\$995.00
Second Cassette — from Commodore	\$95.00
Commodore PET Service Kit	\$30.00
Beeper - Tells when tape is loaded	\$24.95
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Video Buffer - Attach another CRT	\$29.95
Combo - Petunia and Video Buffer	\$49.95
New Serial Printer Interface for PET	\$79.95

Call for Availability _____
PET - Compatible Selectric in Desk \$895.00

SAVE \$195 COMMODORE DISK DRIVES

Reg. \$1,295 Sale \$1,100



apple II plus

\$200 FREE ACCESSORIES

The new Apple II with Applesoft BASIC built-in! Eliminates the need for a \$200 Firmware Card and includes new Autostart ROM for easy operation. This combined with the **FREE** accessories from NCE could save you up to \$400 on a 48K Apple II system!

16K Apple II Plus — \$1195 (take \$100 in free accessories)
32K Apple II Plus — \$1345 (take \$150 in free accessories)
48K Apple II Plus — \$1495 (take \$200 in free accessories)

Apple II Accessories

Centronics Printer Interface	\$225
Disk and Controller	Call for Availability \$595
Second Disk Drive	\$495
Parallel Printer Card	\$180
Communications Card	Call for Availability \$225
Hi-Speed Serial Card	\$195
Firmware Card	\$200
Hobby/Proto Card	\$24
Microverter RF Mod.	\$35
Sanyo M2544 Recorder	\$55

IN STOCK NOW!

EVERY ITEM IN THIS ADVERTISEMENT IS IN STOCK AND READY TO SHIP, EXCEPT WHERE NOTED.

NOW Graphics printer \$1,098 for Apple II

Now you can print high resolution graphics from your Apple using the IP-225 printer and graphics option from IDS. The IP-225 is a tractor feed printer with 96 possible characters. Line length is 80/132 col. with a speed of 50/80 cps. We include software which allows it to use either parallel or serial interface at 1200 baud. **ABSOLUTELY FREE** (you save \$50!)

REMOTE TERMINAL for only \$69

A self-contained module and program cassette enables your PET to function as a 300 baud terminal. Supports Upper/Lower case, Rubout, Escape & all control functions. Output is TTL.

FREE WITH 8K PET PURCHASE

NEW! 800K DISK & MEMORY EXPANSION

You can instantly turn your PET into a speedy and efficient professional computer. Its easy with the new 400K Disk Drive and Memory Expansion from Computhink Add up to 32K internally then load 20K program in only 3 seconds!

800K Disk Drive	\$1295.00
Memory Expansion	
16K	\$425.00
24K	\$525.00
32K	\$615.00

NEW from Heath Data Systems

The All-In-One Computer

Dual Z-80 Processors • Built-in 102K Floppy Disk • 16K to 48K RAM • 25 x 80 Character Display • Upper/Lower Case and Line Graphics • 80 Character Keyboard with Keypad • 8 User-definable Keys • Two BASIC's and Auto-Script Word Processing available • Can support CP/M

Heath's third generation of computers is a compact, hi-style desktop unit which includes a complete terminal, a computer and a disk All-in-One! System includes Bootstrap in ROM, other programs available separately. HDOS operating system includes Heath's BASIC, an assembler and text editor along with important disk utilities. Microsoft language requires HDOS.

WH89 with 16K RAM	\$2,295
WH89 with 32K RAM	\$2,445
WH89 with 48K RAM	\$2,595
WH17 Second Disk Drive	\$550
Dual-port Serial Interface	\$85
HDOS Operating System	\$100
Microsoft BASIC	\$100
Word Processing	\$395



CAT COUPLER

New 300 baud Originate/Answer Acoustic Coupler. Looks good, works great

priced at **\$189**

LOW COST PRINTER FOR PET \$395

IN STOCK NOW

1+1=3-RIGHT!

EDUCATORS ORDER YOUR FREE PET TODAY!

Between now and Nov 30th any educational institution which buys 2 PET's at list price will receive a 3rd PET. **ABSOLUTELY FREE!** That's right. **FREE!** For example, buy 2 8K PET's at \$795 each and get 1 8K PET. **FREE.** Buy 1 16K at \$995 and 1 32K at \$1,295 and your school will receive 1 16K PET absolutely **FREE!** Join the hundreds of public & private schools, colleges, and Universities who have bought from us with confidence. Look at our PET box in the upper left hand corner of this ad for descriptions and prices of the Commodore PET product line. If you need more information just call, we love questions.

SANYO MONITOR

\$169 **\$279**

9-inch ~~\$240~~ 15-inch ~~\$400~~



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IMPORTANT ORDERING INFORMATION

All orders must include 4% shipping and handling. Michigan residents add 4% for state sales tax. All foreign orders (except Canada) need an additional 10% for shipping and handling.

Phones open from 9:00 a.m. to 7:00 p.m. EST Monday-Friday, 10:00 a.m. to 5:00 p.m. Saturdays • P.O.'s accepted from D & B rated companies — shipment contingent upon receipt of signed purchase order • All prices subject to change without notice • Most items in stock for immediate shipment — call for delivery quotation • Sorry, no C.O.D.'s • In the Ann Arbor area? Retail store open 11:00 a.m. to 7:00 p.m. Tuesday-Friday, 10:00 a.m. to 5:00 p.m. Saturdays (Closed Sunday and Monday)

If not satisfied, return your purchase with-in 10 days for full refund of purchase price!

7400 TTL

SN7400N	20	SN7410N	20
SN7401N	16	SN7411N	25
SN7402N	16	SN7412N	25
SN7403N	16	SN7413N	25
SN7404N	16	SN7414N	25
SN7405N	20	SN7415N	25
SN7406N	20	SN7416N	25
SN7407N	20	SN7417N	25
SN7408N	20	SN7418N	25
SN7409N	20	SN7419N	25
SN7420N	20	SN7420N	25
SN7421N	25	SN7421N	25
SN7422N	25	SN7422N	25
SN7423N	25	SN7423N	25
SN7424N	25	SN7424N	25
SN7425N	25	SN7425N	25
SN7426N	25	SN7426N	25
SN7427N	25	SN7427N	25
SN7428N	25	SN7428N	25
SN7429N	25	SN7429N	25
SN7430N	25	SN7430N	25
SN7431N	25	SN7431N	25
SN7432N	25	SN7432N	25
SN7433N	25	SN7433N	25
SN7434N	25	SN7434N	25
SN7435N	25	SN7435N	25
SN7436N	25	SN7436N	25
SN7437N	25	SN7437N	25
SN7438N	25	SN7438N	25
SN7439N	25	SN7439N	25
SN7440N	25	SN7440N	25

INTERNATIONAL TIME ZONE CLOCK

• Four individually programmed clocks to time zone of your choice
• Single synch. switch to synchronize time zones
• Alterable vinyl lettering (change zone identity lettering when desired)
• Hrs., minutes & seconds displayed for each zone
• Hi-bright LED digits (6" character height)
• Continuous AM or PM indication using 12 hr. format

SPECIFICATIONS:
Power: wall plug transformer or input voltage 120VAC/60Hz; output voltage 12VAC 60Hz.
Case: Standard wood molding w/simulated walnut finish re-dielectric glass. Black textured ABS back.
Dimensions: 5" x 9"

T2-4 Assembled... \$159.95

DIGITAL STOP TIMER OR CLOCK



• 10 hour stopwatch timer
• 12 or 24 hour operation
• 6 function controls: fast, slow, hold, reset, 12/24 hour and 5/6 digit
• Large .560" red display
• 50Hz or 60Hz operation
• Includes mounting bracket
• Size: 4" x 2" x 5"

JB 1001A Assembled... \$59.95

TELEPHONE/KEYBOARD CHIPS

AV-5-9100	Push Button Telephone Dialler	\$14.95
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AV-5-9900	CMOS Clock Generator	4.95
AV-5-2736	Keyboard Encoder (86 keys)	14.95
74C222	Keyboard Encoder (86 keys)	7.95
74C293	Keyboard Encoder (20 keys)	6.25

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ICM7045	CMOS Prescaler	24.95
ICM7045	CMOS LED Stopwatch/Timer	19.95
ICM7047	Decoder Counter (36 keys)	19.95
ICM7209	Seven Decade Counter	19.95
ICM7209	Clock Generator	6.95

NMOS READ ONLY MEMORIES

MC6M571	128 X 9 X 7 ASCII Shifted with Greek	13.50
MC6M574	128 X 9 X 7 Math Symbol & Pictures	13.50
MC6M575	128 X 9 X 7 Alpha Control Char. Gen.	13.50

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TL074CN	Quad Low Noise Bifet Op Amp	2.49
TL494CN	Switching Regulator	4.49
TL496CP	Single Switching Regulator	1.75
11C90	DS-Speed Drive 1011 Prescaler	19.95
4N33	Photo-Darlington Opto-Isolator	3.95
MC50240	Tot Pole Freq. Generator	17.50
DS0206CH	5MHz 2-phase MOS clock driver	30.75
TL7418	27' red nm. display w/white logic chip	10.95
MS5320	TV Camera Sync. Gen.	14.95
MS5330	4 1/2 Digit DPM Logic Block (Special)	3.95
LD1101/111	3 1/2 Digit A/D Converter Set	25.00/set
MC1443P	MC1443P	13.95

LITRONIX ISO-LT 1

Photo Transistor Opto-Isolator (Same as MCT 2 or 4N25)
49¢ each

SN 76477

SOUND GENERATOR
Generates Complex Sounds
Low Power - Programmable
\$3.95 each

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AY-3-8500-1 and 2.01 M1 Z Crystal (Choc & Crystal)
Includes score display, 6 games and select angles. **7.95/set**

XR205	58.40	XR2242CP	1.50
XR210	4.40	XR2264	4.25
XR215	4.40	XR2266	3.20
XR320	1.55	XR2267	1.25
XR4-LS55	1.50	XR2268	11.95
XR555	.39	XR1800	3.20
XR556	.99	XR2206	4.40
XR567	.99	XR2207	3.85
XR567CT	1.25	XR2208	5.20
XR1010P	1.95	XR2209	7.75
XR1468CN	3.95	XR2211	5.25
XR1488	1.95	XR2212	4.35
XR1489	1.95	XR2240	3.45
XR1499	1.95	XR2241	1.47

C/MOS

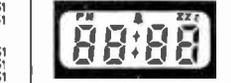
CD4000	23	CD4070	55
CD4001	23	CD4071	55
CD4002	23	CD4072	40
CD4006	119	CD4073	139
CD4007	25	CD4074	39
CD4009	49	CD4082	23
CD4010	49	CD4083	23
CD4011	23	CD4084	23
CD4012	25	CD4085	23
CD4013	25	CD4086	23
CD4014	119	CD4087	23
CD4015	119	CD4088	23
CD4016	119	CD4089	23
CD4017	119	CD4090	23
CD4018	25	CD4091	23
CD4019	25	CD4092	23
CD4020	25	CD4093	23
CD4021	25	CD4094	23
CD4022	25	CD4095	23
CD4023	25	CD4096	23
CD4024	25	CD4097	23
CD4025	25	CD4098	23
CD4026	25	CD4099	23
CD4027	25	CD4100	23

DISCRETE LEDS

XC556R	20W dia.	5/51	XC209R	125' dia.	5/51	
XC556G	green 4/51	XC209G	green 4/51	XC268R	red 5/51	
XC556Y	yellow 4/51	XC209Y	yellow 4/51	XC268G	green 4/51	
XC556C	clear 4/51	XC209C	clear 4/51	XC268Y	yellow 4/51	
XC22Y	20W dia.	5/51	XC268R	red 5/51	XC268G	green 4/51
XC22G	green 4/51	XC268G	green 4/51	XC268Y	yellow 4/51	
XC22Y	yellow 4/51	XC268C	clear 4/51	XC268C	clear 4/51	
MV10B	.170" dia.	4/51	XC111R	red 4/51	XC111G	green 4/51
MV50	.085" dia.	6/51	XC111G	green 4/51	XC111Y	yellow 4/51
1/4"x1/4" x1/16" tall	5/51	XC111C	clear 4/51			

TI-MEX T1001

LIQUID CRYSTAL DISPLAY CLASS M
FIELD EFFECT



4 DIGIT 7 SEG CHARACTERS
THREE ENUNCIATORS
2.00" x 1.20" PACKAGE
INCLUDES CONNECTION

T1001-Transmissive \$7.95
T1001A-Reflective \$7.25

DISPLAY LEDS

TYPE	POLARITY	HT	PRICE	TYPE	POLARITY	HT	PRICE
MAN 1	Common Anode-red	270	2.95	MAN 6700	Common Anode-red-D	1	560
MAN 2	5 x 7 Dot Matrix-red	300	4.95	MAN 6700	Common Anode-red-D	1	560
MAN 3	Common Cathode-red	125	25	MAN 6750	Common Cathode-red	1	560
MAN 4	Common Cathode-red	187	195	MAN 6760	Common Anode-red	560	99
MAN 7G	Common Anode-green	300	125	MAN 6780	Common Cathode-red	560	99
MAN 7F	Common Anode-yellow	300	99	DL700	Common Anode-red	1	300
MAN 7E	Common Anode-red	300	99	DL700	Common Cathode-red	300	99
MAN 7A	Common Cathode-red	300	125	DL707	Common Anode-red	300	99
MAN 8	Common Anode-yellow	300	99	DL728	Common Anode-red	500	149
MAN 8A	Common Cathode-orange	300	99	DL731	Common Anode-red	600	125
MAN 8B	Common Cathode-orange	300	99	DL732	Common Anode-red	1	630
MAN 8C	Common Cathode-orange	300	99	DL749	Common Cathode-red	1	630
MAN 8D	Common Cathode-orange	300	99	DL750	Common Cathode-red	600	149
MAN 8E	Common Cathode-orange	300	99	DL751	Common Cathode-red	1	630
MAN 8F	Common Cathode-orange	300	99	DL752	Common Cathode-red	1	630
MAN 8G	Common Cathode-orange	300	99	DL753	Common Cathode-red	1	630
MAN 8H	Common Cathode-orange	300	99	DL754	Common Cathode-red	1	630
MAN 8I	Common Cathode-orange	300	99	DL755	Common Cathode-red	1	630
MAN 8J	Common Cathode-orange	300	99	DL756	Common Cathode-red	1	630
MAN 8K	Common Cathode-orange	300	99	DL757	Common Cathode-red	1	630
MAN 8L	Common Cathode-orange	300	99	DL758	Common Cathode-red	1	630
MAN 8M	Common Cathode-orange	300	99	DL759	Common Cathode-red	1	630
MAN 8N	Common Cathode-orange	300	99	DL760	Common Cathode-red	1	630
MAN 8O	Common Cathode-orange	300	99	DL761	Common Cathode-red	1	630
MAN 8P	Common Cathode-orange	300	99	DL762	Common Cathode-red	1	630
MAN 8Q	Common Cathode-orange	300	99	DL763	Common Cathode-red	1	630
MAN 8R	Common Cathode-orange	300	99	DL764	Common Cathode-red	1	630
MAN 8S	Common Cathode-orange	300	99	DL765	Common Cathode-red	1	630
MAN 8T	Common Cathode-orange	300	99	DL766	Common Cathode-red	1	630
MAN 8U	Common Cathode-orange	300	99	DL767	Common Cathode-red	1	630
MAN 8V	Common Cathode-orange	300	99	DL768	Common Cathode-red	1	630
MAN 8W	Common Cathode-orange	300	99	DL769	Common Cathode-red	1	630
MAN 8X	Common Cathode-orange	300	99	DL770	Common Cathode-red	1	630
MAN 8Y	Common Cathode-orange	300	99	DL771	Common Cathode-red	1	630
MAN 8Z	Common Cathode-orange	300	99	DL772	Common Cathode-red	1	630

7400

7400	39	7401	249
7402	249	7403	195
7404	39	7404	195
7408	39	7405	195
7410	39	7406	195
7414	195	7407	195
7420	39	7408	195
7428	39	7409	195
7430	39	7410	195
7432	39	7411	195
7434	39	7412	195
7436	39	7413	195
7438	39	7414	195
7440	39	7415	195
7442	39	7416	195
7444	39	7417	195
7446	39	7418	195
7448	39	7419	195
7450	39	7420	195

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CA3013	2.15	CA3008N	2.00
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CA3031	2.48	CA3006N	.85
CA3039	1.35	CA3009N	.75
CA3049N	1.30	CA3130T	1.90
CA3059N	3.25	CA3140T	1.25
CA3060N	3.25	CA3160T	1.25
CA3081N	2.00	CA3400N	1.50
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MC1429L3	2.95
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MC1429L10	2.95
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MC1429L44	2.95
MC1429L45	2.95
MC1429L46	2.95
MC1429L47	2.95
MC1429L48	2.95
MC1429L49	2.95
MC1429L50	2.95

MOTOROLA

MC1408L7	54.95
MC1408L8	5.95
MC1429L1	2.95
MC1429L2	2.95
MC1429L3	2.95
MC1429L4	2.95
MC1429L5	2.95
MC1429L6	2.95
MC1429L7	2.95
MC1429L8	2.95
MC1429L9	2.95
MC1429L10	2.95
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MC1429L29	2.95
MC1429L30	2.95
MC1429L31	2.95
MC1429L32	2.95
MC1429L33	2.95
MC1429L34	2.95
MC1429L35	2.95
MC1429L36	2.95
MC1429L37	2.95
MC1429L38	2.95
MC1429L39	2.95
MC1429L40	2.95
MC1429L41	



CALIFORNIA COMPUTER SYSTEMS

16K RAM BOARD. Fully buffered addressable in 4K blocks. IEEE standard for bank addressing 2114's PCB
\$26.95
Kit 450NSEC\$259.95
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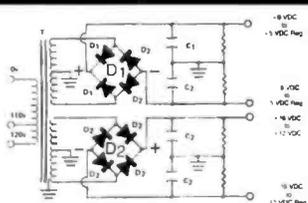
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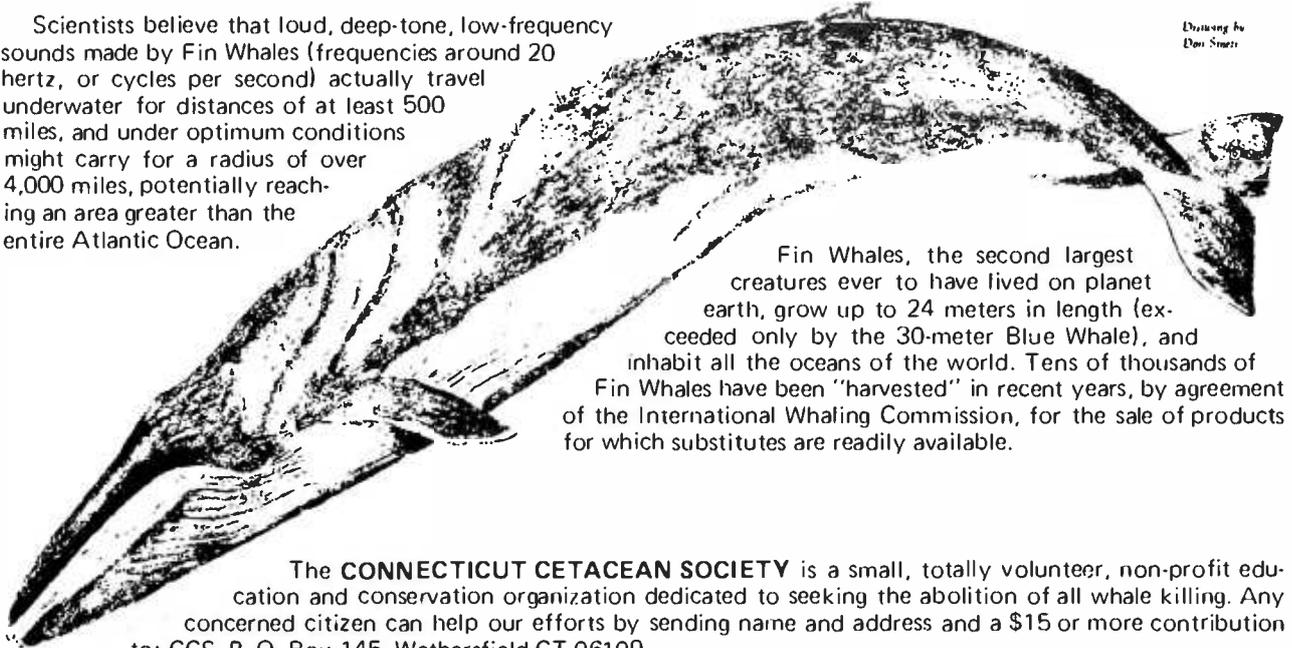
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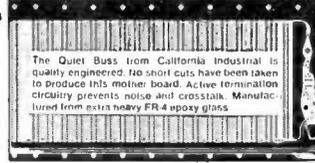
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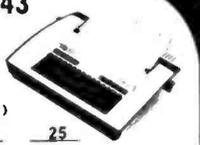
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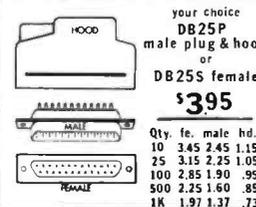
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\$449.50

\$85 KEYBOARD
ASCII ENCODED
KEYTRONIC ASCII & ASCII complement.
* Ten key data pad
* Cursor controls
* Six user switches
* Alpha Lock
* Auto repeat
* Single 5 volt.
* Glass reed.
NEW

MINIATURE SWITCHES
your choice
10 50 100 1k
\$.98 \$8.88 \$173.66
SPDT Miniature Toggles
7101 C&K ON-NONE-ON
7107 J&T ON-OFF(mnt.ON)
7108 C&K ON-(moment.ON)
Rotary J&T DPDT
Rotary 3P-4 Pos.
Rotary 3P-6 Pos.
PushB (N.O.) \$3.9ea, 4/\$1
DIP Switch
10 25 100 1k
\$1.29 \$119.09 \$7.83
specify 4 or 8 pos.

MEMORY
TRS-80 \$65
APPLE II \$65
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-systems. 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.

Regent 25
from
APPLIED DIGITAL DATA SYSTEMS

Buying a CRT Terminal?
Hazeltine • Soroc • Lear Siegler
Well if you really insist upon purchasing one of the above terminals, sure, we'll sell it to you. But when the keyboard starts to double bounce, the screen fades and the power supply just craps out don't call us, complain to the manufacturer.
The alternative, take a serious look at the ADDS Regent 25, we have, and concluded that this terminal offers, the best value in today's market. Through years of research the ADDS Company has evolved a low maintenance, extremely durable CRT terminal capable of withstanding an abusive 24 hour duty cycle. The Regent 25 features built 8085 micro-processor controlled circuitry along with the Cherry Switch long-life capacitance keyboard.
18 key cursor and numeric pad doubles to allow for user definable special functions. True descending lower case characters along with a fully addressable cursor: makes the Regent 25 the ideal word processing terminal. High-resolution screen is capable of displaying 96 upper and lower case ASCII characters and 32 control codes. This unique feature assist in the debugging of programs. The Regent 25 is switch selectable to display six European languages along with Katakana.
Clearly the Regent 25 is not your average terminal, but then, ADDS is not your average terminal company.

Wire Wrap Center
DISCOUNT
IC SOCKETS
Wire wrap low profile
pin ea. 25 50 ea. 25 50
8 17 16 15
14 37 36 35 18 17 16
16 38 37 36 19 18 17
24 99 93 85 36 35 34
40 169 155 139 63 60 58
50ft. **\$98**
KYNAR WIRE WRAP
500 1,000 11,000
\$9. \$15. \$105.
\$2995
BW 630
OK HOBBY WRAP-30 wire wrap & strip tool
\$545

STATIC	1-31	32-99	100-5C	-999	1K+
21L02 450nS.	1.19	.99	.95	.90	.83
21L02 250nS.	1.49	1.39	1.25	*	*
2114 1Kx4-150	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	9.95	9.50	9.00	*	*
4045 1Kx4-150	8.95	8.50	8.00	*	*
4045 1Kx4-250	9.95	9.50	9.00	*	*
5257 low pow.	5.95	5.50	5.00	4.80	4.60

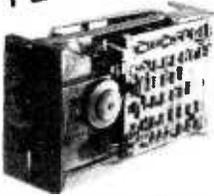
SPECIAL CIRCUITS				
Z80A 4 MHz.	24.95	AY5-1013A UART	4.95	
8080A CPU	9.95	Floppy Disc Controllers		
8085	22.50	WD 1771 single D.	39.95	
8086 Intel 16 bits	85.00	WD 1781 Double D.	65.00	
FAIS9900 16 bits	49.95	WD 1791 1/2 D 3740	*	

E PROMS	1-15	16-63	64+
1702A 2K	4.95	4.50	4.00
2708 8K	9.95	9.50	9.00
2716 5v16K	39.95	35.00	*
2716 T1	24.88	20.00	*
2532	85.00	*	*

PORTABLE DATA ENTRY SYSTEM
\$139.50
These used data terminals were originally designed for data store inventory control and order entry systems. The operator enters the inventory control number, merchandise on hand and the unit price. After all pertinent data has been entered into the recorder, the main warehouse is telephoned, the terminal is placed in the receiver's computer and all the recorded information is transmitted back to the host computer. With a built-in documentation and one of those portable entry systems, you should be able to backdate programs and computer information with associates across the country. All units were removed from service in working condition. Original cost \$2,500. Each system comes complete with:
• Portable Cassette Drive Unit
• Accurate Entry Keyboard with LED Display
• Five Gold "D" Keypads
• 4025 Cable
• Shoulder strap
• Full Documentation

(213)679-9001
All merchandise sold by California Digital is premium grade. Sorry, no COD's. Orders are shipped the same day received. California residents add 6%. Foreign orders add 10%. Orders over \$25, when accompanied by payment, are shipped at our expense. Otherwise, please add \$2.

FLOPPY SYSTEMS



8" Siemens FDD120-8
All Siemens options included in this drive may be configured hard or soft and single or double density. We find this to be an extremely reliable drive. \$399.00



5 1/4" BASF Magical Miniature Mini drive only 2/3 the size of others is reliable and durable and quickly gaining in popularity with our customers. Single or dual density fast access times \$274.00



Tarbell Controller may be re-configured to control 5 1/4" drives and includes short cable for one drive. KIT \$179.00, ASM \$265, but only \$219 with purch. of 2 drives.



Cable Kits For 8" Drives with 10' 50 cond. cable and connectors. Also power cable and connectors. Flat cable assem if you wish. For one drive 27.50, two 33.95, three 38.95

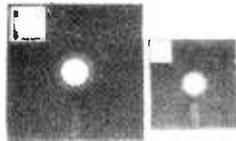
Cable Kits for 5 1/4" Drives as above, but 34 cond. For one drive 24.95, two 29.95.



"Power One" Model CP206 Power Supply adequate for at least two drives. 2.8A/24V 2.5A/5V, 0.5A/-5V beautiful quality. \$99.00

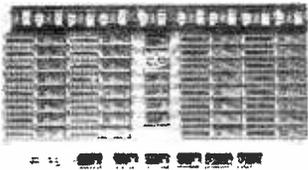


CABINETS for FDD120 and 801 R drives, or CP206 supply. Matte finish in mar resistant black epoxy paint and stacking design 29.95



DISKETTES (3M, MRX, BASF, Georgia Magnetics, & Victor Borge)
8" \$39.95/10
5 1/4" \$29.95/10

32K / 16K Static RAM, 4MHz.
(Showing Amazing Similarity to Tarbell's unit)
(16K Shown in photo)

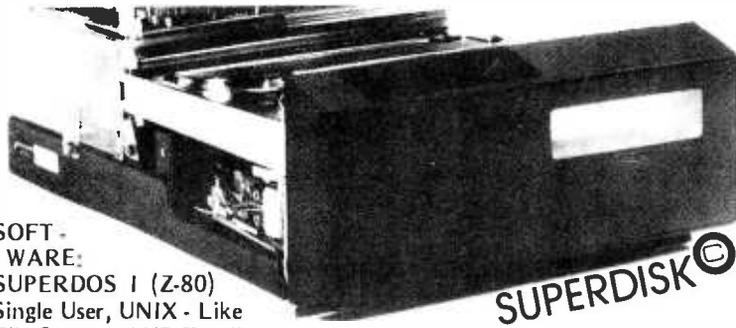


32K - \$549.00 16K - \$349.00

"BACK TO SCHOOL" KEYBOARD SPECIAL



CHERRY "PRO" Keyboard \$119.00
Streamlined Custom Enclosure \$34.95
BOTH ONLY \$124.95 !!!!!!!



10MBy DRIVE \$3300

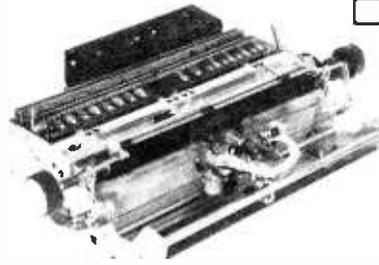
S - 100 DMA CONTROL \$495

POWER UNIT \$395.00

SOFTWARE:
SUPERDOS 1 (Z-80)
Single User, UNIX - Like File System, AND Totally Upward Compatible From "XX/X" (What did you say, Digital Research??)

PS: SUPERDOS-1 runs on the TRS-80, and can transform it from a toy computer to a real business machine !!!

For the first time in something like 10 years, a new STANDARD in removable media has evolved. Selected by Datapoint, and others who have not yet announced, this drive is beautifully simple and easy, if not trivial to maintain. 920kBy/sec. transfer rate, 3600 RPM 39 lbs and only 125 Watts.

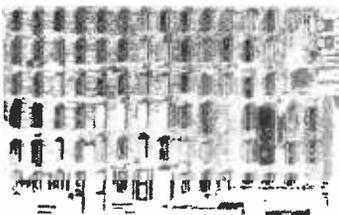


Daisy Wheel Printers Qume Sprint 3\45

PRINTER (factory warr.) \$1199.00
POWER SUPPLY (Boschert) \$349.00
(shown mounted on rear of printer)
COMBINATION SPECIAL \$1499.00

Electrolabs

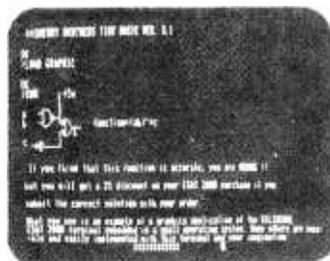
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415-321-5601 800-227-8266
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Visa MC Am. Exp.



ESAT 200B

BI-LINGUAL 80x24 COMMUNICATING TERMINAL

Scrolling, full cursor, bell, 8x8 matrix, 110 - 19,200 baud, Dual Font Applications. Arabic & Hebrew, Multilingual Data Entry Forms Drawing, Music, & Switchyards. \$349.00

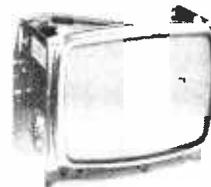


DATA DISPLAY MONITORS

Used 12" Sylvania monitors. Composite Video, 15 MHz, 120VAC. Rebuilt with NEW P39 anti-glare tube \$119.00
New P4, 109.00, used P4 79.00.



"OEM STYLE" as above, will fit any case. (Both versions serviced by qualified tech). Identical to above but subtract \$12.00



Doppler Motion Sensor Intrusion Detector

Extremely effective microwave motion detector for detecting unwanted visitors. Ignores mice and other non-larcenous creatures. Operates on 12VDC or from small transformer supplied. Output is relay closure for alarm control interface, or to switch on lights annunciators. Will operate THROUGH door of closet or thin wall. Best application seems to be to turn on outside lights to help invited guests, and to intimidate unwanted ones. \$159.00
Water Repellent Cover \$24.95



SOCKET SPECIAL

"Won't Let Go"
Low Profile
Solder Tail
1 CENT/ Pin !! (0.75/1000's)
8 14 16 18 20 22 24 28 40

A NEW System CONCEPT!!

BRAND NEW POWER!!
BRAND NEW OPERATING SYSTEM!!
UN-INTERRUPTABLE POWER CAPABILITY!!
DON'T LOSE YOUR DATA!!

FEATURING: Expandability — hardware and OS expand — up to 16 users. Double density — (it works!!!) UNIX like operating system (OS-1). Supports all CP/M utilities and programs. Time sharing capability. Turnkey software included.

BUSINESS DATA WORK SAVER®!!!

Standard features: Enclosure, 10 slot backplane, Z-80 CPU, 32K RAM, I/O and controllers, Bantam terminal, Paper Tiger Printer, OS-1, Two floppies (8" or 5 1/4"). Basic compiler with application programs for accounts payable, accounts receivable, general ledger and payroll **\$6495.00**

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MULTI-USER

UP TO EIGHT STATION WORD PROCESSING

Standard features: Enclosure, 10 slot backplane, Z-80 CPU, 48K RAM, Daisy Wheel Printer, ESAT Terminal with two fonts (Arabic, Hebrew, Cyrillic, Greek, Catakana, any custom font for \$50.00) Three floppies: (8" or 5 1/4") OS-1. Word processor package with additional memory which is expandable up to eight users (each extra terminal \$900.00) **\$8695.00**

ELECTROLABS

POB 6721 Stanford, CA 94305
 415-321-5601 800-227-8266
 Telex: 345567 (Electrolab Pla)

OPTIONS: 10 MBy hard disk (available now!!!) Extra memory, graphics, etc. Call or write for further details. This is the most advanced microcomputer system available at this time.

CP/M* Source Code -- FREE! when you purchase "OS-1"

Electrolabs' new operating system for the Z-80 designed to have exactly the appearance of UNIX**, including virtual I/O, "set TTY", a tree and a shell, filters and pipes PLUS total compatability with CP/M software!

OS-1[®] FEATURES

(Because OS-1 is truly a comprehensive "OS", and not merely a file handling "DOS", we have changed the name from "Superdos" to "OS-1")

VIRTUAL I/O - copy with a single command between floppy and hard disk, or from TTY to printer to tape to disk... etc., etc.

No messy I/O routines to write, & no awkward transfers.

SECURITY - 9 modes of file protection, user and login protection.

MULTI-USER - up to 256 passwords. (non-simultaneous users)

16MBy FILE SIZE - but no limit to no. of directories per device, thus allowing EASY implementation of gigantic storage devices.

"SET TTY" - for printer or crt: tabs, page width, buffer, cursor, UC/LC, fonts, formfeed, arbitrary control characters etc., etc.

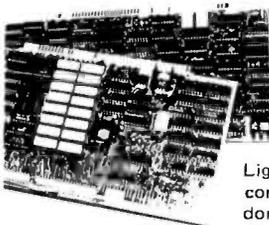
"LOGIN" - automatically executes user selected programs and "set TTY".

OCCUPIES 12KBy - only 50% larger than CP/M, but 500% more features.

CP/M & CDOS COMPATABLE - your library is guaranteed to run!

* (Naturally, we are not giving away the version of CP/M written by Digital Research, Please pardon our pun, but they might object. What we ARE giving you is a greatly enhanced version of CP/M which resides on OS-1, and allows the user of OS-1 to run any and all of his programs, packages or system utilities which are already running on CP/M. We give you the source code at no charge so that you may modify any part of the CP/M to suit your own system requirements. At no charge, you also receive the enhancement allowing 4MBy files instead of 256K.)

OS-1 (with debugger, linker and screen oriented editor)	\$199.00
Update service, per year	29.00
Symbolic Debugger	150.00
MACRO-Assembler (Creates relocatable code)	150.00
"C" Compiler	660.00
FORTRAN Compiler	100.00
BASIC Compiler (very fast)	150.00



Graphics

High Resolution 480 x 512
 for B&W and Color Imaging and Graphics

Light pen, A-D, D-A, TV synchro (needs no time base correction or adjustment with anything between random interface & NTSC commercial standard), T.V. single frame grabber ("snapshot"). Up to 1 Byte of attributions per pixel.

LSI-100 & S-100 applied to:

Graphic Presentation — such as computer generated animation & other graphic displays up to 256 colors & up to 256 b&w gray scales. **Image Analysis** — using built-in FRAME GRABBER, for medical image enhancement, contour analysis, & pattern recognition. **Commercial TV Tilting & Advertising** — using synchronization capability. **Interactive graphics** — using light pen accessory.

BASIC CONFIGURATION —

LSI-11 \$1995. S-100 \$1265.
 For TRS-80/Exidy Add \$595.00
 Includes: Data Board - 32K (480 x 512 x 1 pixel) D-A 16 level video generator. Video Synchronization Circuitry. Address Control & Timing Board.

FEATURES — High speed. DMA or 2KBy window memory mapped interface. Full NTSC commercial color capability. Low power consumption. Excellent Software
Options — Accessories — Software
 Options include: light pen, auxilliary outputs, text mode, memory and much more. Accessories include: b&w and color cameras and monitors. Software: "Plot" 2D or 3D, "Tilting", "Contour", "Image Enhancement", "Vector Curve Generation".

Call for price and details

*CPM and **UNIX

trademarks of Digital Research and Western Electric respectively.

Circle 115 on inquiry card.

Electrolab's System Switcher Model SP04



\$349.00

Tames

RAW POWER

for the

LSI-11/23 ★

And Hard Disks

FEATURES:

- * Brown-Out Proof
- Line Frequency Indifferent
- Very Low EMI
- U.L. Approved
- 20 KHz
- High Efficiency
- Soft Start
- Extremely Lightweight
- Open Frame Design
- Short Circuit and
- OV Protection
- 20,000 Hour MTBF (MIL 217B)
- Adaptable to Un-Interruptable Power applications.
- and
- Low Cost!! (just look at DEC's price)



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... a personal colorgraphics system for the modern computer man ...

- ★ Color Graphics 13" Color CRT
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- ★ 16K Extended Disk Basic
- ★ Up to 117* Key Keyboard
- ★ Up to 32K* RAM
- ★ Minidisk Drive 51.2K Bytes/Side



*option

Model 3 w/8K, 72 Key Keyboard, RS232	SALE TAKE	\$1495.00
Model 4 w/16K, 72 Key Keyboard, RS232	\$100.00 OFF	\$1695.00
Model 5 w/32K, 72 Key Keyboard, RS232		\$1995.00
Options: 101 Key Keyboard	Add	\$150.00
117 Key Keyboard	Add	\$225.00
Formatted Diskettes	2/\$	19.95
Programmed Diskettes		\$19.95
Diskette Library Inc. Hangman, Othello, Math, Chess, Startrek, Blackjack, Cubic Tic Tac Toe, Finance Vol. I, Finance Vol. II, Bonds and Securities, Assembler, Text Editor, Personal Data Base.		

EXIDY SORCERER ONLY \$799.00



\$799 w/8K
\$1099 w/16K
\$1249 w/32K
\$1449 w/48K

User programmable or use cartridges. Combines the desirable features of the PET, APPLE and TRS-80 into a complete expandable computer system.
★ I/O expansion kit \$149.00
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- ★ INCLUDES:
Keyboard & enclosure
90 day Warranty
MICROSOFT BASIC
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KIM-1 Now only \$179.00



- ★★ Power Supply Add \$59.95
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SYM-1 IN STOCK

Reg. \$269.00

Now \$249.00

- ★ KIM-1 Compatible
 - ★ 4K ROM Monitor
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- School & group discounts available.
Buy now and receive \$100.00 worth of discount coupons: i.e.,
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AIM 65



\$375.00

- ADVANCED INTERACTIVE MICROCOMPUTER
- ★ On Board 20 column alphanumeric printer
 - ★ Alphanumeric 20 character display
 - ★ Terminal style Keyboard 54 Keys
 - ★ 6502 based CPU
 - w/1K RAM \$375.00*
 - w/4K RAM \$450.00*
 - Assembler ROM Add \$85.00
 - BASIC IN ROM Add \$100.00
 - Power Supply Add \$99.95
 - Enclosure Add \$44.95

RCA COSMAC VIP



NEW LOW PRICE \$249.00

- Assembled. Regular price \$299.95
w/Sanyo 9" Monitor \$169.95
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 - VP-595 Sound Board 49.95
 - VP-570 4K Expansion Board 95.95
 - VP-580 Expansion Keyboard 15.95
 - VP-700 Tiny Basic ROM 49.95
 - VP-710 VIP Game Manual 10.95

COMMODORE "PET"

Delivery from stock
Advanced 8K Model
only \$775.00



LOW LOW APPLE II PLUS \$990.00

APPLE's new upgraded APPLE II w/16K is now in stock and available for the lowest price ever, only \$990.00. You can add:
★★ M & R Modulator for \$29.95
★★ Sanyo tape recorder for \$44.95
★★ 16K upgrade kit for only \$74.95 ea.
This is a limited offer and we reserve the right to change without notice.

NORTH STAR HORIZON ★DOUBLE DENSITY★

Now in stock North Star Z-80-based high-performance computer.

- ★ 180K Bytes per Disk
- ★ Z-80 Processor
- ★ Motherboard
- ★ 2 Serial + 1 Parallel Port Avail.
- ★ 32 K RAM

Horizon I Kit

Sale \$1849.00



North Star Double Density Disk Subsystem Kit

PROCESSOR TECHNOLOGY SALE SOL-20 DEALERS & USERS INVITED!

We purchased Processor Technology's entire inventory of spare parts, work in process, and finished goods. This material will be sold on a first come first served basis. Advanced will continue to support some SOL products on a limited basis so make sure you get a copy of our complete inventory listing and a place on our SOL mailing list.

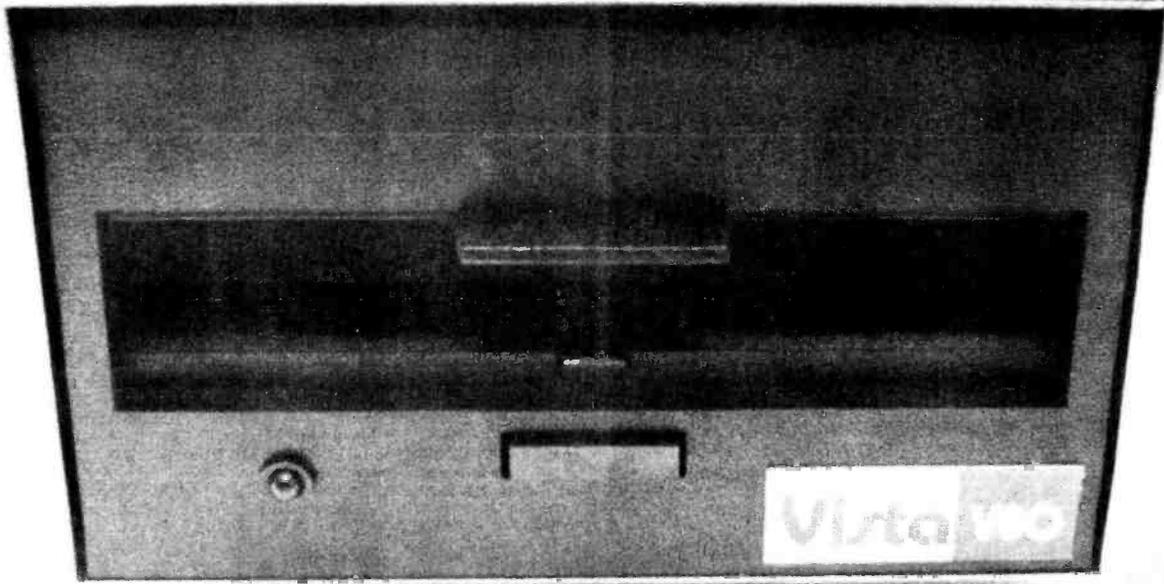
- ★ New SOL-20 w/o Memory \$1095.00
- ★ SOL-20 Keyboards \$139.95
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- ★ NKRA Memory Boards up to 64K \$CALL

Plus more endless PTI bargains send for details.

HERE ARE SOME EXAMPLES

WE TAKE B/A, VISA, AM. EXP. • ADD 2.5% HANDLING & POSTAGE • PRICES SUBJECT TO CHANGE W/O NOTICE

Widen the ability of your TRS-80



The Vista V80: \$395

The Vista V80 Mini Disk System is the perfect way to widen the capabilities of your TRS-80* Micro-computer. Quickly and inexpensively. Our \$395 price tag is about \$100 less than the Radio Shack equivalent. Our delivery time is immediate (24 hour turn-around from our Santa Ana, Ca. factory). And our system is fully interchangeable. That's just the start.

It will give you 23% more storage capacity by increasing useable storage from 55,000 to 65,000 bytes per drive with our new software patch.

It can work 8 times faster than the TRS-80 Mini-Disk system, because track-to-track access is 5ms versus 40ms for the TRS-80. You can realize this added speed

once the new double disk expansion interface is available without expensive modification of the existing unit.

It has a better warranty than any comparable unit warranty available – a full 120 days on all parts and service. When you consider how much more goes into the Vista V80, that shows a lot of faith in our product.

A full 3 amp power supply means you have 2½ times the power necessary to operate the V80, and full ventilation insures that there will be no problems due to overheating.

The Vista V80 Mini Disk System requires Level II Basic with 16K RAM Expansion interface (it operates from the Radio Shack interface system. It

comes complete with a dependable MPI Minifloppy disk drive, power supply, regulator board and vented case. It's shipped to you ready to run – simply take it out of the box and plug it in. You're in business. From the company that means business – Vista Computer Company.



The Vista Computer Company.
Manufacturers of Quality
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and Software.

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1401 Borchard
Santa Ana, Ca. 92705



ATTENTION ELF OWNERS ANNOUNCING QUEST SUPER BASIC

At last a Full Size Basic for 1802 systems. A complete function Basic including two dimensional arrays, string variables, floating point, arithmetic and 32 bit signed integer arithmetic (10 digit accuracy) with I/O routines. Easily adaptable to most 1802 systems. Requires 12K RAM minimum for Basic and user programs. Cassette version in stock now. ROM versions coming soon with exchange privilege allowing some credit for cassette version.

Super Basic on Cassette **\$40.00**

RCA Cosmac Super Elf Computer \$106.95

Compare features before you decide to buy any other computer. There is no other computer on the market today that has all the desirable benefits of the Super Elf for so little money. The Super Elf is a small single board computer that does many big things. It is an excellent computer for training and for learning programming with its machine language and yet it is easily expanded with additional memory, Full Basic, ASCII Keyboards, video character generation, etc.

Before you buy another small computer, see if it includes the following features: ROM monitor; State and Mode displays; Single step; Optional address displays; Power Supply; Audio Amplifier and Speaker; Fully socketed for all IC's; Real cost of in warranty repairs; Full documentation.

The Super Elf includes a ROM monitor for program loading, editing and execution with SINGLE STEP for program debugging which is not included in others at the same price. With SINGLE STEP you can see the microprocessor chip operating with the unique Quest address and data bus displays before, during and after executing instructions. Also, CPU mode and instruction cycle are decoded and displayed on 8 LED indicators.

An RCA 1861 video graphics chip allows you to connect to your own TV with an inexpensive video modulator to do graphics and games. There is a speaker system included for writing your own music or using many music programs already written. The speaker amplifier may also be used to drive relays for control purposes.

Super Expansion Board with Cassette Interface \$89.95

This is truly an astounding value! This board has been designed to allow you to decide how you want it optioned. The Super Expansion Board comes with 4K of low power RAM fully addressable anywhere in 64K with built-in memory protect and a cassette interface. Provisions have been made for all other options on the same board and it fits neatly into the hardware cabinet alongside the Super Elf. The board includes slots for up to 6K of EPROM (2708, 2758, 2716 or TL 2716) and is fully socketed. EPROM can be used for the monitor and Tiny Basic or other purposes.

A 1K Super ROM Monitor \$19.95 is available as an on board option in 2708 EPROM which has been preprogrammed with a program loader/editor and error checking multi file cassette read/write software. (relocatable cassette file) another exclusive from Quest. It includes register save and readout, block move capability and video graphics driver with blinking cursor. Break points can be used with the register save feature to isolate program bugs quickly, then follow with single step. The Super Monitor is written with subroutines allowing users to take advantage of

Tiny Basic Source now available **\$19.00**
S-100 Slot Expansion. Add 3 more S-100 slots to your Super Expansion Board or use as a 4 slot S-100 Mother Board. Without connectors **\$9.95.**

Coming Soon: Assembler and Editor; Elf II Adapter Board. High resolution alpha/numeric with color graphics expandable up to 256 x 192 resolution for less than \$100. Economical versions for other popular 1802 systems also.

16K Dynamic RAM board expandable to 32K for less than \$150.

A 24 key HEX keyboard includes 16 HEX keys plus load, reset, run, wait, Input, memory protect, monitor select and single step. Large, on board displays provide output and optional high and low address. There is a 44 pin standard connector slot for PC cards and a 50 pin connector slot for the Quest Super Expansion Board. Power supply and sockets for all IC's are included in the price plus a detailed 127 pg. instruction manual which now includes over 40 pgs. of software info. including a series of lessons to help get you started and a music program and graphics target game.

Many schools and universities are using the Super Elf as a course of study. OEM's use it for training and research and development.

Remember, other computers only offer Super Elf features at additional cost or not at all. Compare before you buy. Super Elf Kit \$106.95. High address option \$8.95. Low address option \$9.95. Custom Cabinet with drilled and labelled plexiglass front panel \$24.95. Expansion Cabinet with room for 4 S-100 boards \$41.00. Nicad Battery Memory Saver Kit \$6.95. All kits and options also completely assembled and tested.

Questdata, a 12 page monthly software publication for 1802 computer users is available by subscription for \$12.00 per year.

Tiny Basic Cassette \$10.00, ROM \$38.00, original Elf kit board \$14.95. 1802 software; Mowes Video Graphics \$3.50. Games and Music \$3.00, Chip 8 Interpreter \$5.50.

monitor functions simply by calling them up. Improvements and revisions are easily done with the monitor. If you have the Super Expansion Board and Super Monitor the monitor is up and running at the push of a button.

Other on board options include Parallel Input and Output Ports with full handshake. They allow easy connection of an ASCII keyboard to the input port. RS 232 and 20 ma Current Loop for teletype or other device are on board and if you need more memory there are two S-100 slots for static RAM or video boards. A Godbout 8K RAM board is available for \$135.00. Also a K Super Monitor version 2 with video driver for full capability display with Tiny Basic and a video interface board. Parallel I/O Ports \$9.85, RS 232 \$4.50, TTY 20 ma I/F \$1.95, S-100 \$4.50. A 50 pin connector set with ribbon cable is available at \$12.50 for easy connection between the Super Elf and the Super Expansion Board.

The Power Supply Kit for the Super Expansion Board is a 5 amp supply with multiple positive and negative voltages \$29.95. Add \$4.00 for shipping. Prepunched frame \$7.50. Case \$10.00. Add \$1.50 for shipping.

Multi-volt Computer Power Supply
8v 5 amp, ±18v .5 amp, 5v 1.5 amp, ±5v .5 amp, 12v .5 amp, -12 option. ±5v, ±12v are regulated. Kit \$29.95. Kit with punched frame \$37.45. Woodgrain case \$10.00.

60 Hz Crystal Time Base Kit \$4.40
Converts digital clocks from AC line frequency to crystal time base. Outstanding accuracy. Kit includes: PC board, IC, crystal, resistors, capacitors and trimmer.

TERMS: \$5.00 min. order U.S. Funds. Calif residents add 6% tax. BankAmericard and Master Charge accepted. Shipping charges will be added on charge cards.

Same day shipment. First line parts only. Quality tested. Guaranteed money back. Factory IC's and other components at factory prices.

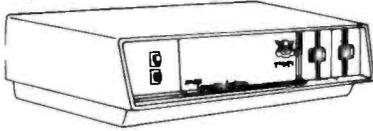
INTERGATED CIRCUITS

74001TL	UJ318	1.35	CD4020	1.02				
74002	LM320K-5	1.50	CD4021	1.02				
74004	LM320K-5	6.95	CD4022	.86	21102-1	1.18		
74006	LM320K-15	1.50	CD4023	.86	21102-2	1.25		
74010	LM320T-5	1.60	CD4024	.75	21102-4	4.95		
74141	LM320T-8	1.60	CD4025	.28	21102-4	4.95		
74201	LM320T-12	1.50	CD4026	.91	21102-4	4.95		
74201L	LM320T-12	1.50	CD4027	.36	2111-1	3.75	NB25126	3.75
74201N	LM320T-15	1.80	CD4028	.28	2111-2	3.75	NB25129	3.75
74330	LM320M	1.15	CD4029	1.02	2112-1	7.40	NB25136	8.75
74401	LM339	1.55	CD4030	.28	2114-3	7.90	NB25137	8.75
7415N	LM340M-5	1.35	CD4031	1.02	2116-1	10.90	DM537	9.25
7447N	LM340M-8	1.35	CD4040	1.02	2313B	6.90	8223	2.90
7448A	LM340K-12	1.35	CD4042	.71	23525	2.90		
7450N	LM340K-15	1.35	CD4043	.63	MM5280	3.00	CONNECTORS	
74780	LM340K-24	1.35	CD4044	.83	MM5320	9.95	30 pin edge	2.50
7479I	LM340T-5	1.25	CD4046	1.67	MM5350	4.91	44 pin edge	2.75
7480A	LM340T-8	1.25	CD4047	1.47	PD410C-3	4.00	100 pin edge	1.60
7489N	LM340T-12	1.25	CD4050	.36	PD4110-3	5.00	100 pin edge WW	5.25
7490I	LM340T-15	1.25	CD4051	1.13	21101L	13.25		
74921A	LM340T-15	1.25	CD4060	1.47	4200A	9.95		
7493N	LM340T-24	1.25	CD4066	.71	82525	2.90		
7495K	LM343A	4.50	CD4068	.40	MM5280	3.00	IC SOCKETS	
74900M	LM345	7.50	CD4069	.40	MM5314	3.30	Socket Low Profile	
74970	LM370	1.15	CD4070	.28	MM5314A	3.30	PIN 1 UP	
74121N	LM377	3.00	CD4072	.28	MM5314B	3.30	PIN 1 UP	
74129N	LM377M	3.00	CD4073	.28	MM5314C	3.30	PIN 1 UP	
74125A	LM380N	1.00	CD4074	.28	MM5314D	3.30	PIN 1 UP	
74145N	LM381	1.60	CD4075	.28	MM5314E	3.30	PIN 1 UP	
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74151N	LM370H	4.00	CD4080	.40	MM5314I	3.30	PIN 1 UP	
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74151N	LM370H	4.00	CD4109	.40	MM5314AL	3.30	PIN 1 UP	
74151N	LM370H	4.00	CD4110	.40	MM5314AM	3.30	PIN 1 UP	

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74151N	LM370H	4.00	CD4157	.40	MM5314CH	3.30	PIN 1 UP	
74151N	LM370H	4.00	CD4158	.40	MM5314CI	3.30	PIN 1 UP	
74151N	LM370H	4.00	CD4159	.40	MM5314CJ	3.30	PIN 1 UP	
74151N								

JADE Computer Products

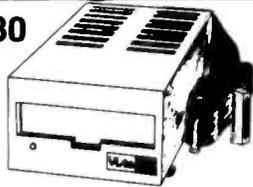
JADE'S NEW MAINFRAME THE PIGGY IS HERE!



This sleek new mainframe is beautifully designed around JADE'S six slot ISO-BUS motherboard and an 18 amp power supply with provisions for up to 3 mini-floppy drives. This is a practical, state-of-the-art design whose looks just can't be beat!
ENS-106320 (without drives) \$475.00

VISTA V80

TRS-80
MINI-DISK
SYSTEM



The V80 out-performs standard Radio Shack drives! ~23% more storage capacity, 8 times faster access time, more reliable, and much less expensive. Includes disk drive, power supply, regulator board, and case. **MSM-358000 \$395.00**
 Interface cable for V80 **WCA-3421 \$24.95**

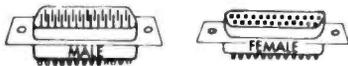
DISKETTE SPECIAL

5.25" SOFT, 10, OR 16 SECTOR
10 for \$29.95

8" SOFT SECTOR IBM COMPATIBLE
10 for \$34.95

S-100 CONNECTOR SALE

100 PIN IMSAI TYPE SOLDER-TAIL CONNECTOR
6 for \$17.50 12 for \$29.95



RS-232 SET SPECIAL \$6.50

DB-25S, DB-25P, DB-25 COVER

DB-25S (FEMALE) \$3.65
 DB-25P (MALE) \$3.15
 DB-25C (COVER) \$1.50

SPST DIP SWITCHES



PART NUMBER	NUMBER OF SWITCHES	PRICE
SWD-103	3	\$1.18
SWD-104	4	\$1.20
SWD-105	5	\$1.24
SWD-106	6	\$1.28
SWD-107	7	\$1.30
SWD-108	8	\$1.34
SWD-109	9	\$1.36
SWD-110	10	\$1.38

TEXT TOOL ZIP* DIP II SOCKETS



16 PIN ZIP* DIP II \$5.50
 24 PIN ZIP* DIP II \$7.50
 40 PIN ZIP* DIP II \$10.25

* ZERO INSERTION PRESSURE

JADE'S NEW INTELLIGENT CONTROLLER THE DOUBLE-D

Read/write in single or double density.
 8" or 5 1/4" drives.
 CP/M compatible in either single or double density.
 On-board Z-80 CPU allows universal compatibility.
 Programmed data transfer. No DMA.
 Controls up to 8 drives.
 Software selectable density.
 Our new controller utilizes the IBM standard formats for proven reliability. Data recovery is enhanced through the use of a phase-locked-loop data separation circuit and write precompensation. Single and double density disk drives can be mixed in the same system.
KIT \$285.00
ASSEMBLED & TESTED \$349.00
BARE BOARD with MANUAL \$55.00
MANUAL \$10.00

SD SYSTEMS VERSA-FLOPPY

KIT \$159.95
ASSEMBLED & TESTED \$239.00

TARBELL FLOPPY DISK INTERFACE

JADE KIT \$190.00
ASSEMBLED & TESTED \$260.00

FLOPPY DISK SPECIAL

TWO SIEMENS 8" DISK DRIVES
 JADE DOUBLE-D CONTROLLER KIT
 POWER SUPPLY FOR DRIVES
 CP/M OPERATING SYSTEM W/BASIC-E
 BOX OF 10 DOUBLE DENSITY DISKS
 INTERFACE CABLES---A \$1594.95 VALUE.
JADE SPECIAL \$1225.00

FLOPPY DISK DRIVES

NEW BASF MINI-FLOPPY \$319.95
 Shugart SA400 compatible but only two-thirds the size! 40 track, double density 5 1/4" drive. Very low power consumption!

MPI B51 5 1/4" DRIVE \$295.00
 Single or double density, up to 40 tracks, track-to-track access time of 5ms. Shugart SA400 compatible.

MPI B52 5 1/4" DRIVE \$450.00
 Double-sided version of MPI B51.

SHUGART SA400 5 1/4" DRIVE \$325.00
 Single density, 35 track.

SIEMENS FDD100-8 8" DRIVE \$495.00
 Certified double density Shugart 801R replacement. Runs much cooler and quieter.

SIEMENS FDD200-8 8" DRIVE \$575.00
 Double-sided, double density version of FDD100-8.

SHUGART 801R 8" DRIVE \$575.00
 Hard or soft sectored, 400K byte drive.

PERSCI 277 DOUBLE 8" DRIVE \$1595.00
 Limited quantity with slim line case & power supply.

POWER SUPPLIES

For a single 5 1/4" disk drive.
PSD-249A \$52.00

For a single 8" disk drive.
PSD-205A \$89.95

For two 8" disk drives
PSD-206A \$125.00

For Rockwell AIM-65
PSX-030A \$59.95

For KIM-1 or SYM-1
PSX-020A \$59.95

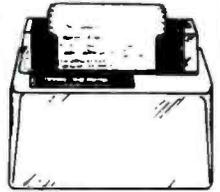
CP/M 2.0

Digital Research has done it again! This new release of their industry standard disk operating system is bound to be an even bigger hit than the original version. All of the fundamental file-size restrictions of release 1 have been eliminated, while maintaining full compatibility with the earlier versions. This new release can be field-configured by the user for a single mini-disk up through a multiple drive hard-disk system with 128 megabyte capacity. Field configuration can be accomplished easily through use of the Macro Library (DISKDEF) provided with CP/M 2.0.

A powerful operating system for only \$150.00

INTEGRAL DATA SYSTEMS MODEL 440 PRINTER THE PAPER TIGER

Up to 198 CPS
 1.75 to 9.5 inch adjustable tractor feed.
 Parallel and serial interface.
 98 character ASCII set
 132 columns- 6 or 8 lines/inch
 Eight software selectable character sizes
 110, 300, 600, 1200 baud.



PRM-33440 \$995.00
 For the Graphics Option with 2K Buffer add \$199.00

JADE JP80-T PRINTER HARD COPY.....EASY PRICE!

JADE is proud to announce the low-cost solution to your hard copy needs. The JADE JP80-T printer is a high quality 80 column dot matrix printer with an adjustable width tractor feed mechanism. We are certain that you can not get a better printer in this price range!

FAST-150 cps print speed, 80 columns per line.
VERSATILE-adjustable tractor feed 2" to 10".
Upper and lower case 96 character ASCII set.
5 X 7 dot matrix with software selectable character widths.
Centronics-type parallel interface.
Interface/cables available for most popular microcomputers.
PRM-27081 \$749.95

CENTRONICS 730 PRINTER THE ANY-PAPER PRINTER

This printer can use roll paper, fanfold paper, or single sheets because it is equipped with both friction feed and pin feed mechanisms.

RS232 or parallel interface.
96 ASCII character set, upper and lower case.
80 characters per line, 7 X 7 dot matrix.
50 cps print speed.
Weights less than 10 pounds!
PRM-15730 \$950.00

EXIDY SORCERER

FREE 12 INCH B & W MONITOR WITH EVERY 16K SORCERER

Flexibility is the key. The Sorcerer Computer gives you the flexibility of using ready-to-run, pre-packaged programs or doing your own thing and personalizing the programs for yourself. Whichever you choose, The Sorcerer is the personal computer that speaks your language.

The Sorcerer also provides full graphics capabilities. Each character formed by an 8 x 8 dot cell, can be programmed as a graphic symbol set. High resolution (512 x 240 addressable points) gives a total of 122,880 locations for super animation and extremely light plotting curves. The alphanumeric set gives 64 x 30 characters on the video screen.
With 16K of memory \$1150.00

LEEDEX MONITOR \$139.00

- 12" Black and White
- 12 MHZ Bandwidth
- Handsome Plastic Case

JADE DISK CABLES

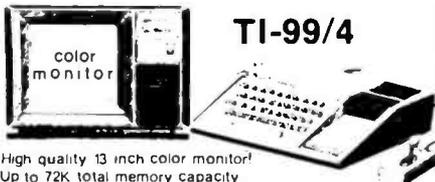
MINI-DISK CABLE KIT--Connects two 5 1/4" mini-floppies to your disk controller board and power supply. Includes 5' signal cable with three 34 pin edge connectors, plus power supply connectors and cables. WCA-3431K \$34.95

SIGNAL CABLE ONLY--Connects one 5 1/4" drive to edge type controller card. WCA-3421A \$24.95
For two 5 1/4" drives. WCA-3431A \$29.95

8" DISK CABLE KIT--Connects two 8" disk drives to edge type controller card such as the Versafloppy and Double D. Includes 5' signal cable with three 50 pin edge connectors, plus power supply cables and connectors. WCA-5031K \$38.45

8" DISK CABLE KIT--Same as WCA-5031K except controller end of signal cable has a pin type connector such as the Tarbell controller. WCA-5032K \$38.95

TEXAS INSTRUMENTS



TI-99/4

High quality 13 inch color monitor!
Up to 72K total memory capacity
16-color graphics capability - easy to access high resolution graphics have special features that let you define your own characters, charts, graphs, etc.
Music and sound effects - build three-note chords and adjust frequency, duration and volume quickly and simply. Five full octaves Built-in equation calculator—Unique convenience feature helps you find quick solutions to everyday math problems, as well as complex scientific calculations
Programs are sealed securely in SOLID STATE SOFTWARE COMMAND MODULES. These ROM pack actually add memory to the TI-99/4 so that the console's memory can be utilized for user input. **SYO-8994A** **\$1150.00**

SD SYSTEMS Z-80 STARTER KIT

Based on the powerful Z-80 CPU, this kit is an ideal introduction to microprocessors. It has an on-board keyboard and display, plus cassette tape interface and expansion provisions for two S-100 connectors. This "Do-it-all-Board" will also program the 2716 2K KII **\$249.95**
Assembled and tested **\$439.00**

SD SYSTEMS SBC-100

An S-100 single board computer. Z-80 CPU with 1024 bytes of RAM. 8-32K bytes of PROM. Serial I/O port **\$239.95**
Assembled **\$369.95**

Solid State Music I/O 4

2 Serial and 2 Parallel I/O
Ports S-100 with full hand shaking
JADE KII **\$149.95**
Assembled **\$199.95**
Bare Board **\$29.95**

PARALLEL/SERIAL INTERFACE

S-100 compatible. 2 serial I/O ports. 1 parallel I/O
KII **\$124.95**
Assembled & Tested **\$179.95**
Bare Board W/ Manual **\$30.00**

PROTO BOARD

Includes gold plated fingers. S-100 size. holds 72-16 pin dips. accommodates all 8 thru 40 pin dip packages. Reg. 19 95
TSXA-140B **\$16.95**

SYM-1

6502-Based single board computer with keyboard display. KIM-1 hardware compatible. Complete documentation
SYM-1 CPK-5002A **\$245.00**
SYM-1 CASE, ENX-000005 **\$39.95**

JADE'S NEW MOTHERBOARDS THE ISO-BUS

The only motherboard available today that is designed to IEEE S-100 Bus Standards—a unique network theory of design in which each signal line is surrounded by current mirrored ground lines, significantly reducing RF radiation virtually eliminating crosstalk. No need for active termination. The perfect foundation for a 4MHz system.

6-SLOT

BARE BOARD **\$24.95**
KIT **\$49.95**
ASSEMBLED & TESTED **\$59.95**

12-SLOT

BARE BOARD **\$39.95**
KIT **\$89.95**
ASSEMBLED & TESTED **\$99.95**

18-SLOT

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Everything you need to add 16K of memory to your computer. Your kit comes neatly packaged with easy to follow instructions. In just minutes your computer is ready to tackle more advanced software.

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THE BIG Z

THE NEW Z-80 CPU BOARD FROM JADE

Features include: ● S-100 Compatible available in 2MHz or 4MHz versions ● On-board 2708, 2716, or 2532 EPROM can be addressed on any 1K, 2K or 4K boundary with power-on jump to EPROM ● On-board EPROM may be used in SHADOW mode, allowing full 64K RAM to be used ● Automatic MWRITE generation in front panel is not used ● On-board USART for synchronous or asynchronous R232 operation (on-board baud rate generator) ● Reverse channel capability on USART allows use with buffered peripherals or devices with not-ready signal

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Expandable to 32K or 64K

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Uses 4115 (8K X 1, 250ns) Dynamic RAMs. Can be expanded in 8K increments up to 32K

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An 80 by 24 I/O mapped video board for S-100 systems. An on-board Z-80 processor is used to control all functions. A total of 256 user-programmable characters are available, including 128 characters that are supplied with the board. This is virtually a stand-alone terminal!
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DE 9S	9 Pin Female	1.50 1.30 1.20
DE 9C	9 Pin Cover	2.15 2.05 1.95
DA15P	15 Pin Male	1.50 1.30 1.15
DA15S	15 Pin Female	2.20 2.00 1.80
DA15C	15 Pin Cover	3.20 3.00 2.80
DB-25P	25 Pin Male	1.60 1.45 1.30
DB-25S	25 Pin Female	2.90 2.65 2.50
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DB1226-1A	2 pc. Black Hood	1.85 1.40 1.20
DB110963-3	2 pc. Grey Hood	1.90 1.80 1.50
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DC37S	37 Pin Female	5.75 5.50 5.20
DC37C	37 Pin Cover	2.20 1.95 1.75
DD50P	50 Pin Male	1.80 1.55 1.35
DD50S	50 Pin Female	2.50 2.20 1.90
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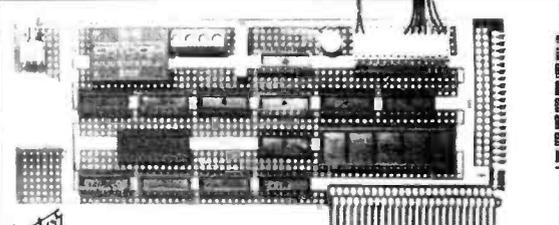
CG 1MSAI Style Card Guides 5/8" 0d

3 LEVEL GOLD WIRE WRAP SOCKETS

Sockets purchased in multiples of 50 per type may be combined for best price

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14 pin	39	38	36	34	32
16 pin	50	42	40	36	34
18 pin	70	60	55	50	45
20 pin	90	80	75	65	62
22 pin	95	85	80	70	65
24 pin	95	85	80	70	65
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All sockets are GOLD 3 level closed entry 2 level Tail. Low Profile. Tin Sockets and Dip Plugs available. CALL FOR QUOTATION.



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Add \$3.00 for programming Jumpers for TRS-80 Keyboard

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\$395⁰⁰



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The Vista V80 Mini-Disk System is the perfect way to widen the capabilities of your TRS-80[®] Micro-computer. Quickly and inexpensively. Our \$395 price tag is about \$100 less than the Radio Shack equivalent. Our delivery time is immediate. And our system is fully interchangeable. That's just the start.

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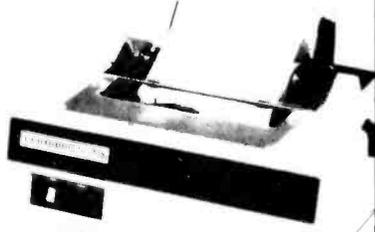
The Vista V80 Mini-Disk System requires Level II Basic with 16K RAM Expansion interface (It operates from the Radio Shack interface system. It comes complete with a dependable MPI Minifloppy disk drive, power supply, regulator board and vented case. It's shipped to you ready to run - simply take it out of the box and plug it in. You're in business. From the company that means business - Vista Computer Company.

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- Use with TRS-80
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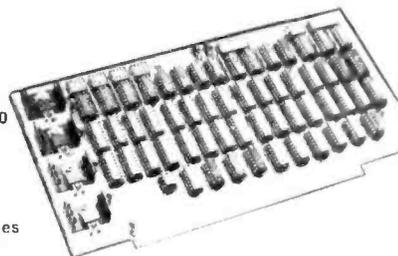
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FEATURES:

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- Uses popular 2114 static RAMS
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- Bank Select available by bank port and bank byte
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- Addressable in 4K blocks
- 4K blocks can be addressed anywhere within 64K in 4k increments
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DON'T SETTLE FOR ANYTHING LESS THAN SCOTCH

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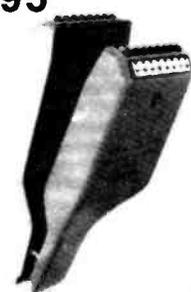
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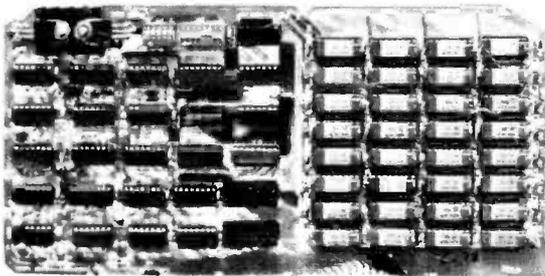
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The EXPANDORAM is available in versions from 16K up to 64K, so for a minimum investment you can have a memory system that will grow with your needs. This is a dynamic memory with the invisible on-board refresh, and IT WORKS!

- Interfaces with Altair, IMSAI, SOL-8, Cromenco, SBC-100, and others.
- Bank Selectable
- Phantom
- Power BVDC, ± 16VDC, 5 Watts
- Lowest Cost Per Bit
- Uses Popular 4116 RAMS
- PC Board is doubled solder masked and has silk-screen parts layout.

SD EXPANDORAM

The Ultimate S-100 Memory

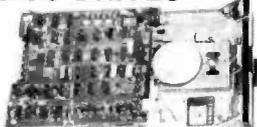


- Extensive documentation clearly written
- Complete Kit includes all Sockets for 64K
- Memory access time: 375ns, Cycle time: 500ns.
- No wait states required.
- 16K boundaries and Protection via Dip Switches
- Designed to work with Z-80, 8080, 8085 CPU's.

EXPANDO 64 KIT (4116)

	SALE PRICE
16K	\$219
32K	\$285
48K	\$350
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SHUGART SA 400

with attractive metal case with cutouts for Data Cable switch, fuse and power cord
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SHUGART SA400

with Cabinet and Power Supply Assembled, tested & guaranteed
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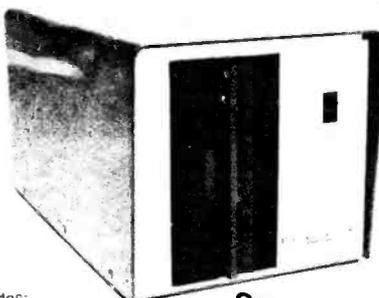
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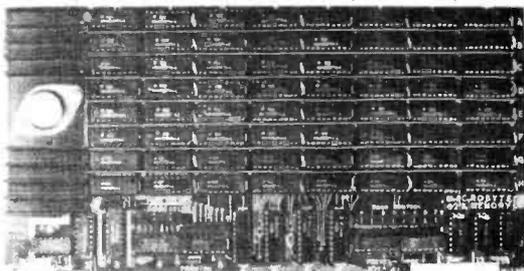


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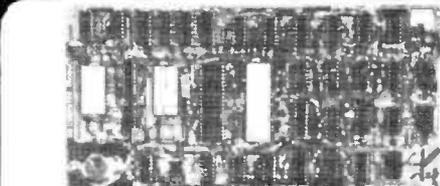
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- 4K hardware or software selectable.
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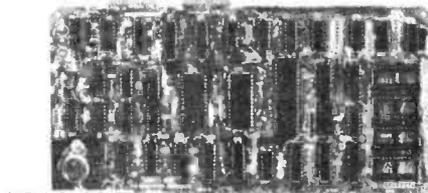
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\$299 KIT

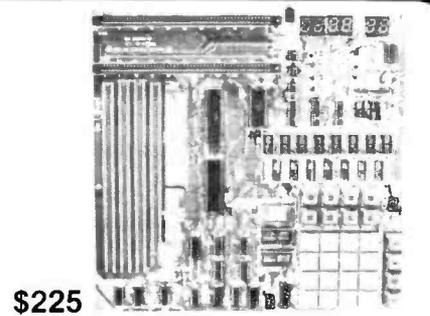
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FOR SALE: Sharp and Associates Selectric conversion with instructions. Also Axiom EX-801P printer, 20/40/80 columns, software selectable, with cable and software driver for TRS-80. Like new. Make offer. J R Reich Jr, 585 E Market St, Marietta PA 17547.

FOR SALE: Morrow processor/front panel card. 8080, S-100, octal display, built-in keyboard, operating system in read-only memory. Works perfectly, with all documentation. \$82 postpaid in 48 states. Money order or certified check. Ron Tipton, POB 227, Greenwood MO 64034, (816) 537-7927.

FOR SALE: Super ELF operating and in good condition. Also have expansion board completed, but not connected. Includes RS-232, teletypewriter, cassette input/output (I/O), and 8-bit parallel I/O ports. Power supply for ELF board only. I'll include encoded ASCII keyboard. \$300. Jess Hillman, POB 642, Columbus MS 39701, (601) 327-1244 after 5 PM.

WANTED: 1802 computer systems and parts. Any condition, any quantity, immediate cash. Prefer RCA systems, but will accept ELF II by Netronics, memory, and support boards. Tom Inskip, 6504 Democracy Blvd, Bethesda MD 20034.

FOR SALE: Teletype ASR33 teletypewriter with paper-tape reader punch and stand. \$595 and shipping. 32 K static programmable memory, four 8 K, S-100 boards factory assembled and tested. \$150 each. I pay postage. Mark Lyon, 6320 Red Prairie Rd, Sheridan OR 97378.

FOR SALE: Vandenberg 16 K static-memory board. 4 MHz, each 4 K block addressable to any 4 K boundary; S-100 bus compatible; \$275. Also Practical Automation DMPT-6-3 96-column printer with cabinet, power supply, and two CY-480 universal printer controllers; serial or parallel hookup with all documentation and driving software; \$650. Both items presently in use with a SOL-20 system. Send SASE for sample printout. Larry Rosen, POB 2197, Williamson WV 25661.

FOR SALE: TRS-80, 16 K, Level II processor. Perfect working condition. In original carton with cassettes, cables, power pack, manuals, and software. Will include Pixie-Verter to connect to regular TV for \$10 more. Retail price \$690, will sell for \$595 or best offer. I pay freight anywhere in US. Charles Fields, 924 W Washington Pl, Broken Arrow OK 74012.

FOR SALE: IMSAI 8080 processor kit. Still in factory box with warranty. \$600 or best offer. (Interface boards also available.) I am moving. Jim Siegman, 17602 Oakwood Dr, Hazel Crest IL 60429. (312) 798-2536.

FOR SALE: Complete set of BYTE magazine thru December 1978. Excellent condition. Best offer. I pay shipping. Netronics/HCA Cosmac 1802 ELF II computer kit unassembled in original carton, RCA User's Manual, applications articles: all for \$75 or best offer, postpaid. Mike Au, 2006 Alaaloa St, Honolulu HI 96821, (808) 548-5318.

WANTED: TI-59 or HP-67 calculator with all standard accessories in perfect condition. The more accessories the better. Willing to trade Shugart SA400 minifloppy disk drive (never been used) for calculator. Best offer will be notified by mail or phone. Gary R Eschborn, 513 Follett Run Rd, Warren PA 16365.

APPLE USERS: Add line input capabilities to your AppleSoft II programs which will enable you to input commas, colons, quotes, etc. This fix is available for \$1 to cover the cost of postage and duplication. Jules H Gilder, 2022 79th St, Brooklyn NY 11214.

FOR SALE: PDP-8/L minicomputer; \$600. PDP-8/L with BAO8 memory extension 8 K and peripheral adapter; \$1200. Checked out with DEC diagnostics. Certified checks only. O Glaser, 508 3rd St. West Roundup MT 59072, (406) 323-2339.

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PET OWNERS: Group of three PET owners have 26 game programs. We will trade one for one for other PET programs. Those wishing to trade should send their cassette with programs. Keith Selby, 7205 S Utica Av Apt 1016 Cinnamon Stick Apartments, Tulsa OK 74136.

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FOR SALE: Centronix printer Model 306. Prints 64 ASCII characters, 5 by 7 dot-matrix impact, 120 cps, up to 80 columns, tractor feed to 9 1/2 inches wide, parallel input. Includes RS-232 interface to 9600 bps, HW vertical form control, auto motor control, stand, and paper tray. Technical manual. Excellent condition. \$800. Tom Jacobs, 100 W University Pky Apt 3G, Baltimore MD 21210, (301) 467-0703.

FOR SALE: Texas Instruments SR-52 handheld programmable calculator. Factory reconditioned on April 13, 1978. In perfect working order. Unit comes with two AC adapters, three sets of cards, and copies of Statistics, Financial, and EE program libraries. Best offer. Donald L Mitchell, 24466 Mutholland Hwy, Calabasas CA 91302. (213) 347-3617.

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FOR SALE: Altair 8800A, VDM-11 video, MITS 1 K, S and D Sales 4 K, SwTPC/CT-1024 and seven or eight assorted boards with documentation. Mostly Mini Micro Mart stuff, not working. \$450 or best offer. Dave Johnson, 3054 Roundtree, Ypsilanti MI 48197, (313) 434-3832 after 6 PM EST.

WANTED: Seeking documentation for the Merlin display board. Also seeking super-dense graphics option and documentation. Dick Walter, 2891 Baylis Dr, Ann Arbor MI 48104, (313) 991-7944.

FOR SALE: Three 32 K static programmable-memory boards. S-100, assembled and working perfectly (with 2114's low-power 250 ns), used for 300 hours. \$495 each. Also have 2114s for \$5 each, 4116s at 150 ns for \$15 each, Dynamic N MOS ceramic 8 K by 1 22-pin with specification sheets, \$4 each, eight for \$30 and 4 K by 1 Dynamic 16 pin, \$3 each, eight for \$22. Richard Smith, 3648 Madrid Dr, San Jose CA 95132, (408) 946-0735.

FOR SALE: Apple 1 with 8 K programmable memory and 44-pin mother board, power supply, keyboard and 4 K BASIC on cassette plus documentation. \$250. National Multiplex SwTPC 2SIO controller board and CC-8 recorder set up for 4800 bps. Unit is for SWATBUG read-only memory with serial interface in control port. Documentation included. Best offer over \$330. Digital Group Phi-Deck controller card plus Triple I single-deck controller card and remote control box. Included is one Phi-Deck, documentation, and 8080/Z80 program on cassette. Unit used only a few times; guaranteed to work. Best offer over \$290. Items shipped collect. Clinton Cook, 2737 Beachwood Dr, Merced CA 95340, (209) 723-0516.

FOR SALE: SYM-1 in original carton and under warranty. First check for \$230 gets it. COD is ok. Darian Carr, 13709 Peyton, Dallas TX 75240.

WANTED: Jolt computer and Martin Research 8008-based computer. Can also use an Intel SIM-8 board. J Titus, POB 242, Blacksburg VA 24060, (703) 951-9030 or (703) 951-2684.

WANTED: I wish to purchase two random-beam video displays for use as vectored graphic displays. Displays must measure 12 inches or larger. Prefer working units, but can repair or modify if necessary. Will pay top dollar for quality equipment. Send description and price. Edward Rees, 8835 S Oak Park Dr, Apt #20, Oak Creek WI 53154, (414) 764-3093.

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August BOMB Results

The first and second place winners of the August BOMB were "Anyone Know the Real Time?" by Steve Ciarcia (page 50) and "An Overview of LISP" by John Allen (page 10). These articles placed 1.30 and 1.09 standard deviations above the mean. First and second prizes of \$100 and \$50 will be awarded to the authors. Third place went to "A Preview of the Motorola 68000" by A I Halsema (page 170) followed by "Exploring TRS-80 Graphics" by George H Yeager (page 82). ■

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\$399. (40-track) & \$675. (77-track)

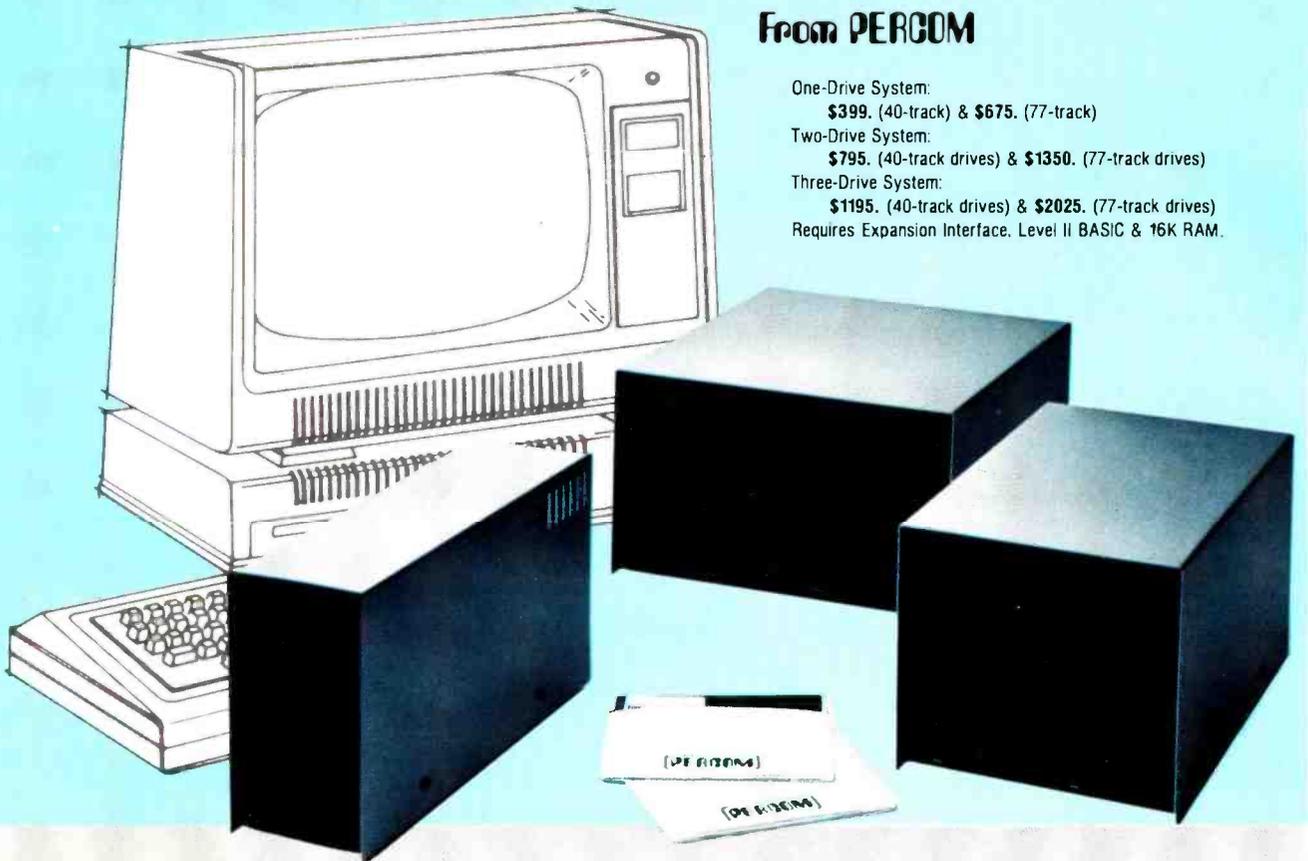
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\$795. (40-track drives) & \$1350. (77-track drives)

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\$1195. (40-track drives) & \$2025. (77-track drives)

Requires Expansion Interface. Level II BASIC & 16K RAM.



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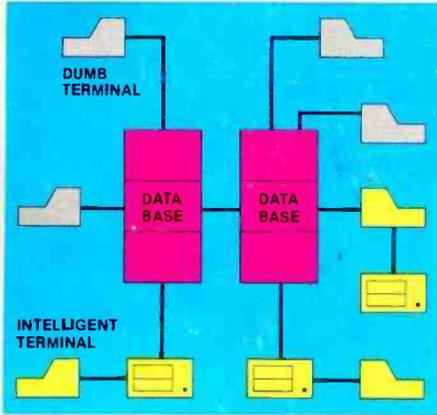
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Percom 'peripherals for personal computing'

Microcomputing comes of age.

Ohio Scientific's OS-65U Level 3 operating system software brings new networking and distributed processing capabilities to microprocessor based computer systems.



Until now, the only alternative for low cost multiple-user computer applications was time-shared systems. However, a serious drawback of microcomputer or mini-computer multi-user time-share systems is the fact that under heavy work loads they slow down to a crawl since the central processor time in such a system is shared by all of the users.

In a microprocessor based distributed processing system, using floppy based microcomputers as intelligent terminals (local systems) most of the work load is handled locally. Overall system performance does not degrade under heavy job loads. Each local system performs entry, editing and execution while utilizing the central data base for disk storage, printer output, and other shared resources.

For more demanding applications it is desirable to have several data bases, each with its own collection of local systems. Such an inter-connected set of data bases is called a network. Each data base and its local intelligent and dumb terminals is called a cluster.

Level III

OS-65U Level 3 now supports this advanced networking and distributed processing capability as well as conventional single user operation and time-sharing. Level 3 now supports local clusters of intelligent microcomputer systems as well as

dumb terminals for the purpose of utilizing a central Winchester disk data base and other shared resources. The system also has full communications capability with other Level 3 data bases providing full network capability.

The system utilizes Ohio Scientific's low cost, ultra high performance computer systems throughout for intelligent terminals as well as data bases. This general systems configuration provides a cost/performance ratio never before attained in this class of computer power.

Level 3 resides in each network data base. A subset system resides in each intelligent terminal. Each data base supports up to 16 intelligent systems and up to 16 dumb terminals. However, since dumb terminals can heavily load the system, they should be kept to a minimum. Level 3 also supports a real time clock, printer management, and other shared peripherals.

Data Base Requirements

Minimal requirements for a Level 3 network data base are a C3-C or C3-B computer system with 23 or 74 megabytes respectively, console terminal, 100K bytes RAM and a CA-10X 16 port I/O board for network and cluster communications.

Intelligent Terminal Requirements

Any Ohio Scientific 8" floppy based computer with 56K RAM and one data base communications port.

Connections

Intelligent terminals and networked data bases are connected by low-cost cabling. Each link can be up to 10,000 feet long at a transfer rate of 500K bits per second, and will cost typically 30¢ a foot (plus installation).

Syntax

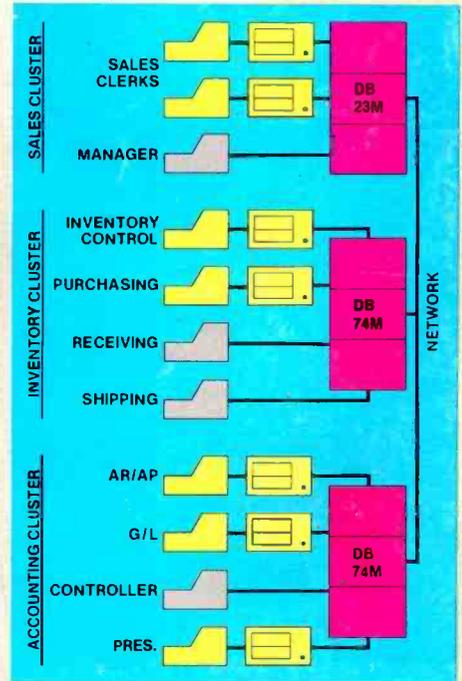
Existing OS-65U based software can be directly installed on the network with only *one* statement change! Level 3 has the most elegantly simple programming syntax ever offered on a computer network.

File syntax is as follows:

DEV A, B, C, D.	Local Floppies	} unchanged from single user and timeshare systems
DEV E	Local hard disks	
DEV K-Z	Specific network Data Bases	

Each of up to 8 open files per user can be from 8 separate origins. Specific file and shared peripheral contentions are handled by 256 network semaphores with the syntax Waite N Waite N, close.

The network automatically prioritizes multiple resource requests and each user can specify a time out on resource requests. Semaphores are automatically reset on errors and program completion providing the system with a high degree of automatic recovery.



A Typical System

A typical system with two network data bases will have 148 megabytes of disk, four intelligent subsystems equipped with dual floppies, two dumb terminals, a word processing printer, a fast line printer, network data base manager software and 1000 ft. of inter-connecting cable. Utilizing .7 MIPS processors throughout it will cost less than \$50,000 plus installation. GT option computers (1.2 MIPS) can be utilized at a slightly higher cost.

One Step at a Time

Best of all, Ohio Scientific users can develop distributed processing systems economically one step at a time. A user can start with a single user floppy system, add a hard disk, then time-sharing, then a second Winchester data base for backup and finally cluster intelligent terminals to achieve a full network configuration.

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