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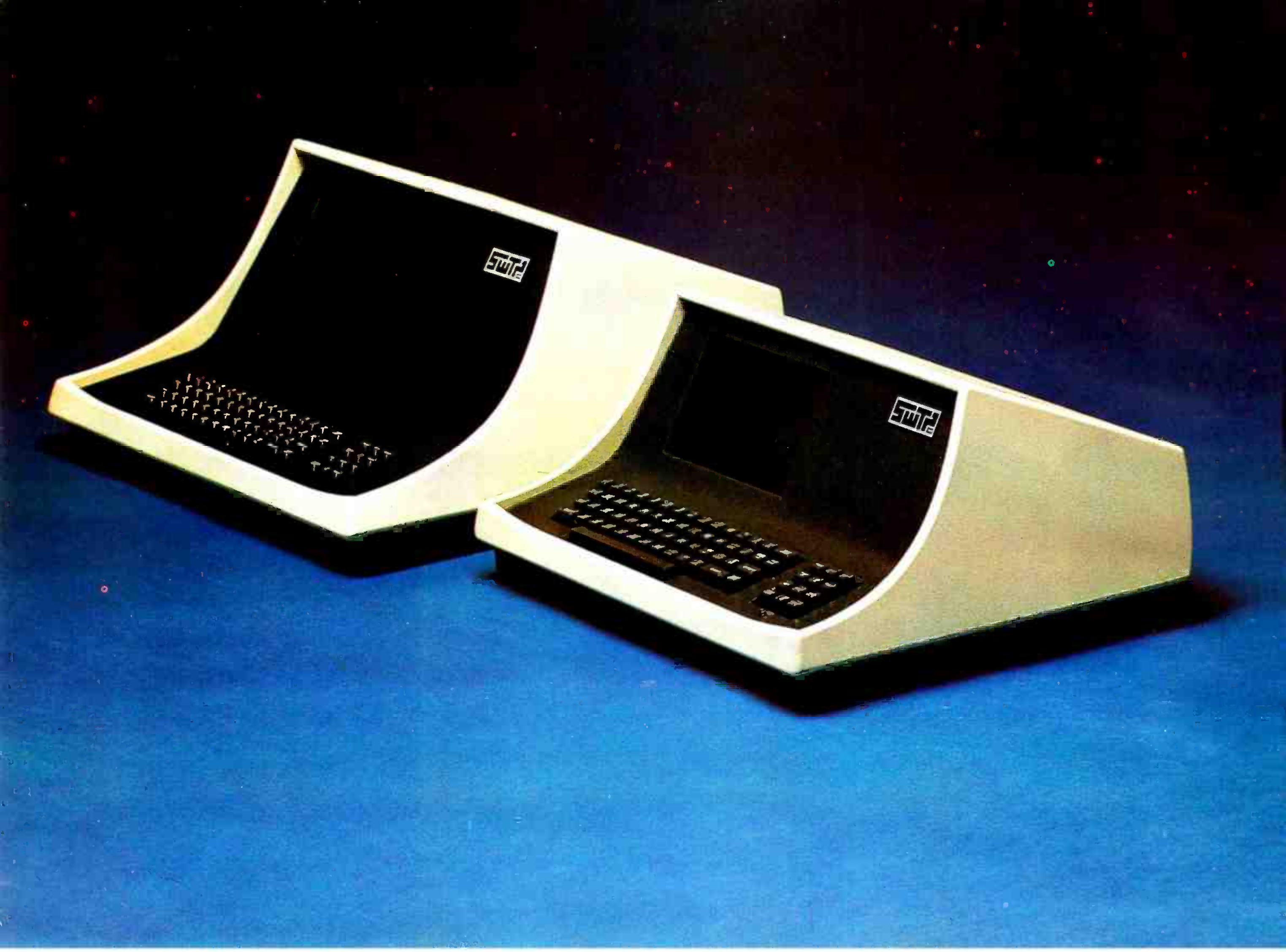
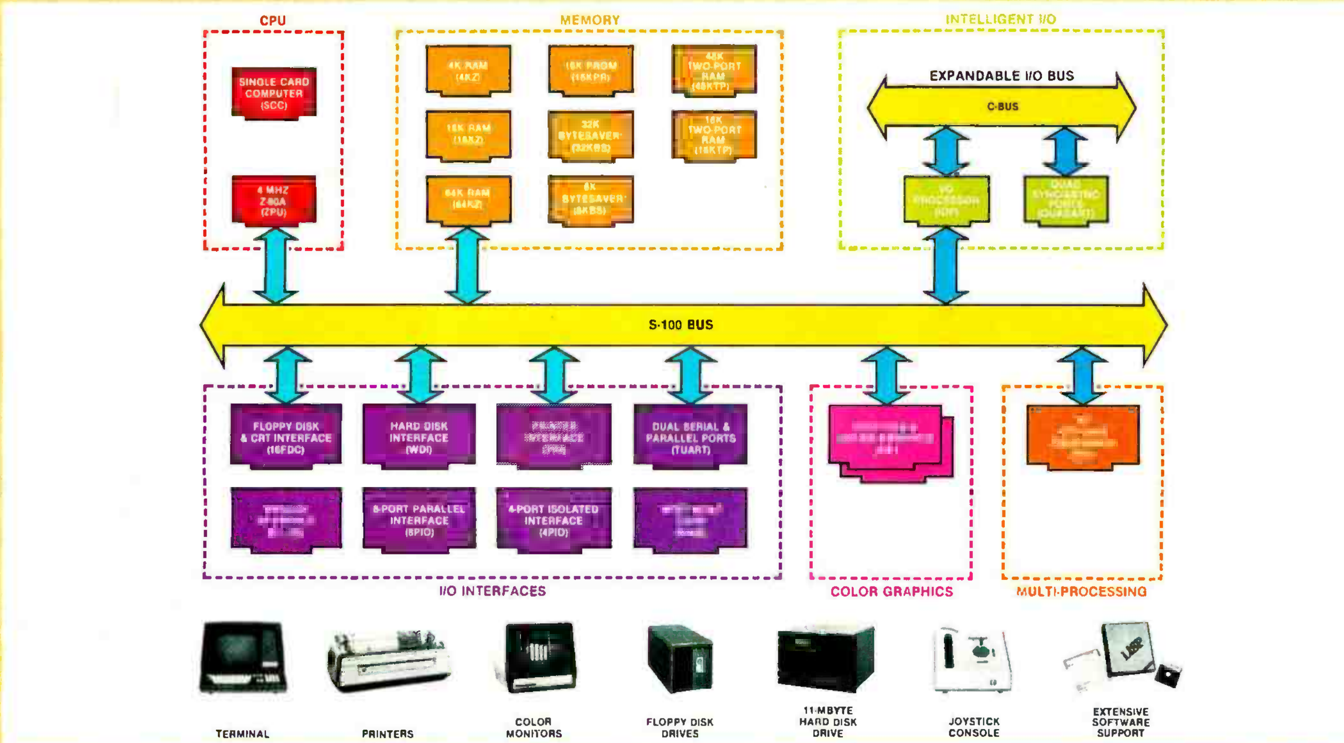
# BYTE

the small systems journal


FUTURE COMPUTERS?



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# In The Queue

Volume 6, Number 4 April 1981

## Features



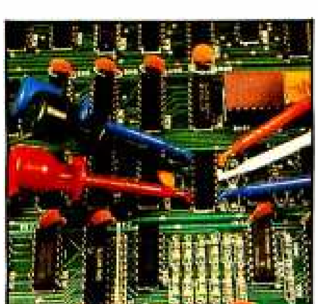
## Reviews



## Nucleus



BYTE



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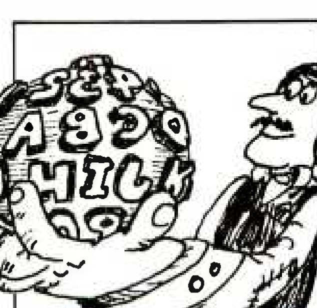

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# In This Issue

"Future Computers" is our cover theme this month and the subject of the editorial. Before you write to comment on our cover's "unusual" design approach (created by artist Robert Tinney), keep in mind the proximity of April 1.

Elsewhere in this issue we describe Steve Ciarcia's latest project, a low-cost logic analyzer, and tell how to build your own Turing machine. Other articles include: a follow-up to our earlier review of the Sinclair computer, this time a description of the MicroAce kit version; a reformatter for CP/M and IBM-format floppy disks; a closer look at the TI Speak & Spell; a fascinating review of three different APL packages for the patient (but eager) APL fans in our audience; details about data compression; all about intercomputer data links and the game of Go; and the conclusion of an article from last month about 3-D computer graphics.

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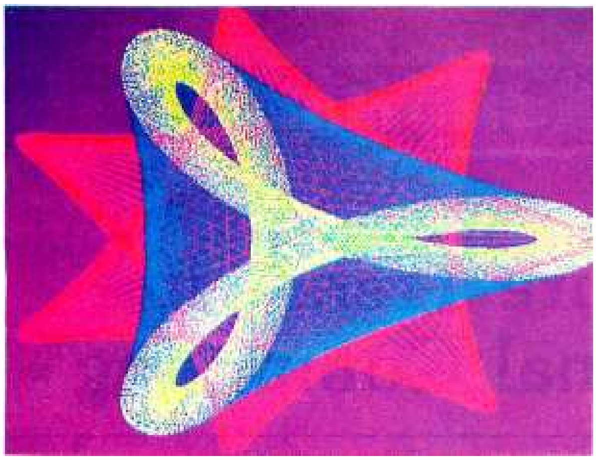
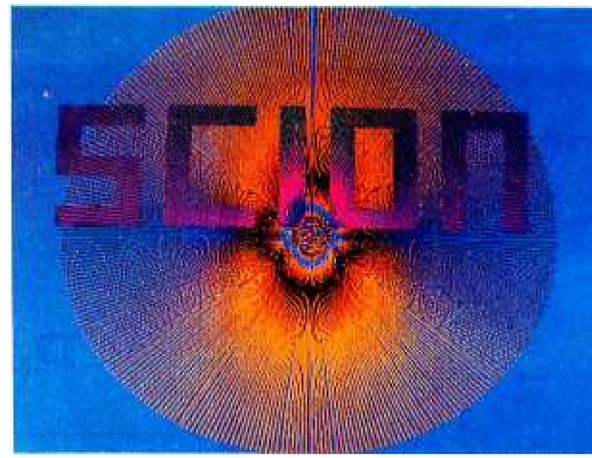
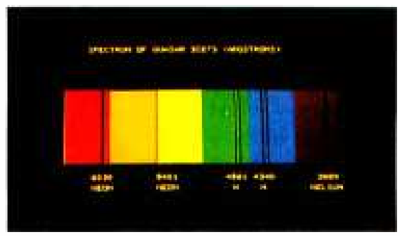





"...stands well above other S-100 graphics displays in its price and performance range."
BYTE, Product Review



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

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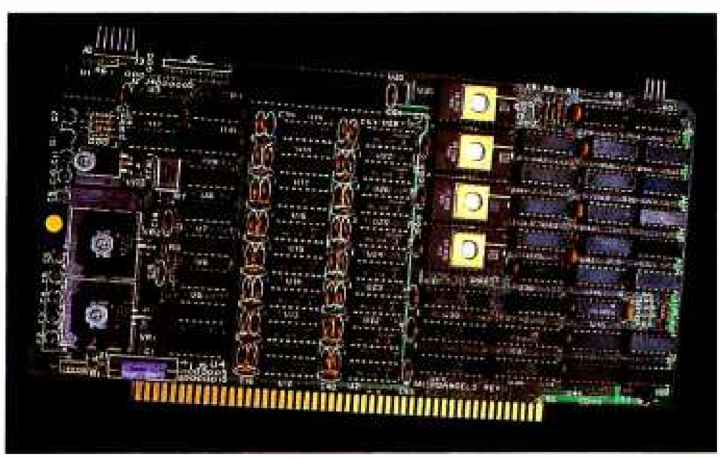

- Light pen interface
- Time multiplexed refresh
- 4K resident Screenware™ Pak I operating system
- 32K RAM isolated from host address space
- High speed communications over parallel bus ports

## Screenware™ Pak I

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

## Screenware™ Pak II

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

## And now...COLOR!!

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

Circle 2 on inquiry card.

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## Editorial

# Future Trends in Personal Computing

*Chris Morgan, Editor in Chief*

Future Computers—what will they be like?

Some exciting developments have been occurring in the industry lately that should give us some clues. I attended the Consumer Electronics Show in Las Vegas this past January, where Toshiba introduced what could be the most significant product of the year for the personal-computing market: a pocket-size flat-screen television set. While no specific mention was made of its possible use with a personal computer, it takes only a moment's thought to see the potential of this engineering marvel.


**Photo 1:** *Toshiba's new pocket-size television prototype. A built-in zoom feature is available that enlarges any one of the four screen quadrants for close-up viewing. Photo by Stan Miastkowski.*

First introduced in Japan some months ago, the Toshiba television has a 4.1 by 3.1 cm (1⅗ by 1⅕ inch) LCD (liquid-crystal display) screen housed in a case measuring 17.3 by 8.2 by 1.8 cm (6⅘ by 3⅕ by 7/10 inches)! It has only half the resolution of a standard CRT (cathode-ray tube) display, but its small size masks that fact effectively. Toshiba has also solved the problem of liquid-crystal "overhang," the slow-fade effect that plagues LCDs in electronic games. The response time of this particular design is fast enough to handle the 1/30 of a second television-frame refresh rate. Although the screen is dimmer than a CRT display (the image is formed from reflected rather than transmitted light), it has acceptable contrast and sharpness. The screen is fed by a bank of shift registers; it would be an easy task to display computer graphics and characters on it.

The Toshiba flat-screen unit is still in the prototype phase and will probably not be available for a year or so, retailing for approximately $600. I predict that within two years the market will be flooded with portable computers having built-in screens of every size and shape.

Sony has introduced a new electronic "typewriter" that fits in a briefcase and lets you enter, store, and edit up to 200 pages of text using a built-in microcassette recorder. Text is displayed on a one-line liquid-crystal display. Combine such a device with a flat-screen multiline video display and you have a very attractive concept, indeed.

Another Sony breakthrough is a new miniature floppy-disk system (see photo 3, page 10). Each disk measures 8.9 cm (3½ inches) in diameter and holds over 800,000 bytes! The disk resides in a rigid housing for protection. Sony plans to introduce the disk as part of a new, miniature word-processing system.

**Photo 2:** *The Osborne I personal computer. This new 64 K, Z80A machine has two floppy-disk drives and fits under an airline seat. Price: $1795. Photo by Elliot Varner Smith.*

Although no official word has come from the company, we have learned that it is developing a complete personal-computer system. Fujitsu and Seiko are also developing personal computers for the U.S. market.

### New Trends in Portability: The Osborne I

This month Adam Osborne introduced a new personal computer, called the Osborne I, at the West Coast Computer Faire in San Francisco. Its features include: a Z80A processor; 64 K bytes of dynamic programmable memory (60 K bytes are available to the programmer; the remaining 4 K bytes are used by the display screen); IEEE and RS-232C interfaces; modem electronics; a 5-inch video monitor with 24 rows of 50 characters, upper- and lowercase, two display intensities, and underlining for all characters; two 5-inch single-density, single-sided floppy-disk drives; standard typewriter keyboard; 10-key numeric pad; two pockets for storing floppy disks; and the following software: the CP/M operating system, CBASIC, WordStar, Mailmerge, and a CP/M-compatible spread sheet program that resembles VisiCalc.

There are two particularly interesting points about this computer: (1) it will cost $1795, and (2) it's portable! An optional battery pack will be sold with the unit. Also optional are a 9-inch monitor, an acoustic coupler, and double-density, double-sided floppy-disk drives. The $1795 price tag (which includes all the software) is remarkably low. It remains to be seen if the company can turn a profit at this price. I recently had an opportunity to see the Osborne I in action. I was impressed with its compactness: it will fit under an airplane seat. (Adam

Photo 3: *Sony's new 3½-inch floppy disk and drive. Each double-sided floppy disk can hold up to 875 K bytes of information, unformatted. The recording density is 1.47 times that of the 5-inch disk.*

Osborne is currently seeking approval from the FAA to operate the unit on board a plane.) One quibble: the screen may be too small for some people's taste. Consulting Editor Mark Dahmke is preparing a full test report on this computer for an upcoming issue of BYTE.

* * *

## Update

We have received numerous requests for more information on the Microterminal described in the January editorial. We cannot divulge any more information at this time, but watch for a complete report coming soon.

Also in the works: full reports on the Commodore VIC-20 color computer; the TRS-80 color computer hi-res (high-resolution) graphics; a special issue on local networks; reviews of three LISP packages; the new spelling-correction programs; Logo for the Apple II and TI 99/4; and our annual August language issue, this year on Smalltalk, one of the most exciting languages in the computer field today. Watch our upcoming editorials for further information about future computers. ■

**The Carl Helmers Newsletter**

*Readers of recent issues of BYTE are probably aware that Carl Helmers, former Editorial Director of BYTE, is now working on projects outside of McGraw-Hill. One of Carl's new undertakings is the* Carl Helmers Personal Computer Newsletter, *which will cover the present state of personal computing, future developments in hardware and software, artificial intelligence, mass storage, and many other topics. The newsletter will contain no advertising, cost $200 per year, and will appear monthly. Carl is also considering a free "personal computer industry conference call," which would be made available via a toll-free 800 number if interest among subscribers is high enough. The setup would enable up to twenty people to participate in a regularly scheduled monthly "roundtable" discussion.*

*For more information about subscribing to the newsletter, write to North American Technology Inc, Strand Building, Suite 23, 174 Concord St, Peterborough, NH 03458, or call 603-924-6048. We wish Carl luck in his new venture...CM*



# BYTE's Bugs

### Invisible Software Review

Because of a last-minute scheduling change, the product review by BYTE editor Gregg Williams, "The muSIMP/muMATH-79 Symbolic Math System" (November 1980 BYTE, page 324), did not appear on the "In the Queue" page for that issue. We regret the omission.

### Getting the Number Straight

In the February 1981 BYTE, on page 345 of the "What's New?" section, the telephone number given for General Digital Corporation was incorrect. The correct number is (203) 289-7391. We apologize for any difficulties that may have arisen due to the error. ■

# Make the Apple II* a powerful IEEE-488 Controller in a snap.

**Just plug the SSM A488 board into any Apple II* expansion slot for a low-cost, full-featured instrumentation interface.** SSM gives the Apple II the power and versatility of a $9,000 IEEE-488 controller. At a fraction of the price. Our board converts the Apple II into a truly sophisticated controller that programs and controls up to 15 different instruments connected together on the 488 bus.

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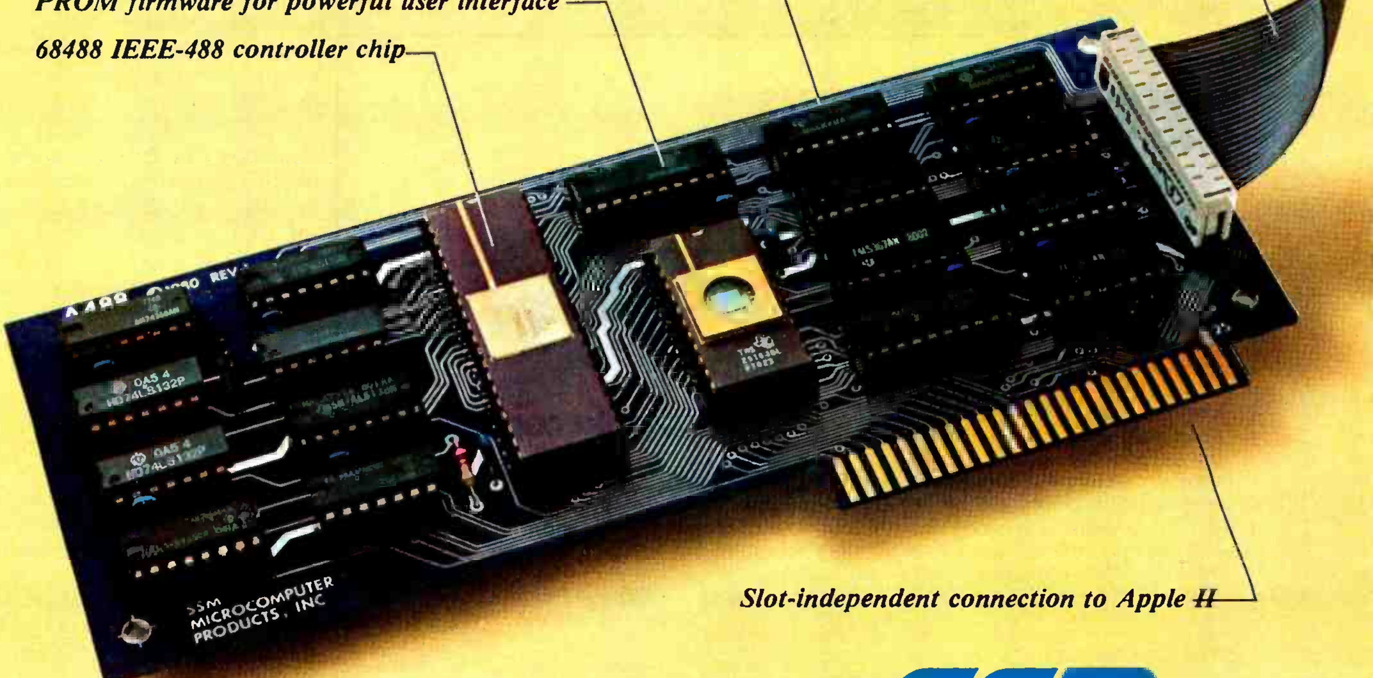
**Suitable for OEMs as well as end users.** Whether you make test/measurement systems for resale, or simply for yourself, the SSM/Apple combo gives you top performance. As it cuts your costs. Call your local dealer or SSM today for complete details.




*SSM's A488 board expands the Apple II to a high-performance IEEE-488 controller.*

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## Computers and Trees: The HHC Forest

I read Gregg Williams and Rick Meyer's article about the Panasonic/Quasar hand-held computers (January 1981 BYTE, page 34), and I could hardly contain my excitement over the potential use for these devices in my field: forest measurements and statistics.

Forest inventory and survey work typically involves many man-hours in the forest collecting information on tree size, species, sawtimber quality and value, growth, etc. This information is normally hand-written on tally sheets in the field, and either hand-tabulated in an office or key-encoded for statistical summary and analysis by computer. Forest scientists and practicing foresters are continually looking for more economical methods of obtaining resource information at the level of precision required for complex management planning and decision-making.

The HHCs (hand-held computers) appear to have the capability of being used in the field as data-entry devices, thereby eliminating the need for subsequent key-encoding of hand-written information. With their alphanumeric capability, they should be able to store and manipulate descriptive text as well as numeric information. With suitable applications programs, I would think they are also capable of handling a fairly large repertoire of forestry problems (eg: compiling tables describing timber volumes by species, log grade, and size class; estimating stumpage values for timber sales, etc). For larger data-processing requirements, they could transmit their data, through the modem attachment, to a host computer. In short, I see in these devices a potential for greatly reducing the man-hours required for routine data-entry and processing applications in forestry.

**George L Martin Jr**
**Assistant Professor of Forest Biometry**
**Department of Forestry**
**College of Agricultural and Life Sciences**
**University of Wisconsin**
**1630 Linden Dr**
**Madison WI 53706**

*The advent of HHCs will be a boon to many who must perform data entry and sophisticated calculations in the field. Unfortunately, neither the price nor the availability date of the Panasonic/Quasar unit was announced at the CES (Consumer Electronics Show), as I had originally hoped. As an educated guess, I would place the price in the $400 to $650 range, with the units possibly being available as early as mid-1981....GW*

## Oddest Programming Language of Them All

In the December 1980 BYTE, Mr Daniel Weise presented a version of a self-reproducing program. (See "Thief-Reproduthing Programth," page 16.) The following version of the same fundamental algorithm is written in my favorite programming language—English:

Replace every occurrence of "x" in " x 'x'." by "Replace every occurrence of 'x' in 'x "x".' by ".

Which executes as follows:

Unquote " x 'x'." to obtain the form x "x".

Replace "x" by the quoted substitute to obtain *x "Replace every occurrence of 'x' in 'x "x".' by ".*

Replacing x by the unquoted substitute we obtain *Replace every occurrence of "x" in " x 'x'." by "Replace every occurrence of 'x' in 'x "x".' by ".*

The operations quote and unquote work as follows:

Quote text = "text*".
Unquote "text*" = text.

where text* is a faithful copy of text, except for the replacement of each quote mark, single or double, by its complement. This transformation is idempotent. This is a time-honored syntactic device of English.

I leave it to you, dear reader, to judge the relative perspicuity of this English version and the LISP version provided by Mr Weise.

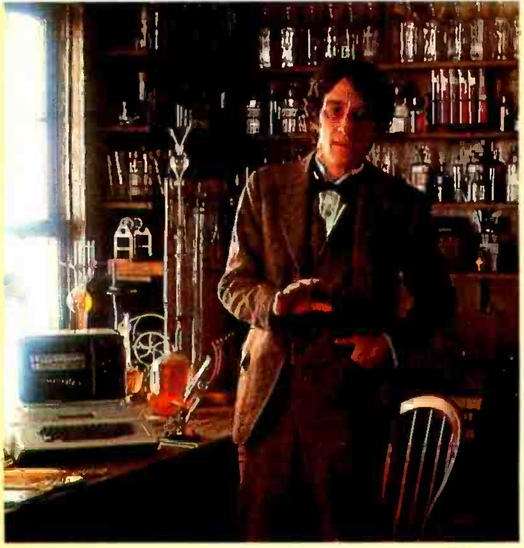
**James P Corbett**
**24 Sheffield Lane**
**Florence MA 01060**

*Readers should note that they may not be able to get this program to run on every model of the human brain—which is probably just as well, since once running, it would use up all available processing time and memory space....CPF*





Circle 10 on inquiry card. →



# Edison had over 1,800 patents in his name, but you can be just as inventive with an Apple.

Apple is the company with the brightest ideas in hardware and software *and* the best support — so you can be as creative with a personal computer system as Edison was with the incandescent bulb.

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Since more than 100 companies create software for Apple, you'll have the most extensive library in the personal computer world. Want to write your own programs? Apple is fluent in BASIC, Pascal, FORTRAN, PILOT and 6502 assembly language.

There's even a series of utility programs called the DOS Tool Kit that not only lets you design high-resolution graphic displays, but lets you work wonders with creative animation.

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## Vive la Guerre

I have a few comments on Bruce Carbrey's article "A Pocket Computer? Sizing up the HP-41C." (See the December 1980 BYTE, page 244.) The article was very interesting, since I use both an HP-41C and a TI-59 frequently. Mr Carbrey did a comparison that I had planned but had never done.

On page 246, he states that storing a number in a register on a TI-59 requires three lines. This applied to the earlier SR-52, but only two lines are needed with a TI-59. Two is better than three, but the one-line approach of the HP-41C is better. It makes editing a program without a printer much easier, especially since you don't have to remember key codes.

Mr Carbrey's benchmark test program does not, however, use the TI-59's strengths well. A major difference between the calculators is that both label and absolute addressing exist on the TI-59, while the HP-41C uses only labels. Since the HP-41C program is compiled, it is not penalized. Using absolute addressing in the TI-59 program cuts run time by 3 seconds and saves a step.

Listing 1 is a benchmark program that uses the TI-59's parenthesis feature. This seemed especially apt considering Hewlett-Packard's and Texas Instruments' battle over Reverse Polish Notation vs Algebraic Operating System. My program is 10 steps shorter, uses 4 data registers, and runs in 33 seconds. This improved performance is achieved by reducing the number of relatively slow memory arithmetic operations and utilizing the TI-59's stack. (Also note that the correct answer in Mr Carbrey's table 1, on page 254, is \$17553.30, not \$17533.30.)

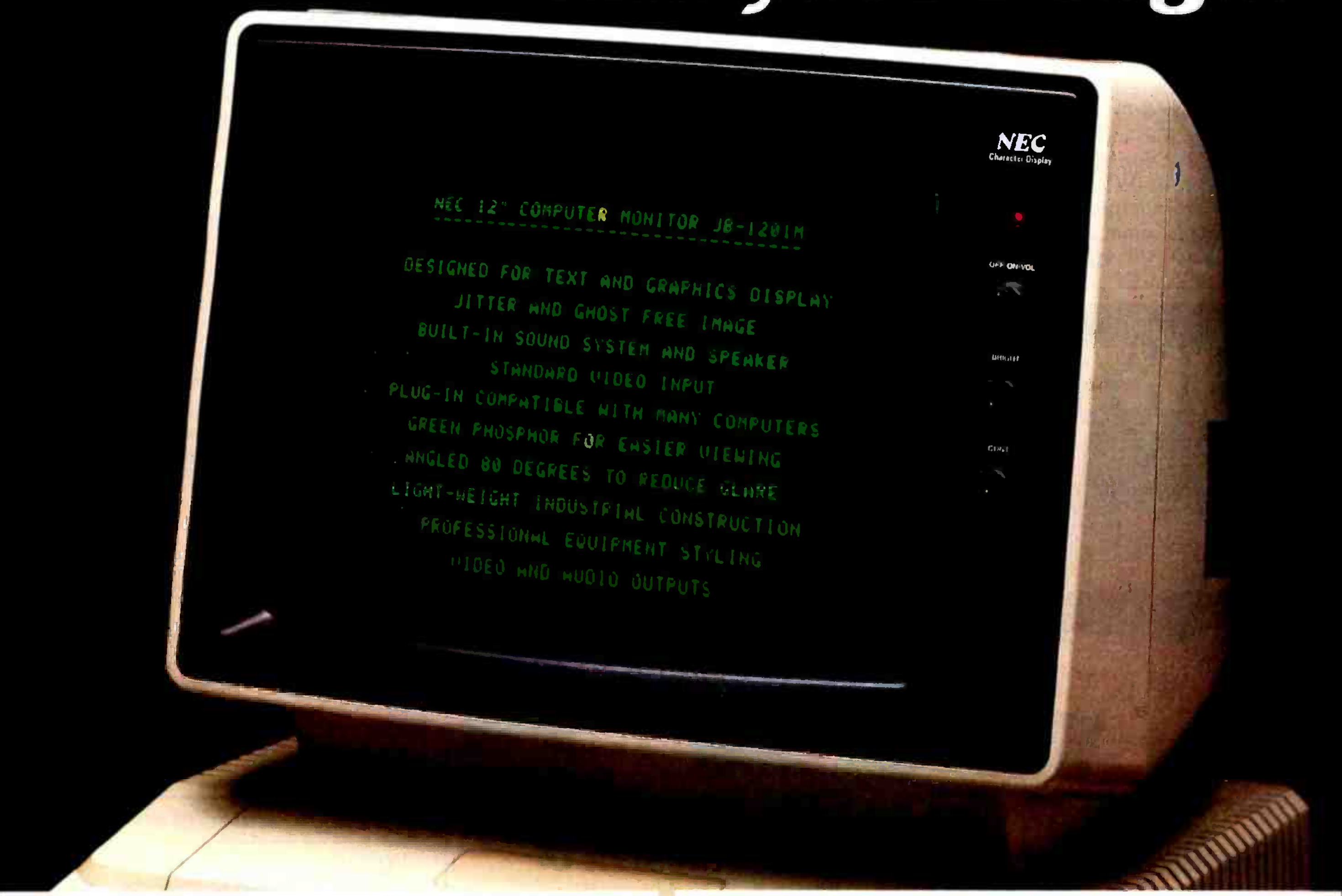
**Listing 1**

| | | |
|---|---|---|
| 000 | 76 | LBL |
| 001 | 11 | A |
| 002 | 58 | FIX |
| 003 | 02 | 02 |
| 004 | 42 | STO |
| 005 | 01 | 01 |
| 006 | 91 | R/S |
| 007 | 42 | STO |
| 008 | 02 | 02 |
| 009 | 91 | R/S |
| 010 | 42 | STO |
| 011 | 03 | 03 |
| 012 | 91 | R/S |
| 013 | 55 | ÷ |
| 014 | 01 | 1 |
| 015 | 00 | 0 |
| 016 | 00 | 0 |
| 017 | 85 | + |
| 018 | 01 | 1 |
| 019 | 95 | = |
| 020 | 42 | STO |
| 021 | 04 | 04 |
| 022 | 45 | $Y^x$ |
| 023 | 43 | RCL |
| 024 | 02 | 02 |
| 025 | 94 | +/− |
| 026 | 65 | × |
| 027 | 43 | RCL |
| 028 | 01 | 01 |
| 029 | 85 | + |
| 030 | 53 | ( |
| 031 | 00 | 0 |
| 032 | 85 | + |
| 033 | 43 | RCL |
| 034 | 04 | 04 |
| 035 | 45 | $Y^x$ |
| 036 | 43 | RCL |
| 037 | 02 | 02 |
| 038 | 94 | +/− |
| 039 | 97 | DSZ |
| 040 | 02 | 02 |
| 041 | 00 | 00 |
| 042 | 32 | 32 |
| 043 | 54 | ) |
| 044 | 65 | × |
| 045 | 43 | RCL |
| 046 | 03 | 03 |
| 047 | 95 | = |
| 048 | 91 | R/S |

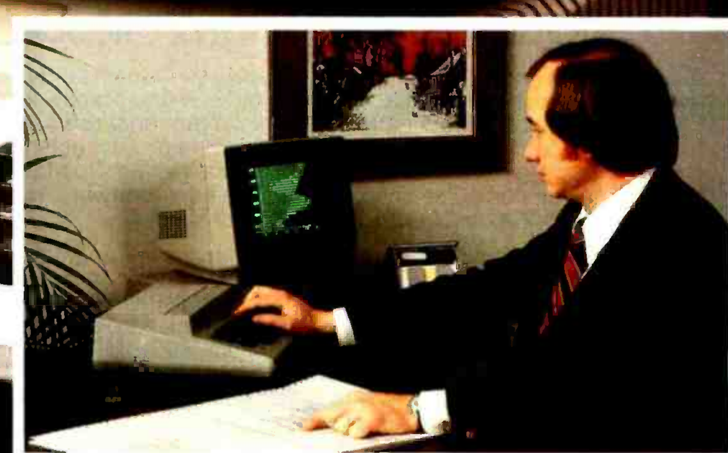
Much has been made of the HP-41C's plug-in accessories, but I wonder if they are really a major design change. They obviously follow TI's development of the printer attachment and Solid State Software. The HP printer has excellent print quality and features, but it is very slow. The Bar-Code reading "Wand" is the only significant advance in my opinion.

The capacities of the two calculators are about equal in my experience. Most users want both a printer and a card

# Easy on your Eyes and your Budget




80 character display makes it ideal for word processing and scientific applications.



This high quality professional computer monitor provides sharp, clear display of up to 80 characters by 25 lines of text, making it ideal for word processing as well as standard business applications.

Lightweight industrial grade construction gives maximum portability with reliable operation.

**NEC** America, Inc.
130 Martin Lane, Elk Grove Village, IL 60007

reader, so only two memory modules can be added. Thus, a maximum of 830 program lines is available without data registers in practical applications, and this limit is quickly reduced. Even allowing for the HP-41C's greater storage efficiency (I find a 50% improvement over the TI-59), the HP-41C is only marginally better.

The lack of a TI response to the HP-41C threat mystifies me. Although users were surveyed last spring, no new product has appeared. The discounts being offered on TI's "59" calculators clearly suggest that something is coming soon, but it has been a year since the HP-41C's introduction. Perhaps the pocket computers from Radio Shack and Sharp threw a wrench into the works. TI has always played a game of increased capacity at lower cost in the programmable-calculator marketing wars. I await TI's next entry with great anticipation. Users have profited immensely from the battles between Hewlett-Packard and Texas Instruments in this market. (Take out your old calculator and try using it now.) Vive la guerre!!!

G John Garner
319 Blue Haven Rd
Dollard des Ormeaux, PQ, Canada

## Compollution

Steve Ciarcia's article "Electromagnetic Interference" (January 1981 BYTE, page 48) is a very good and long-overdue summary of the electronic noise-pollution problem. Many radio engineers have been fighting the battle against the plastic computer box and the poorly designed digital boards that dominate the industry. We are ready for some stiff regulations regarding fundamentals, such as simple metallic shielding and grounding practices, so that the rest of the world can continue to use RF (radio-frequency) communications.

One omission in Mr Ciarcia's article is the reference to a state-of-the-art handbook or text for more comprehensive information on the subject. One of the best comes from Bell Laboratories, in Henry W Ott's book *Noise Reduction Techniques in Electronic Systems* (New York: John Wiley & Sons Inc, 1976).

R W Burhans
Ohio University
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*This omission was caught and rectified. See "BYTE's Bits" March 1981 BYTE, page 314, for additional reading material. Also, see J N Demas's review in the September 1980 BYTE, page 311....GW*

## Well-Rounded Machine

We at Hewlett-Packard were very pleased to see Brain Hayes's excellent article on the HP-41C calculator. (See "The HP-41C: A Literate Calculator?", January 1981 BYTE, page 118.) He did make some statements that deserve clarification, however. In particular:

> *There is something absurd about the world's fanciest calculator not being able to give results accurate to more than seven or eight decimal places.*

The example he used was the $(\sqrt{2})^2$ computation, which is a good illustration of a common misunderstanding about computer arithmetic. When calculating $\sqrt{2}$, the 41C works internally with 13 digits and then rounds correctly to 10 digits. This helps to insure the accuracy of the displayed result. But this result is still not really $\sqrt{2}$, merely the best representation possible on this, or any other, 10-digit machine: 1.414213562.

At this point, the calculator does not know where this number came from: it could be a previous result, or it could have been entered exactly as such through





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the keyboard. Squaring this number correctly and rounding again yields 1.999999999. Any 10-digit calculator that does otherwise is either doing "funny arithmetic," or else is not telling you everything it knows. But the 41C has lived up to its claim: each calculation was performed correctly to 10 digits. Also, and at least as important, the behavior of the calculator is *utterly predictable and repeatable.*

A calculator is a tool, and, like any tool, it has its limitations. These limitations must be understood if the tool is to be used properly. The point is this: there exist sequences of calculations that will generate errors of *any* magnitude on *any* finite-precision arithmetic machine. Keeping this in mind, the "world's fanciest calculator," the HP-41C, is a tremendously powerful tool indeed.

**Steve Abell**
**Research and Development Engineer**
**Hewlett Packard Company**
**Corvallis Division**
**1000 NE Circle Blvd**
**Corvallis OR 97330**

## MicroAce: More Power to Sinclair

I disagree with John McCallum's statement in "The Sinclair Research ZX80" (see the January 1981 BYTE, page 94) that by building the kit version "you will not save any money." My MicroAce cost a mere $150—a savings of 25% over the price of a ZX80. It was easy to build, although the instructions were not nearly as elaborate as Heathkit's.

The MicroAce has room for two more programmable-memory integrated circuits than the ZX80. The increase to 2 K bytes almost triples the possible program length (portions of the first 1 K bytes are used for "housekeeping"). This expanded capacity gives you a much more usable computer. Its unique design means that you can store as much information as other systems that use 3 K to 4 K bytes.

I couldn't afford $500 or more for a computer, but, for about $175 (kit plus memory chips), I have learned quite a bit and gained much enjoyment while doing so.

**John R Mullen**
**8518 Terrang Ct**
**Rockford IL 61111**

*The MicroAce kit is reviewed by Delmar Searls on page 46 of this issue.*

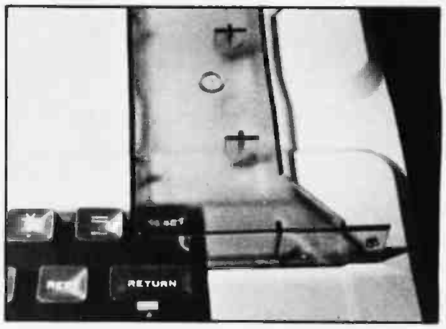
## Calling Z8000

The "BYTELINES" section of the January 1981 BYTE (page 200) contained an item saying that Microsoft proposed a standard set of calling conventions specifying parameter-passing and register usage for the Z8000 microprocessor. It was actually Zilog Inc, inventor of the Z8000, that established the conventions. Zilog announced the Z8000 standards at last year's WESCON show in Anaheim, California. The announcement contained the statement that the conventions "have thus far been adopted by Microsoft and are under consideration by several other companies."

Thank you, BYTE, for letting me set the record straight by pointing out that Zilog originated the Z8000 calling conventions that were subsequently adopted by Microsoft.

**Bruce Weiner**
**Product Marketing Manager**
**Zilog Inc**
**10460 Bubb Rd**
**Cupertino CA 95014**

## Why Didn't We Think....




I always look forward to the latest issue of BYTE, as I am sure many others do. I would like to pass along this suggestion to my fellow readers who use an Apple II computer. It is my solution to the well-known "accidental RESET" problem that plagues users of that machine.

**Manauba Sakuta, MD**
**6324 Wilryan Ave**
**Edina MN 55435**

## December Adventure

BYTE's "Product Reviews" of games in the December 1980 issue were absolutely perfect. There are too many bad programs on the market; being able to see a picture of the display (along with a description of how the game is played) is a big help.

I noticed that BYTE didn't continue this policy in the January 1981 issue—I realize that you can't have seven game reviews in *every* issue, but it would be nice....

Thanks.

**PAD from Livermore CA**■



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# Recurrence in Numerical Analysis

James J Davidson
c/o BYTE Publications
POB 372
Hancock NH 03449

Although Taylor's series are the most universally useful method of computing higher mathematical functions, they do have their drawbacks. In particular, many functions have representations only in the form of alternating series. This can cause great difficulty in maintaining accuracy if large arguments are required. Often, so many significant digits are lost in the process of computation that the results are, at best, useless. At worst, if you do not suspect that gross inaccuracies are occurring, you may make severe engineering mistakes.

If the various remedies such as argument scaling are ineffectual in improving accuracy, the only recourse is to seek alternate methods of computation. Of those alternatives, recurrence relations have the widest applicability.

## What's a Recurrence Relation?

Various functions have the mathematical property that if you know two consecutive values, you can use those to find a third. This process can be repeated to find a fourth from the second and third, and so on. Of course, you need to pick the right pair to start from, but if you do, you can get to any value you want.

The simplest illustration of a recurrence relation is the Fibonacci series. This is a series of special numbers known in medieval times to Leonardo of Pisa, surnamed Fibonacci (1175-1230). Fibonacci numbers are found in botany and other natural sciences, as well as in certain mathematical theories of aesthetics. They are interesting in their own right, and there is at least one society devoted to study of their mathematical properties.

The Fibonacci series proceeds in the following fashion:

$$0, 1, 1, 2, 3, 5, 8, 13, 21, 34, 55, \ldots$$

Each term is obtained by adding the two previous terms. As a formula, the series can be expressed as:

$$a_{n+2} = a_{n+1} + a_n$$

where the initial terms must be specified as 0 and 1. Once you get started, it is obvious that you can keep going indefinitely using the same formula. It is not even necessary to begin at the beginning. If you know the thirteenth and fourteenth terms, for instance, you can find the fifteenth by adding them together.

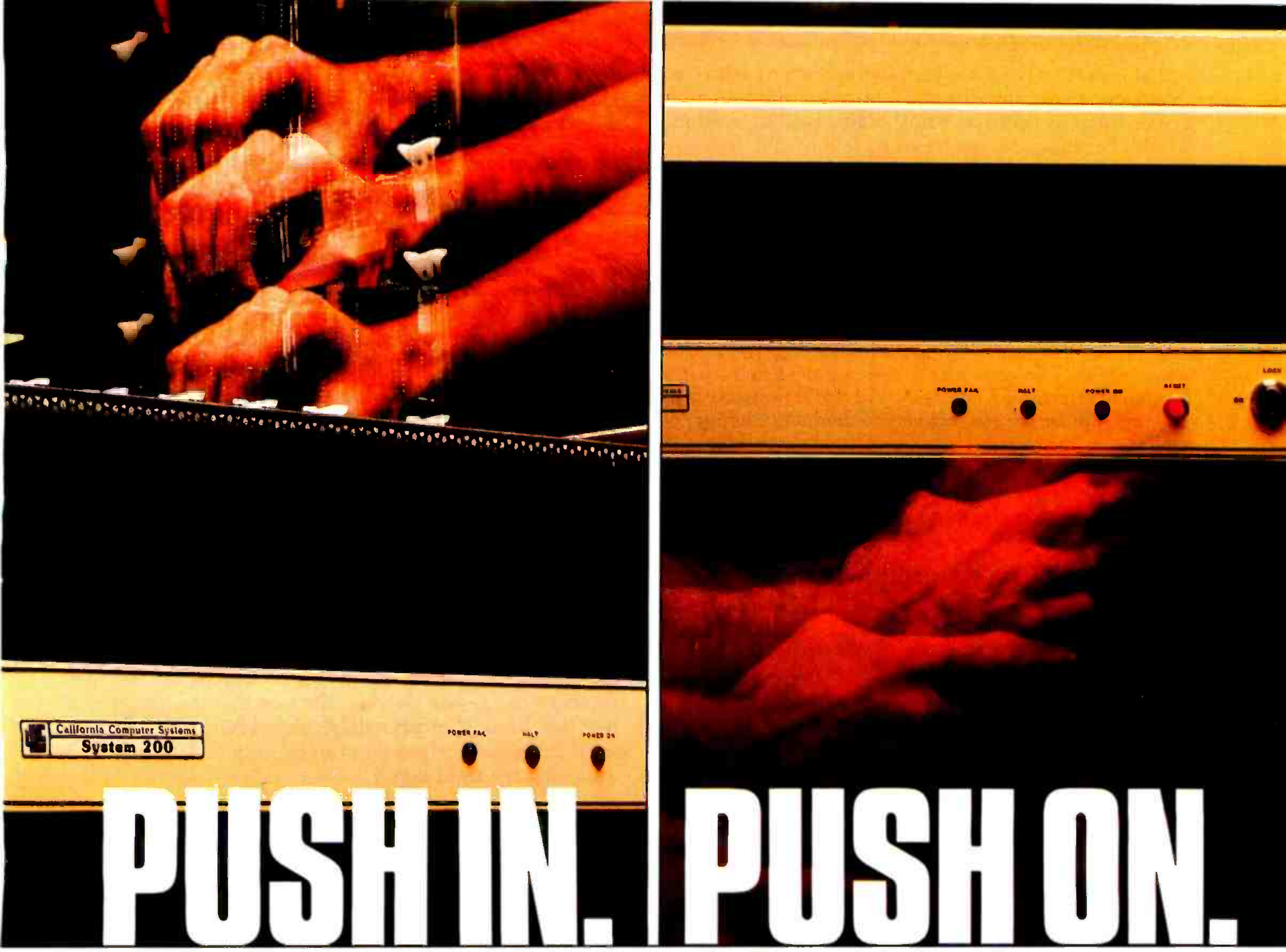
Programming this recurrence relation is not going to be much of a chore. The important thing to keep in mind is that three values must exist within the computer simultaneously: the $n$ and $(n+1)$ terms, and the sum of these two, which is the value being calculated. Then, after the value is found, it must be *slid* into the $(n+1)$ position, with that one being slid into the $n$ position. This sliding process is the only tricky part because it must be done in the proper order, and it is the heart of all recurrence programming.

Listing 1 shows how simple the job is. After initialization, the FOR...NEXT loop handles the calculation in 6 lines. The new term is calculated in line 160 and printed in line 170. The sliding process is done in lines 180 and 190. Note that A1 must be slid into A0 before A2 is slid into A1; otherwise, A1 will be lost. That, in principle, is all there is to programming recurrence relations.

## Forward and Backward Recurrence

Recurrence relations have a property that on first acquaintance seems absolutely incredible: if you go in the "right" direction, you increase the number of significant digits in your answer with every new term. This means that in certain cases you can start out with a completely arbitrary guess and, if you go long enough, end up with eight or nine significant digits in your final result! On the other hand, if you go in the "wrong" direction, you lose digits with each iteration and end up with garbage.

There is nothing at all mysterious about this property. If you think about the Fibonacci series, you will realize

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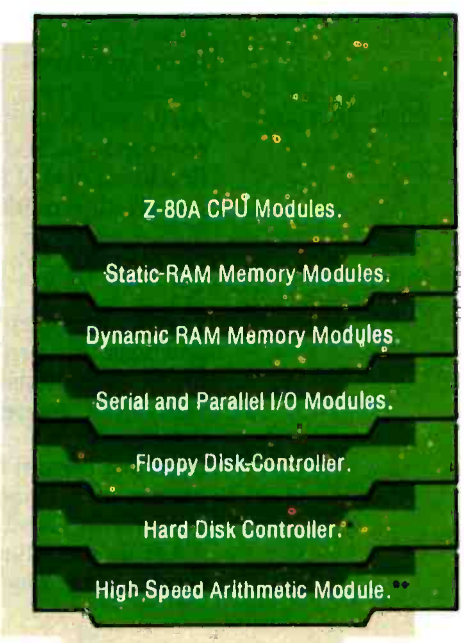


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that that is exactly what happens there. Starting with two numbers one digit long (0 and 1), you can build up after thirty or forty terms to as many digits as your machine will hold. For this case, we are going in the right direction because the answers get progressively larger as we calculate each new term.

In this case also, we are moving in the direction of increasing index, $n$. This is called *forward recurrence*. If we were to start out with a high-order pair of terms and calculate down towards zero, that would be called *backward recurrence*. For the Fibonacci series, backward recurrence is "wrong" (because you lose significant digits) and forward recurrence is "right" (because you gain them), but for some other functions the reverse is true.

**Listing 1:** *The Fibonacci numbers through recurrence. The Fibonacci numbers are used here to demonstrate how easy it is to program a recurrence relationship. All that is necessary is to keep proper order in the calculation and the shifting of variables.*

```
0010  REM
0020  REM *** FIBONACCI NUMBERS
0030  REM *** BY RECURRENCE RELATION.
0040  REM

0100  INPUT "HOW MANY FIBONACCI NUMBERS",N

0110  A0=0
0120  PRINT A0
0130  A1=1
0140  PRINT A1

0150  FOR I=1 TO N-2
0160  A2=A1+A0
0170  PRINT A2
0180  A0=A1
0190  A1=A2
0200  NEXT I

0210  END
```

**Listing 2:** *A Taylor's series program for the Bessel functions. Lines 160 thru 190 calculate the first term. (Line 160 should not be necessary, but many BASICs insist on executing a FOR...NEXT loop at least once, regardless of index and target.) This program is not recommended if the argument will ever exceed about five or ten, depending on your BASIC.*

```
0010  REM
0020  REM *** BESSEL FUNCTIONS, FIRST KIND, INTEGER
      ORDER
0030  REM *** BY TAYLOR'S SERIES.
0040  REM

0100  INPUT "ARGUMENT", X0
0110  INPUT "ORDER", N

0120  X=X0/2
0130  X2=X*X

0140  S=0
0150  T=1

0160  IF N=0 THEN 200
0170  FOR I=1 TO N
0180  T=X/I*T
0190  NEXT I

0200  FOR I=1 TO 999
0210  S=S+T
0220  T=-X2/I/(N+I)*T
0230  IF S<>S+T THEN NEXT I

0240  PRINT S
0250  END
```

**Of the various mathematical functions that can be calculated by recurrence, the ones with the greatest engineering utility are the Bessel functions.**

Putting it another way, if you lose digits going one way, it is because (and only because) you are subtracting nearly equal large numbers. Avoidance of that situation is one of the cardinal principles of numerical calculation. In this case, avoidance consists simply of going in the opposite direction, in which case you are adding the numbers instead of subtracting them.

But how do you know which direction to go in? Very simply, look in a mathematics handbook. If that fails, and you have no knowledge of function behavior to guide you, trial and error is a solution. Set the program up for forward recurrence (which usually is easier) and see whether the terms get larger or smaller. If they get smaller, you guessed wrong. (Be sure that the decrease is not just local. Unfortunately, global function behavior must be known before you can be fully certain that you are going the right way.)

## Bessel Functions

Of the various mathematical functions that can be calculated by recurrence, the ones with the greatest engineering utility are the Bessel and the Bessel-related functions. This is fortunate because many of these are strictly alternating series with no hope of argument scaling, and large arguments always seem to be the ones of greatest interest.

The family of Bessel functions includes many variations. There are the first, second, and third kinds; integer, fractional, and noninteger orders; and regular and modified types. The related functions include Kelvin, Airy, and Ricatti-Bessel. For now, though, we will be concerned exclusively with regular Bessel functions of the first kind, and of integer order. These arise as solutions of Bessel's differential equation:

$$x^2 \frac{d^2y}{dx^2} + x\frac{dy}{dx} + (x^2 - n^2)y = 0$$

This equation appears in a wide variety of engineering and scientific problems, such as heat transfer and membrane vibrations. It also shows up indirectly in the analysis of frequency-modulated signals. Any time cylindrical coordinates are used in analysis, Bessel's equation is almost certain to be involved somewhere. As a consequence of that fact, Bessel functions are also called (particularly in German) cylinder functions.

Let us see where the problem lies in computing these functions by Taylor's series. The Taylor's expansion is;

$$J_n(x) = \left(\frac{x}{2}\right)^2 \sum_{c=0}^{\infty} \left(\frac{-x^2}{4}\right)^i \times \left(\frac{1}{i!(n+i)!}\right)$$

This is clearly a strictly alternating series, and the critical

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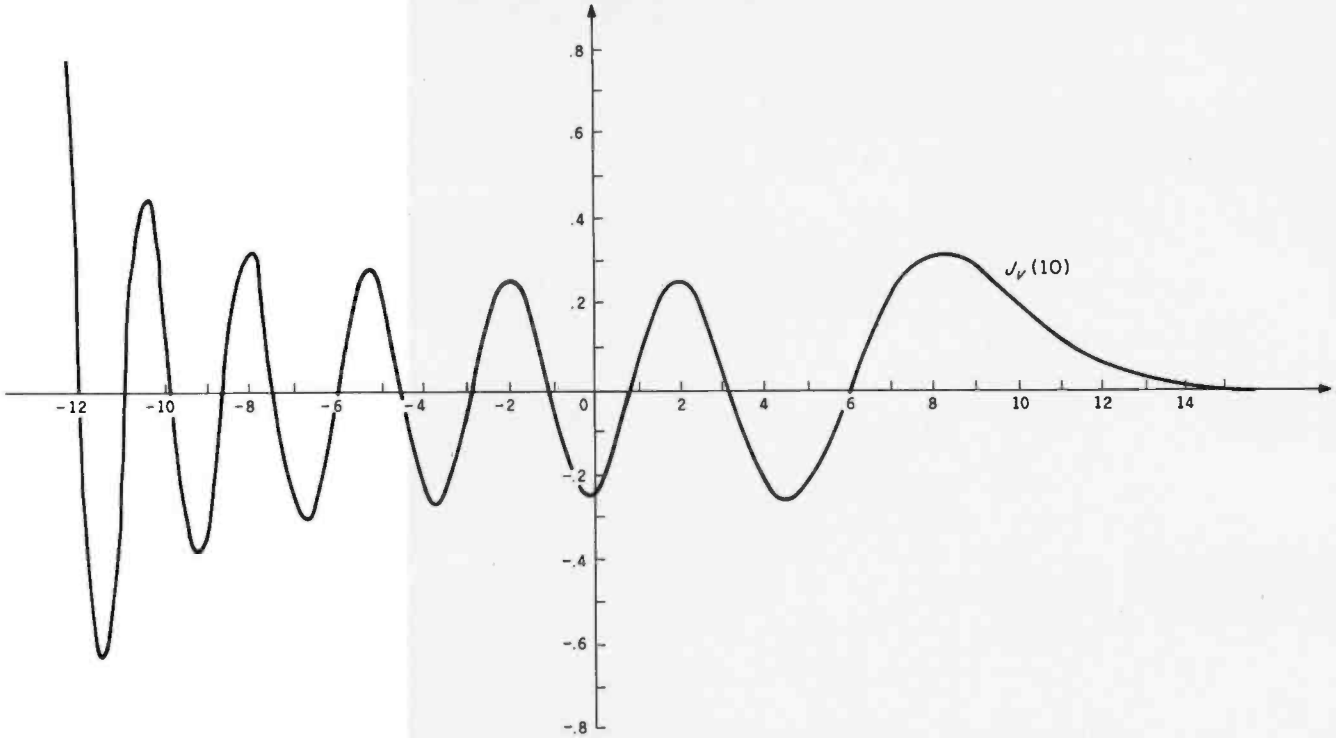


**Figure 1:** *The Bessel function of argument 10 and variable order v. When progamming a recurrence relation, information such as this is needed to determine whether to use backward or forward recurrence. Since the function goes to zero for large orders (values of v), we conclude that we need to use backward recurrence to achieve good accuracy. The Bessel function behaves similarly for other arguments: as soon as the order (v) exceeds the argument (x), the function rapidly declines to zero.*



argument occurs at $x=2$. But it is rare that one is satisfied with values that small.

Listing 2 is the program for this series. Keep in mind that the magnitude of the Bessel function can never exceed unity, and see where your machine starts to bomb. If you have double precision, you may want to see how much difference it makes. Recognize, too, that a range of $10^{38}$ can be a real limitation. For $x=100$, the largest term nearly reaches $10^{41}$. Depending on your BASIC, a maximum argument of five to ten is recommended.

### Bessel Recurrence Relation

Now to recurrence. The relation we will use is:

$$J_{n+1}(x) = (2n/x)J_n(x) - J_{n-1}(x)$$

and the first thing we need to know is which direction to go. This is a recurrence in order, not argument, so the question is whether the function increases or decreases as the order gets larger and the argument stays constant. Figure 1 (from the National Bureau of Standards handbook) answers this clearly. At large positive arguments, the function heads toward zero. This means that, when we want to calculate $J_n(x)$ for a given $n$, we must calculate higher-order values of $J(x)$ and use the recurrence formula to calculate down to order $n$.

The next problem is where to start. This is quite an involved question, and, unfortunately, there are no established answers.

Let us suppose we want to calculate $J_8(22)$. We have to start someplace above eight, but where, and with what? If we knew, for example, $J_{18}(22)$ by calculation, we would probably just as easily know $J_8(22)$ by calculation and

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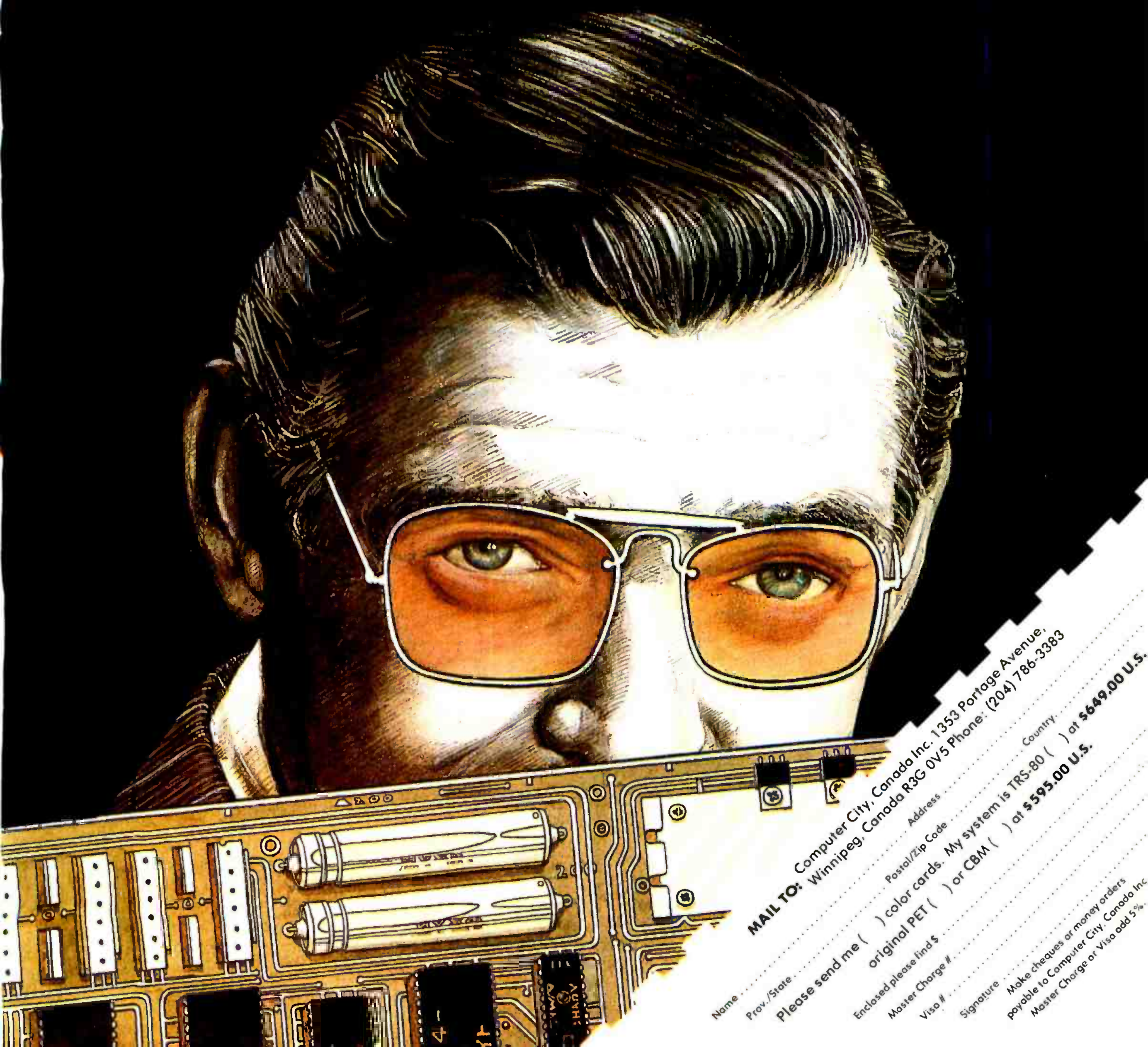

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would not need to use recurrence. We will make an arbitrary guess (using it and zero as the two numbers needed to start recurrence) and let the virtues of "right" recurrence provide our significant digits.

However, while it is true that recurrence can provide increased accuracy, this is true only relative to the initial guess, which was arbitrary. This means the result we get may be highly precise but completely inaccurate. What we look for, then, is some way of normalizing, or adjusting, the result. Perhaps somewhere in the process, or in the final answer, there is a clue to what the right output should be. If so, that clue can be used to give us the correct value.

## Normalizing Sum

The solution lies in one nice formula:

$$1 = J_0(x) + 2J_2(x) + 2J_4(x) + 2J_6(x) + \ldots$$

If we simply double each even term as we calculate it and add them all together, then subtract one zeroth term (because it is not doubled in the formula), we should get unity. If we do not (and we will not), divide the recurrence result by this sum and out comes a closer approximation to the correct answer.

This does mean, however, that every calculation will always have to proceed all the way to zero order. The formula also tells us how far up we must start: at an order high enough that its contribution to the sum will be negligible.

The full process goes like this: you begin by choosing an argument at random, then finding the highest order that makes a difference in the total sum. If the total sum is greater than 1.00, divide the beginning argument by this number and repeat the process. The final result should be a beginning argument and an order high enough so that two conditions are true: first, that the next higher-order term does not contribute significantly to the sum; and second, that the sum is approximately equal to 1.00.

You will find that the starting point depends both on the argument and the order of the answer you desire. Larger arguments always require higher starting points, as do higher orders. But the relationship is not simple, and no single equation will fit all points exactly. If the equation must err (and it must), it is best that it do so on the high side, although it should not be too far on the high side.

If the starting point is too low, the normalizing sum is inaccurate, degrading the answer. If it is too high, execution time becomes excessive and you run the risk of exceeding your machine's range. (The sum can grow very quickly.) Note, however, that it is the normalizing sum, not the recurrence calculation, that is the main source of trouble. Recurrence starts with an arbitrary guess anyway and goes in the "right" direction (backward), so accuracy is not an issue here (with one important exception that will be explained later).

Programming all of this—except for the equation derivation—really is not too difficult, but it is messy and time-consuming. Fortunately, it has been gone through by various mathematicians, and formulas do exist for finding the starting order. The results listed will vary, though, depending on the number of significant digits in the particular machine they were developed for.

Table 1 gives the raw data rounded to the next higher even integer of the starting order necessary for ten-place accuracy. This information was compiled by Samuel G Allen of New York on an SR-56 pocket calculator. From

| n \ i | 1 | 5 | 10 | 15 | 20 | 25 | 30 | 35 | 40 | 45 | 50 | 55 | 60 | 65 | 70 | 75 | 80 | 85 | 90 | 95 | 100 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | | | | 36 | 38 | 50 | 56 | 64 | 70 | 76 | 86 | 88 | 94 | 98 | 104 | 110 | 116 | 122 | 128 | 134 | 138 |
| 15 | 22 | 24 | 30 | 36 | | | | | | | | | | | | | | | | | |
| 17 | 24 | 28 | 32 | 36 | | | | | | | | | | | | | | | | | |
| 20 | 26 | 30 | 36 | 38 | 38 | | | | | | | | | | | | | | | | |
| 25 | 30 | 36 | 38 | 42 | 44 | 50 | | | | | | | | | | | | | | | |
| 30 | 36 | 40 | 42 | 44 | 46 | 52 | 56 | | | | | | | | | | | | | | |
| 35 | 40 | 44 | 46 | 48 | 48 | 54 | 58 | 64 | | | | | | | | | | | | | |
| 40 | 46 | 48 | 50 | 54 | 56 | 58 | 60 | 64 | 70 | | | | | | | | | | | | |
| 45 | 54 | 54 | 56 | 58 | 60 | 62 | 64 | 68 | 70 | 76 | | | | | | | | | | | |
| 50 | 58 | 58 | 60 | 62 | 64 | 66 | 68 | 70 | 74 | 78 | 86 | | | | | | | | | | |
| 55 | 62 | 64 | 64 | 66 | 68 | 70 | 72 | 74 | 78 | 80 | 86 | 88 | | | | | | | | | |
| 60 | 66 | 68 | 70 | 72 | 74 | 76 | 78 | 80 | 80 | 82 | 86 | 90 | 94 | | | | | | | | |
| 65 | 70 | 72 | 72 | 76 | 78 | 80 | 82 | 84 | 84 | 86 | 88 | 92 | 94 | 98 | | | | | | | |
| 70 | 74 | 76 | 78 | 80 | 82 | 84 | 86 | 88 | 88 | 90 | 92 | 94 | 96 | 102 | 104 | | | | | | |
| 75 | 80 | 82 | 84 | 84 | 86 | 88 | 88 | 90 | 92 | 94 | 96 | 98 | 100 | 104 | 106 | 110 | | | | | |
| 80 | 86 | 86 | 88 | 90 | 90 | 92 | 94 | 96 | 98 | 98 | 100 | 102 | 104 | 106 | 108 | 112 | 116 | | | | |
| 85 | 92 | 92 | 92 | 94 | 96 | 98 | 98 | 100 | 102 | 104 | 106 | 106 | 106 | 108 | 112 | 116 | 118 | 122 | | | |
| 90 | 96 | 96 | 98 | 100 | 100 | 102 | 104 | 104 | 106 | 108 | 110 | 110 | 110 | 112 | 116 | 118 | 120 | 122 | 128 | | |
| 95 | 100 | 100 | 102 | 104 | 106 | 106 | 106 | 108 | 110 | 112 | 114 | 116 | 116 | 116 | 118 | 122 | 124 | 126 | 130 | 134 | |
| 100 | 104 | 104 | 106 | 108 | 110 | 110 | 112 | 112 | 114 | 116 | 118 | 120 | 120 | 120 | 122 | 126 | 126 | 128 | 132 | 134 | 138 |

| n \ i | 0.1 | 0.5 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 6 | 8 | 10 | 14 | 16 | 18 | 20 | 22 | 24 | 26 | 26 | 28 | 30 | 32 |
| 1 | 6 | 10 | 10 | 14 | 16 | 18 | 20 | 22 | 24 | 26 | 26 | 28 | 30 | 32 |
| 2 | 8 | 10 | 12 | 14 | 16 | 18 | 20 | 22 | 24 | 26 | 26 | 28 | 30 | 32 |
| 4 | 10 | 12 | 12 | 14 | 16 | 18 | 20 | 22 | 24 | 26 | 26 | 28 | 30 | 32 |
| 6 | 12 | 12 | 14 | 14 | 18 | 18 | 20 | 22 | 24 | 26 | 26 | 28 | 30 | 32 |
| 8 | 12 | 14 | 16 | 16 | 18 | 20 | 22 | 22 | 24 | 26 | 26 | 28 | 30 | 32 |
| 10 | 14 | 16 | 18 | 18 | 20 | 22 | 22 | 24 | 26 | 26 | 26 | 28 | 30 | 32 |

**Table 1:** *Raw data used by S G Allen to derive his equation for the starting order of the recurrence relation.*

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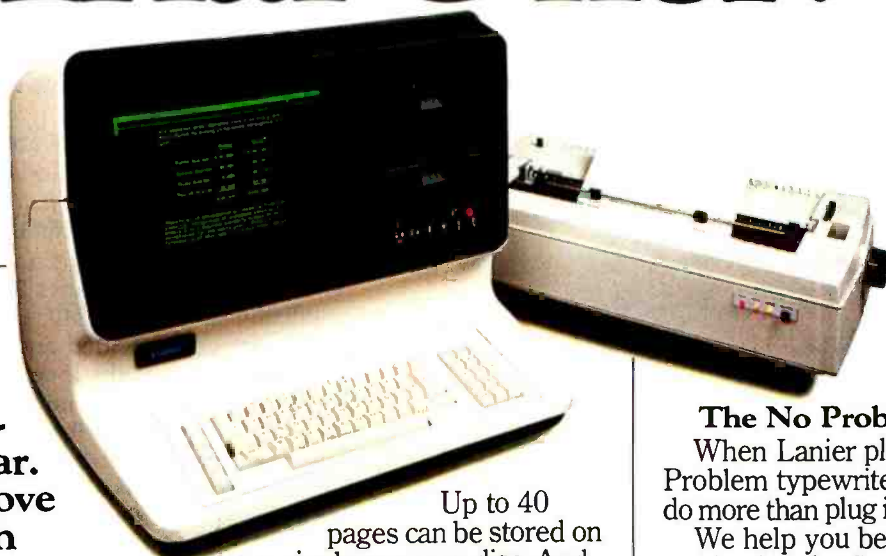

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**Listing 3:** *Generating Bessel functions by recurrence. This one is slower than Taylor's series for small arguments, but is vastly more accurate for large ones. Within the accuracy range of a machine, no limit has been found on maximum order or argument.*

```
0010  REM
0020  REM *** BESSEL FUNCTIONS, FIRST KIND, INTEGER
      ORDER
0030  REM *** BY RECURRENCE RELATION.
0040  REM

0100  INPUT "ARGUMENT", X0
0110  INPUT "ORDER", N

0120  X=X0
0130  IF ABS(X)<1.E-10 THEN X=1.E-10

0140  Y=X
0150  IF N>X THEN Y=N
0160  N9=INT(Y+3*SQR(X)+9)

0170  J9=0
0180  J8=1.E-30
0190  S=0

0200  FOR I=N9 TO 0 STEP -1
0210  J7=2*I/X*J8-J9
0220  J9=J8
0230  J8=J7
0240  IF INT(I/2)=I/2 THEN S=S+2*J9
0250  IF I=N THEN J=J9
0260  NEXT I

0270  S=S-J9
0280  J=J/S
0290  PRINT J
0300  END
```

the data, he derived a fairly simple equation which errs conservatively by about ten percent in the region $N=4X$. The equation is as follows:

$$N9 = int(max(N,X) + 3\sqrt{X} + 9)$$

which is implemented in lines 140 thru 160 of listing 3.

## Program Comments

If you have followed the discussion to this point, the program in listing 3 should be straightforward. Lines 140 thru 160 calculate the starting order, and lines 170 thru 190 do the initialization. Note that the arbitrary guess for J8 ($J_n(x)$) is $1.0 \times 10^{-30}$. It is chosen small (and can be much smaller if your range goes to $10^{-99}$), so that large arguments can be accommodated without overflowing the normalizing sum. J9 ($J_{n+1}(x)$) is initialized to zero, which reflects the assumption that the next higher term is too small to be significant.

The recurrence loop (lines 200 thru 260) includes the normalizing sum at line 240. Line 250 picks out the particular order you specified and stores it as variable J.

After exiting from the loop, line 270 subtracts a zero-order term from the sum, and line 280 divides the chosen value by S to normalize it properly.

One fact has not yet been mentioned: the recurrence relation involves a division by $x$, so that $x=0$ causes an error message. But this is a perfectly legitimate argument at any order, so line 130 assigns a small value instead. It cannot be too small, though, or overflow will occur rapidly because of that division by $x$.






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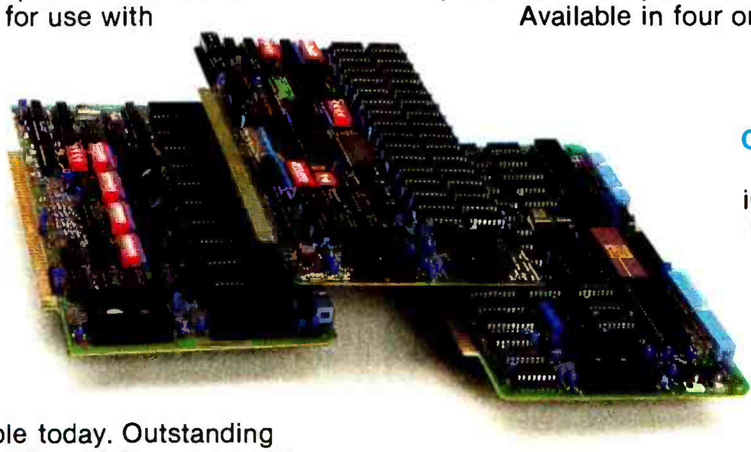

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Altering this program to give a complete array of Bessel functions of various orders for a given argument is easy. Simply define an array of dimension N+1 and start storing values when the variable I becomes equal to N. At the end, each value must be divided by S.

You will find that execution time for this program is quite long. For small $x$, the Taylor's series is much faster and therefore may be preferred for arguments that are guaranteed restricted. When in doubt, use the recurrence method (listing 3).

### Negative Orders

Note from figure 1 that the behavior at negative orders is very different than that of positive orders. So, instead of trying to adapt listing 3 to handle negative N, use the absolute value of N for N and transform the output by the relationship:

$$J_{-n}(x) = (-1)^n \times J_n(x)$$

### How Accurate Is It?

There is only one practical way to check accuracy on a routine like this: compare the results against known values in a published table. But that creates a problem because available tables give out before the program does. The massive compilation by the staff of the Harvard Computation Laboratory (Harvard: 1947) goes up to $x=100$ and $n=135$.

The most sensitive test, though, is to check in the region of the zeros at various orders. The Bessel functions look like damped sine or cosine waves, crossing zero at intervals that look as though they might be periodic. (However, they aren't and the exact locations of the zeros is of considerable interest to mathematicians.) Obviously, if you put in an argument that is supposed to be at a zero of the function, you expect to get a result of zero. This is unlikely for two reasons:

**The most sensitive test is to check in the region of the zeros of the function.**

- The locations of the zeros are transcendental numbers and cannot be specified exactly. The theoretical result, then, should not be exactly zero.
- Backward recurrence is "right" only when the function increases as you proceed in that direction. But at a zero, the function suddenly nosedives down (see figure 1). Here, $(2n/x) \times J_n(x)$ is supposed to equal $J_{n+1}(x)$, so their difference is zero. This is subtraction of nearly equal large numbers, which usually results in a small truncation error.

For the above reasons, all errors and inaccuracies accumulate at the zeros. In particular, truncation errors show up flagrantly here. Not only does truncation cause the output to be nonzero, it actually translates the apparent location of the zero to a lower value. The truncation is not really bad (it usually affects only the last digit), but those interested in the mathematical properties of Bessel functions should be aware that this bias does exist.

With that background, we can state that the accuracy of the program of listing 3 on a nine-digit truncating BASIC is seven to eight decimal digits. Note that I said *decimal* digits, not *significant* digits. As far as I can determine, the seventh digit after the decimal point is good to within one count anyplace, including zeros. Away from the zeros, the eighth digit appears good to within one count. This includes any $x$ or $n$ up to one hundred, based on spot and systematic checks against the Harvard tables.

Using the Royal Society tables of zeros, further checks can be made under worst-case conditions. For example, the forty-eighth zero of order 19 occurs at $x=178.846699$. The actual output there is $7.6 \times 10^{-8}$, which will cause the seventh digit to be off by one count. Worse errors may be possible, but this one is the largest I found.

Other BASICs with fewer digits should have similar properties: about a two-digit loss as long as the range is not exceeded by the normalizing sum. For engineering use, this should be entirely adequate.■


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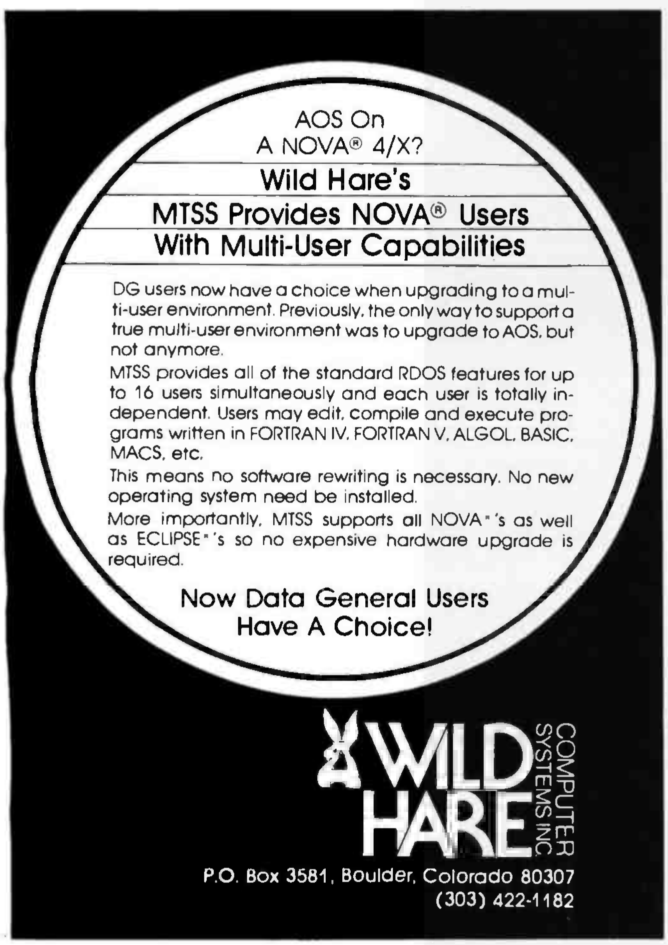
1. Abramowitz, M and I A Stegun. *Handbook of Mathematical Functions with Formulas, Graphs, and Mathematical Tables*. Washington: National Bureau of Standards, 1964.

2. Harvard Computational Laboratory Staff. *Tables of the Bessel Functions of the First Kind*. Cambridge: Harvard University Press, 12 volumes, 1947 and following years.

3. Olver, F W J (editor). *Royal Society Mathematical Tables, Volume 7: Bessel Functions Part III, Zeros and Associated Values*. New York: Cambridge University Press, 1960.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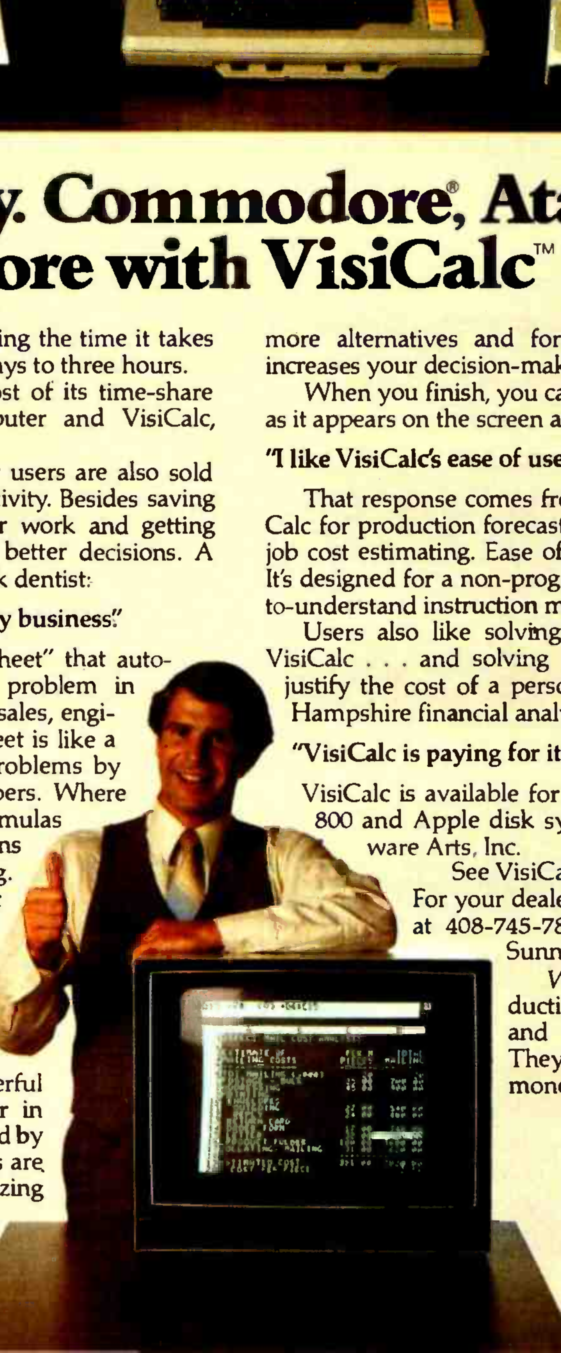

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# Programming Quickies

# Apple Name-Address

Gary Stotts, 10390 Owens Cr, Broomfield CO 80020

Name-Address is a program that will store up to 100 names, addresses, and telephone numbers. It is written for the Apple personal computer and requires one disk drive. The program is organized as a binary tree so that names can be entered in any order and stored in alphabetical order. A larger number of names and addresses can be stored by changing the DIM statements in lines 30 thru 90.

The program first asks if there is an address file. Next the menu appears as follows:

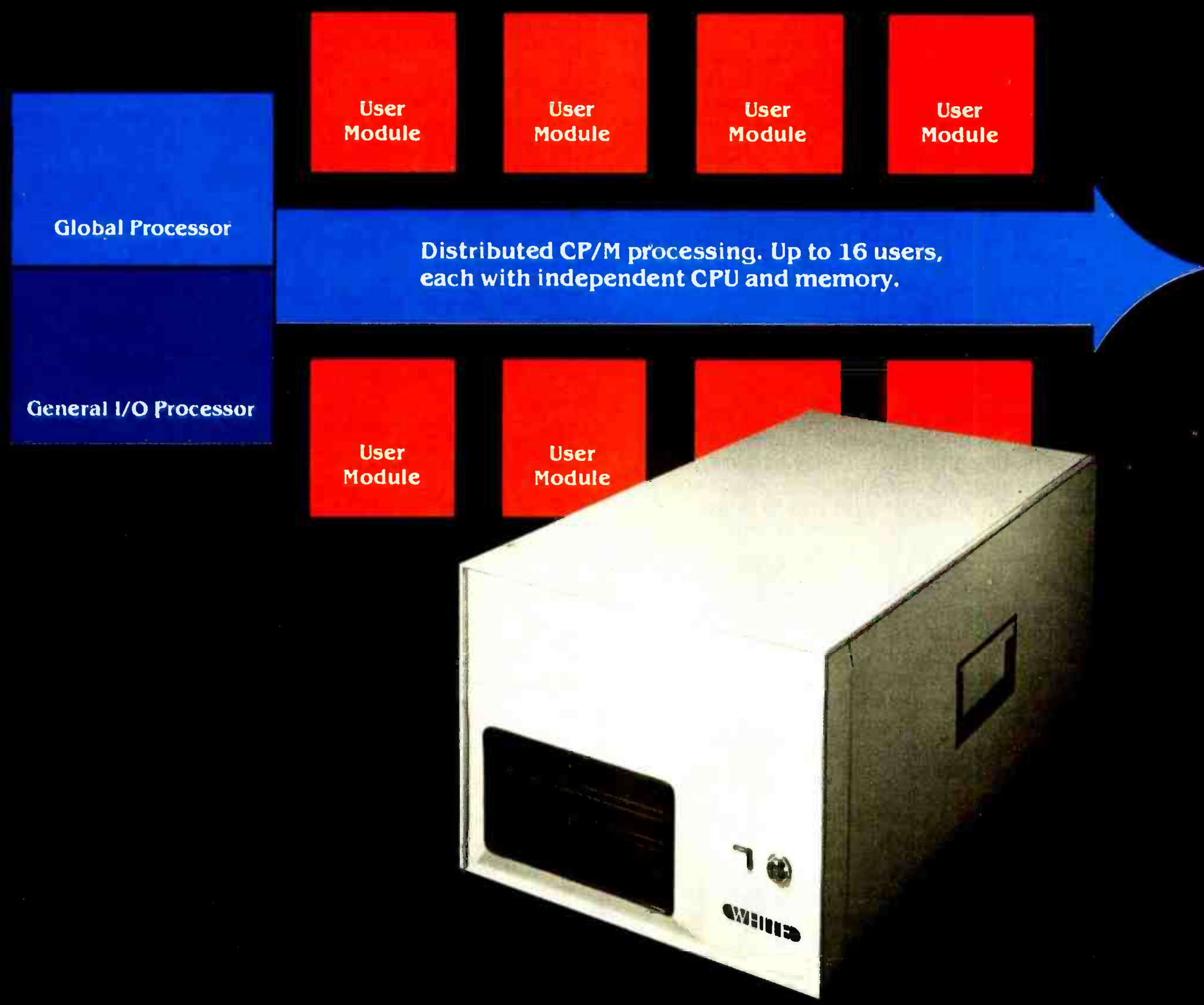
1 - Add a Name
2 - List a Name
3 - List All Names
4 - Change a Name
5 - End

The required entries to add or change a name-address record are the name, the street address, the city-state-zip, and the telephone number. To list any one address, enter the name. The name must be entered as last name first with no commas. Option 5, "END", will always create a new name-address file.■

**Listing 1:** *Name-Address—a program for the Apple II that will store up to 100 entries, as shown here. More entries can be stored by changing the DIM statements in lines 30 thru 90.*

```
10  REM  BINARY TREE NAME/ADDRESS FILE
20  REM  AUTHOR GARY A STOTTS
30  DIM N$(100): REM  NAME ARRAY
40  DIM A$(100): REM  ADDRESS ARRAYS
50  DIM B$(100)
60  DIM L%(100): REM  LEFT LINK ARRAY
70  DIM R%(100): REM  RIGHT LINK ARRAY
80  DIM P$(100): REM  PHONE # ARRAY
90  DIM S%(50): REM  STACK ARRAY
100 D$ =  CHR$ (4)
110  PRINT D$;"OPEN NAMADR, S6, D1"
120  CALL  - 936: INPUT "IS THERE AN ADDRESS FILE (Y/N) ";Y$
130  IF Y$ = "N" THEN 200
140  PRINT D$;"READ NAMADR"
150  INPUT E
160  FOR I = 1 TO E
170  INPUT N$(I): INPUT A$(I): INPUT B$(I): INPUT P$(I): INPUT L%(I): INPUT R%(I)
180  NEXT
190  PRINT D$
200  CALL  - 936: PRINT  TAB( 7);"NAME/ADDRESS PROGRAM": PRINT
210  PRINT "1 - ADD A NAME"
220  PRINT "2 - LIST A NAME"
230  PRINT "3 - LIST ALL NAMES"
240  PRINT "4 - CHANGE A NAME"
250  PRINT "5 - END"
260  PRINT : INPUT "   ENTER YOUR SELECTION ";A$:M1 =  VAL (A$)
270  IF M1 < 1 OR M1 > 5 THEN 260
280  ON M1 GOSUB 320,720,930,1120,1340
290  GOTO 200
300  REM
310  REM  ADD A NAME SUBROUTINE
320  CALL  - 936: PRINT  TAB( 7);"ADD NAME RECORD": PRINT
330 E = E + 1: REM  FIRST EMPTY POSITION IN LIST
340 I = 1: REM  START SEARCH AT ROOT
350  INPUT "ENTER NAME ";N1$
380  IF  LEN (N1$) < 1 THEN 350
370  INPUT "ENTER STREET ADDRESS ";A1$
380  IF  LEN (A1$) < 1 THEN 370
390  INPUT "ENTER CITY-STATE-ZIP ";B1$
400  IF  LEN (B1$) < 1 THEN 390
410  INPUT "ENTER PHONE NUMBER ";P1$
420  REM  IF NAME IS LARGER THAN ITH, SEARCH RIGHT BRANCH
430  IF N1$ > N$(I) THEN 600
440  IF N1$ <  > N$(I) THEN 480
450  PRINT "DUPLICATE NAME"
460  INPUT "ENTER C TO CONTINUE ";C$
470  RETURN
480  REM  IF LEFT LINK NOT NULL, SEARCH LEFT BRANCH
490  IF L%(I) <  > 0 THEN I = L%(I): GOTO 430
500  REM  HANG NEW LEFT LINK ON PRIOR
510 L%(I) = E
520 N$(E) = N1$: REM  FILL NEW RECORD
530 A$(E) = A1$
540 B$(E) = B1$
550 L%(E) = 0
560 R%(E) = 0
570 P$(E) = P1$
580  RETURN
590  REM  IF RIGHT LINK NOT NULL, SEARCH RIGHT BRANCH
600  IF R%(I) <  > 0 THEN I = R%(I): GOTO 430
610  REM  HANG NEW RIGHT LINK ON PRIOR
620 R%(I) = E
630 N$(E) = N1$: REM  FILL NEW RECORD
640 A$(E) = A1$
650 B$(E) = B1$
660 L%(E) = 0
670 R%(E) = 0
680 P$(E) = P1$
690  RETURN
700  REM
710  REM  LIST A NAME SUBROUTINE
720  CALL  - 936: PRINT  TAB( 7);"LIST A NAME/ADDRESS"
730  PRINT : INPUT "ENTER NAME TO LIST ";N1$
740  IF  LEN (N1$) < 1 THEN 720
750 I = 1
760  IF N1$ > N$(I) THEN 870
770  IF N1$ <  > N$(I) THEN 850
780  PRINT N$(I): REM  FOUND
790  PRINT A$(I)
800  PRINT B$(I)
810  PRINT P$(I)
820  PRINT : INPUT "KEY C TO CONTINUE ";C$
830  RETURN
840  REM  SEARCH LEFT
850  IF L%(I) <  > 0 THEN I = L%(I): GOTO 760
860  REM  SEARCH RIGHT
870  IF R%(I) <  > 0 THEN I = R%(I): GOTO 760
880  REM
890  PRINT "NAME NOT FOUND"
900  RETURN
910  REM
```

*Listing 1 continued on page 34*

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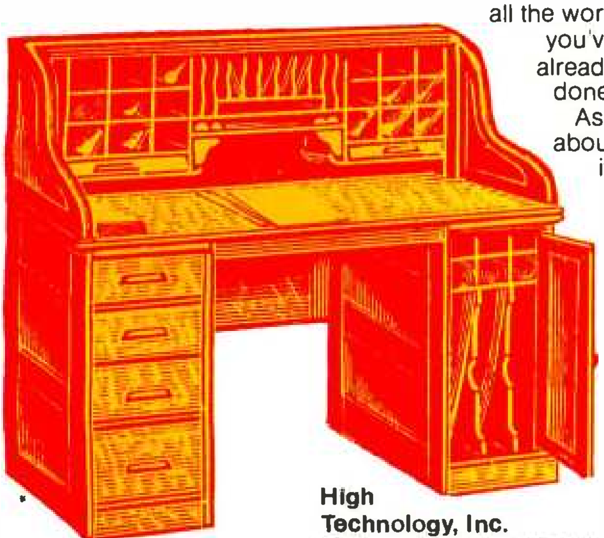






*Listing 1 continued:*

```
920  REM  LIST ALL NAMES SUBROUTINE
930 P = 1:L1 = 0:T = 0: CALL  - 936
940 T = T + 1
950 S%(T) = P: REM  PUSH STACK
960  IF P <  > 0 THEN P = L%(P): GOTO 940
970 T = T - 1
980  IF T <  = 0 THEN  INPUT "ENTER C TO CONTINUE ":C$: RETURN : REM   ALL NAME FOUND
990 P = S%(T): REM  POP STACK
1000  PRINT N$(P): REM  PRINT NAME
1010  PRINT A$(P)
1020  PRINT B$(P)
1030  PRINT P$(P)
1040  PRINT
1050 L1 = L1 + 5
1060  IF L1 = 20 THEN L1 = 0: INPUT "ENTER C TO CONTINUE ":C$
1070 T = T - 1
1080 P = R%(P): REM  CHECK FOR RIGHT LINK
1090  GOTO 940
1100  REM
1110  REM  CHANGE AN ADDRESS
1120  CALL  - 936: PRINT  TAB( 7);"CHANGE A NAME/ADDRESS": PRINT
1130  INPUT "ENTER NAME TO CHANGE ":N1$
1140  IF  LEN (N1$) < 1 THEN 1120
1150 I = 1
1160  IF N1$ > N$(I) THEN 1310
1170  IF N1$ <  > N$(I) THEN 1290
1180  PRINT "OLD ":A$(I)
1190  INPUT "NEW ":A$(I)
1200  IF  LEN (A$(I)) < 1 THEN 1190
1210  PRINT "OLD ":B$(I)
1220  INPUT "NEW ":B$(I)
1230  IF  LEN (B$(I)) < 1 THEN 1220
1240  PRINT "OLD ":P$(I)
1250  INPUT "NEW ":P$(I)
1260  PRINT
1270  RETURN
1280  REM  SEARCH LEFT
1290  IF L%(I) <  > 0 THEN I = L%(I): GOTO 1160
1300  REM  SEARCH RIGHT
1310  IF R%(I) <  > 0 THEN I = R%(I): GOTO 1160
1320  REM
1330  REM  EOJ
1340  PRINT D$:"DELETE NAMADR"
1350  PRINT D$:"OPEN NAMADR"
1360  PRINT D$:"WRITE NAMADR"
1370  PRINT E
1380  FOR I = 1 TO E
1390  PRINT N$(I): PRINT A$(I): PRINT B$(I): PRINT P$(I): PRINT L%(I): PRINT R%(I)
1400  NEXT
1410  PRINT D$:"CLOSE"
1420  END
```

# A Graphic Execution Display

R B Minton, 8617 E Stearn Lake Dr, Tucson AZ 85730

I wrote a program for my Ohio Scientific Superboard to compute artificial satellite orbits and noted it ran slower and slower as time and the number of orbits progressed.

It occurred to me that I could graphically display how fast the program was executing and find out where it was slowing down by adding some extra code. Every 20 lines or so, I inserted K9=K9+1:GOSUB 2000, and then at the end:

```
2000  S9=54244
2010  POKE S9+K9,48+K9
2020  FOR Z=1 TO 30:NEXT Z
2030  POKE S9+K9,32
2040  IF K9=9 THEN K9=0
2050  RETURN
```

This flashes the numbers 1 thru 9 from left to right on the bottom row of the video screen every time the main portion of the program loops. You can easily note the delay between certain numbers; this helps to pinpoint where the program is spending most of its time. The troublesome area or line can be further narrowed down by adding more GOSUBs, or by moving those from the faster part to the slower part. (Be sure that there are nine GOSUBs and that each is executed only once within the loop.)

This method alerted me to a poorly written line of code I would have otherwise never suspected. ■

# Build a Low-Cost Logic Analyzer

Steve Ciarcia
POB 582
Glastonbury CT 06033

The Digital Age has spawned a variety of electronic troubleshooting aids, including logic probes, integrated-circuit test clips, multi-trace oscilloscopes, and logic analyzers. All are useful, up to a point, but it is important to know when to use a particular test instrument and how much you can depend on it.

If the logic states of signal lines were the only information needed, a simple voltage measurement would suffice in digital troubleshooting. But *timing*, rather than absolute voltage level, is the more important consideration in digital systems. Most digital systems operate by setting discrete logic conditions on bus lines and then *strobing* that data through the system at the occurrence of edges of specific clock pulses. A system operates correctly only if all the parallel states are set correctly at a specific instant in time. The system fails if any single logic state is in error at any clock time during program execution.

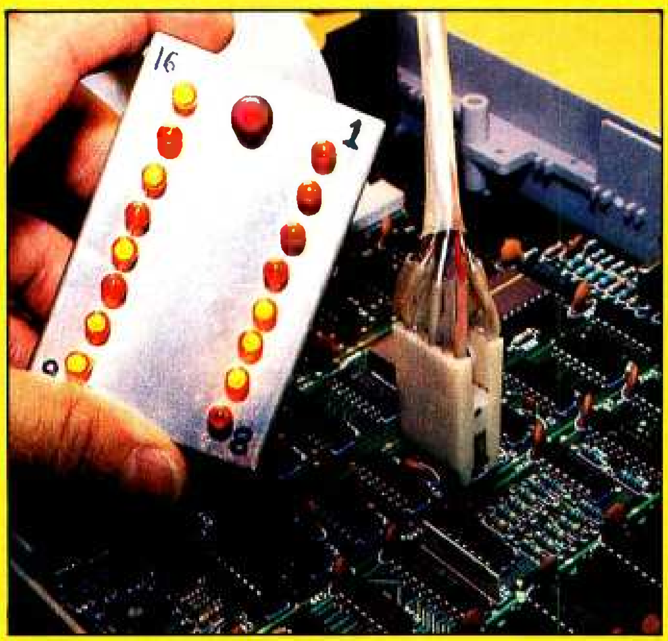



**Photo 1:** *One frequently used test instrument is a direct-reading state indicator. The sixteen indicators are transistor-driven incandescent lamps or LEDs (light-emitting diodes). The indicator panel is attached to a "chip-clip" connector so that the logic states on any TTL (transistor-transistor logic) or LS (low-power Schottky-diode-clamped) TTL dual in-line package can be read while the circuit is energized. The display is most valid for static conditions.*

The first special digital instrument was the logic probe. A schematic diagram of a typical logic probe is shown in figure 1. This device accurately indicates the logic state on LED (light-emitting diode) indicators at any selected point in a circuit. However, it is a static device and will not follow rapidly clocked digital logic other than to indicate general activity. Even when the concept is expanded to include fourteen or sixteen separate indicators on the probe (as shown in photo 1), effective use still depends on stopping the system clock (or slowing it substantially) to examine static logic states. Unfortunately, stopping the clock changes the dynamics of circuit operation and may, in many instances, mask the true cause of problems.

More frequently, digital-logic errors are dynamic and occur during clock-state transitions. The errors are often due to timing problems associated with the propagation of signals through the circuit or with miscuing of multiplexed components. Because the logic state at clock transitions often determines either proper operation or failure, a more suitable test instrument would be one that provides the operator with a view of all logic activity coincident with the transition of the clock.

To most people this sounds like a job for a multi-trace oscilloscope with its sweep triggered from the system clock. An oscilloscope can in many instances be of value, but unless it is an expensive storage-tube scope, fast system-clock rates can make viewing difficult. Also, viewing two signals with respect to each other in real time is of little help when the error occurs intermittently and involves more signals than can be viewed simultaneously.

### What Is a Logic Analyzer?

One solution to the digital-troubleshooting dilemma is called a logic analyzer. This is an instrument that displays a "truth table" of the activity of the digital circuit being tested under actual operating conditions. After you have selected a key combination of input signals, called a *trigger* or *sync word*, and activated the analyzer, it stores all signal-input logic states for a specific number of system-clock transitions. Depending upon the sophistication of the particular unit, many commercial logic analyzers can accommodate 32 or more inputs and store up to 256 clock cycles before and after the trigger event.

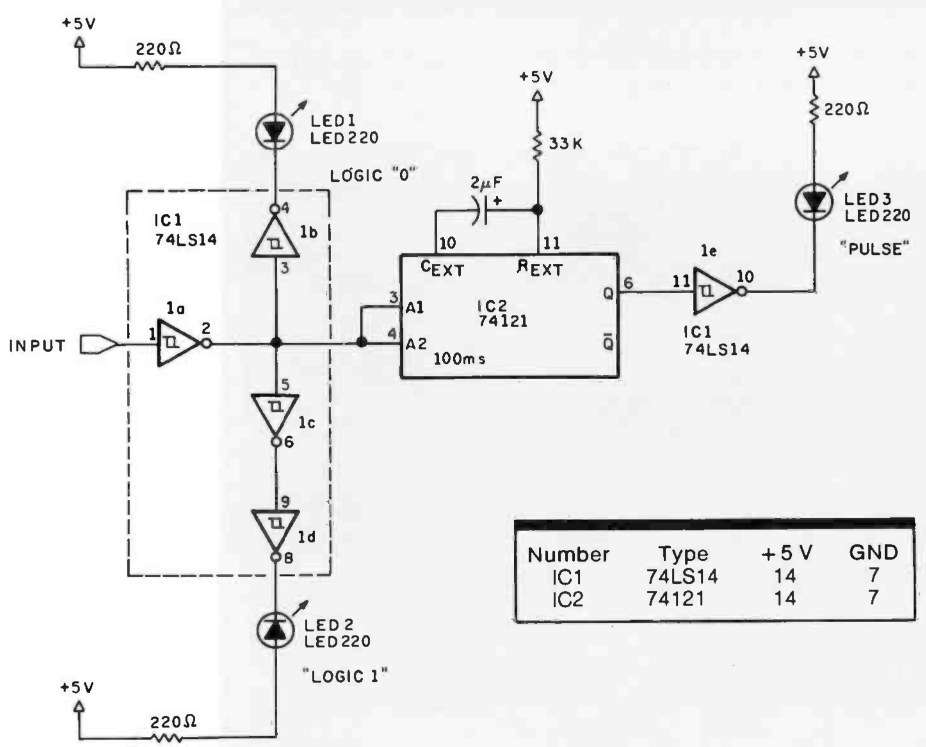
**A logic analyzer acts like an electronic time machine.**

In effect, a logic analyzer acts like an electronic time machine. When sequentially displayed in the order it was acquired, the stored data can be used to form state tables or timing diagrams of the circuit's operation.

For example, a logic analyzer might be used to troubleshoot a malfunctioning microcomputer I/O (input/output) port that keeps receiving consistent but wrong data. You don't know whether the error is caused by the wrong data being sent to the output register or by an incorrect address signal strobing the register at the wrong time (try troubleshooting this kind of problem with just an oscilloscope). You can find out by connecting the logic analyzer to the address and data buses of the microcomputer.

Set the trigger-word switches to produce a trigger pulse when the address bus contains the I/O port address. When the trigger pulse occurs, you can examine the logic states on the data bus with the analyzer to see what value was being loaded into the port register at the occurrence of the trigger pulse, as well as those states following the pulse. It is like having an 8- to 32-channel oscilloscope with the display frozen in time on a specific clock cycle.

Commercial logic analyzers are generally stand-alone instruments with integral video-monitor or oscilloscope displays. They can present stored data in a variety of ways. A *data-domain* analyzer ordinarily displays logic states as lists of 1s and 0s. The listings are sequential and in either binary, octal, or hexadecimal format. This display method is particularly helpful when you are debugging address-bus problems. In such cases, data is most easily read as




| Number | Type | +5 V | GND |
|---|---|---|---|
| IC1 | 74LS14 | 14 | 7 |
| IC2 | 74121 | 14 | 7 |

**Figure 1:** *A simple logic probe that uses two integrated circuits. When a logic-0 signal voltage is applied to the input, the "logic 0" LED will light. When a logic-1 signal voltage is applied to the input, the "logic 1" LED indicator will light. If the input oscillates between the 0 and 1 states, the "Pulse" LED indicator will also light.*

4-digit hexadecimal values.

For hardware troubleshooting, a *time-domain* analyzer is preferred. This unit presents the stored data in timing-diagram format. The result appears like the display of an 8- or 16-channel oscilloscope. The vertical scale has a high-voltage value that represents a logic 1 and a low-voltage value that represents a logic 0. The data signals are plotted with respect to each other and can be displayed as a function of actual time.

A third data format is the *mapped* mode. Essentially, the display screen is divided into an $x$, $y$ coordinate system, and data points are plotted as dots on the screen. In some units, vectors between dots connect successive data points so that it is easier for an operator to trace sequential activity in the device under test. The process of interpreting this kind of display is essentially one of recognizing a "good" pattern and identifying wild vectors. Presumably, a properly operating program will have a repeatable pattern. Any discrepancies will show up as an extra dot or "wild vector."

The various types of logic-analyzer display formats are shown in figure 2 on page 40.

Regardless of the display format, all logic analyzers share a common internal structure. Generally, they incorporate the subsystems outlined in the block diagram of figure 3. All logic analyzers have some form of input conditioning, trigger-word selection and comparison, memory, and display (LEDs, oscilloscope, or raster-display tube, etc). The combination of capabilities is usually a function of price, which can range from $2500 to $10,000.

## A Low-Cost Logic Analyzer

Obviously, we cannot hope to construct a logic analyzer that is equivalent to an $8500 Hewlett-Packard unit. However, we can design a special logic analyzer as a peripheral device of a personal computer. By utilizing the display and processing power of the computer, we can greatly enhance the capabilities of a relatively simple hardware interface. Also, for those readers interested in the concept but not quite ready to grab their soldering irons, I will outline a method that demonstrates how to use your present computer to perform logic-analyzer functions totally in software. First, the hardware approach.

Figure 4 is the schematic diagram of a low-cost eight-input logic-analyzer interface that requires only one and a half parallel I/O ports (9 output and 6 input bits) for complete operation. It is easily expandable to 16 or even 32 inputs.

All probe inputs and clock signals are conditioned through Schmitt triggers to reduce noise and false triggering. When the sync word, set on external switches (SW1 through SW8), appears on the input lines, the analyzer automatically collects and stores 16 sequential words repre-

**Photo 2:** *The prototype logic analyzer described in this article. The switches on the left are for setting the trigger (sync) word.*

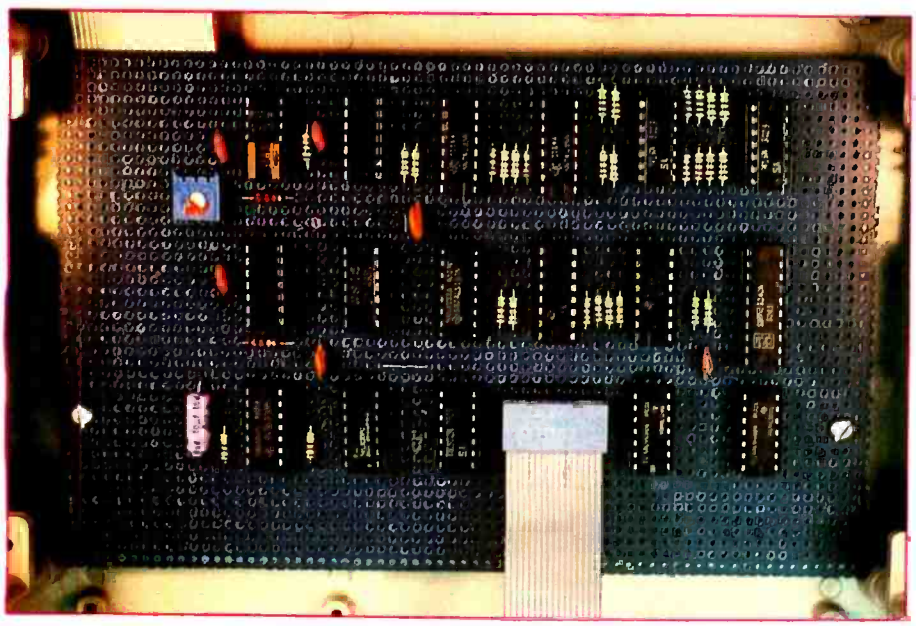


**Photo 3:** *Inside the box of photo 2 is the circuit of the analyzer as shown schematically in figure 4. Seventeen integrated circuits are used.*

senting input status at the instant of either an internal or external clock signal (usually the system clock). It can operate on either edge of the clock pulse and store data at frequencies as fast as 5 MHz. The prototype interface is shown in photo 2.

Unlike commercial logic analyzers, this unit has no integral CRT (cathode-ray tube) display: it has eight externally controlled LEDs. It depends instead upon the computer to display the list of stored data. After the interface has taken sixteen samples, it sends a Scan Complete signal to the computer. A computer program sets the Read/Write line to the Read mode and sets a 4-bit address to access the contents of the 16-word scratch-pad memory. As the 4-bit address is incremented, the appropriate 8-bit output is placed on the analyzer's data-output lines from the scratch-pad memory and is stored by the computer. In addition, as the computer reads the scratch-pad memory, the contents of each location are displayed on eight LEDs. If the addresses are changed slowly, or are otherwise physically set, the 16 stored words can be viewed directly without a special display program.

Once the data has been acquired by the computer, a format-and-display program lists the values on the computer's display in binary, octal, or hexadecimal format, simulating a commercial analyzer display. To gather an additional 16 words, the computer program merely sets the Read/Write line to the Write mode and toggles the Sample Enable line. The BASIC program in listing 1 on page 43 exercises the interface and displays the output shown in listing 2.

### Inside the Interface

The analyzer hardware (shown in photo 3) has an interface consisting of seventeen integrated circuits. Input signals are fed through IC1 and IC2, which are hex Schmitt-trigger inverters. Photo 4 shows typical test connections. These conditioned outputs are in turn buffered and gated through to the memory section by IC3, a type-74LS240 8-input bus driver. The output of this driver is compared to eight preset switches through two 74L85 4-bit comparators (IC7 and IC8). (Trigger-word initiation is disabled by setting all switches to the logic-1 state. Storage will commence on the first clock pulse after Sample Enable.) If the switch settings and data input are equal, a pulse is generated which stores the current input data. The first word stored is usually the sync word (assuming that the trigger word and external clock-pulse edge are synchronous).

On the trailing edge of the WE (memory-write-enable) pulse, the 4-bit memory-address counter IC9 is incremented. Data will be stored again at the occurrence of the next edge (positive or negative as selected) of the clock pulse.

*Text continued on page 42*

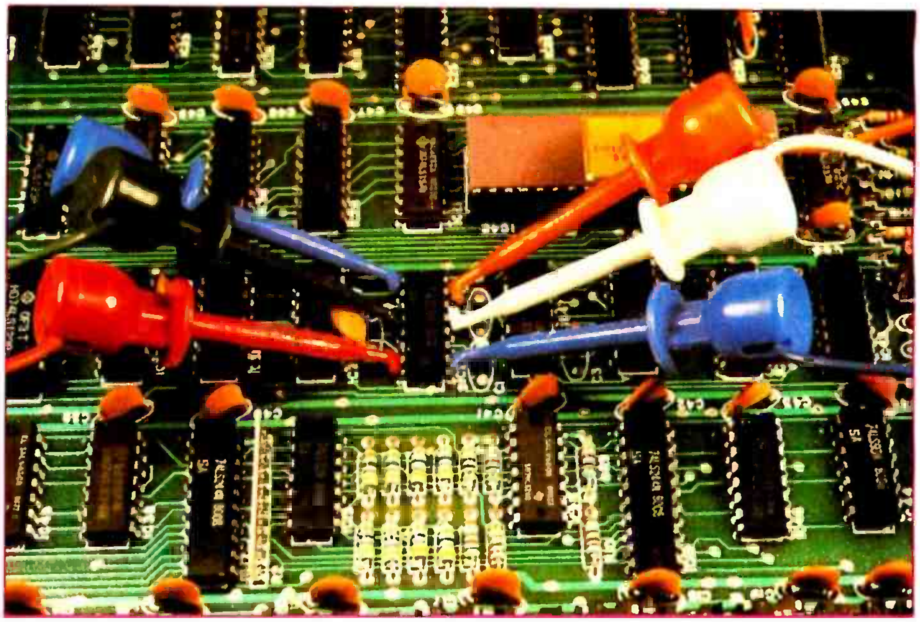


**Photo 4:** *The analyzer is intended for use while a circuit is in dynamic operation. Connection to the circuit can be done with the "chip-clip" method shown in photo 1, or by using separate test probes. The latter is more versatile. The circuit shown under test is the Disk-80 expansion interface from last month's Circuit Cellar.*

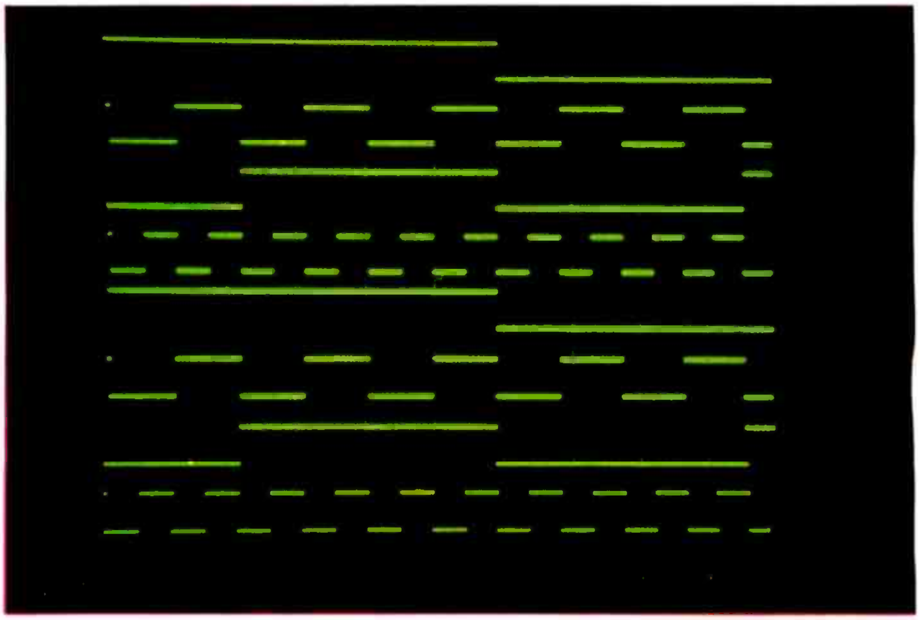
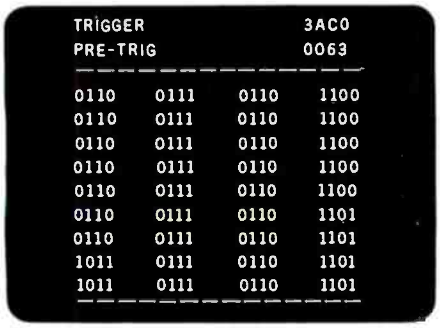
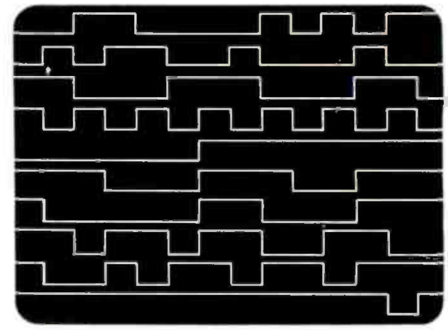


**Photo 5:** *When the circuit of figure 5 (on page 42) is attached to the logic analyzer, a data-domain display can be converted to a time-domain display. Essentially nothing more than an eight-channel scope multiplexer, this circuit greatly expands the display potential of the average oscilloscope, as the photo demonstrates.*

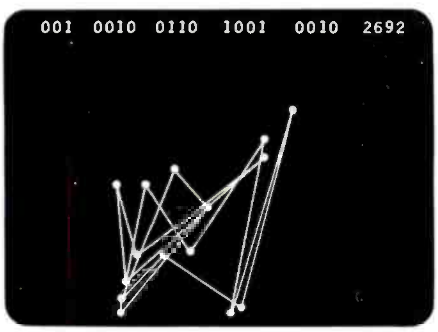



(2a)


(2b)



(2c)




(2d)

**Figure 2:** *The data acquired by a logic analyzer can be displayed in various formats. The different types are:*

*(2a) The ones and zeros logic-state display. In this format, binary words are plotted against clock pulses in a matrix* m *bits wide by* n *clock pulses deep. This format is used most often where word flow or data sequence is of prime concern.*

*(2b) Same as 2a except that the data is listed in hexadecimal notation. Hexadecimal listings are most frequently used in logic analyzers specifically designed for microprocessor troubleshooting, where thirty-two to forty inputs are not uncommon.*

*(2c) The timing-diagram display. In the timing format, data words are plotted against time. This format is used most often for hardware troubleshooting to detect incorrect timing between signals.*

*(2d) Vector-display analyzer. In the vector-display format, data words define points on an x, y coordinate system. Usually, the data word is divided in half with a separate D/A converter attached to each segment. One output goes to the display's x input and the other goes to the y input.*

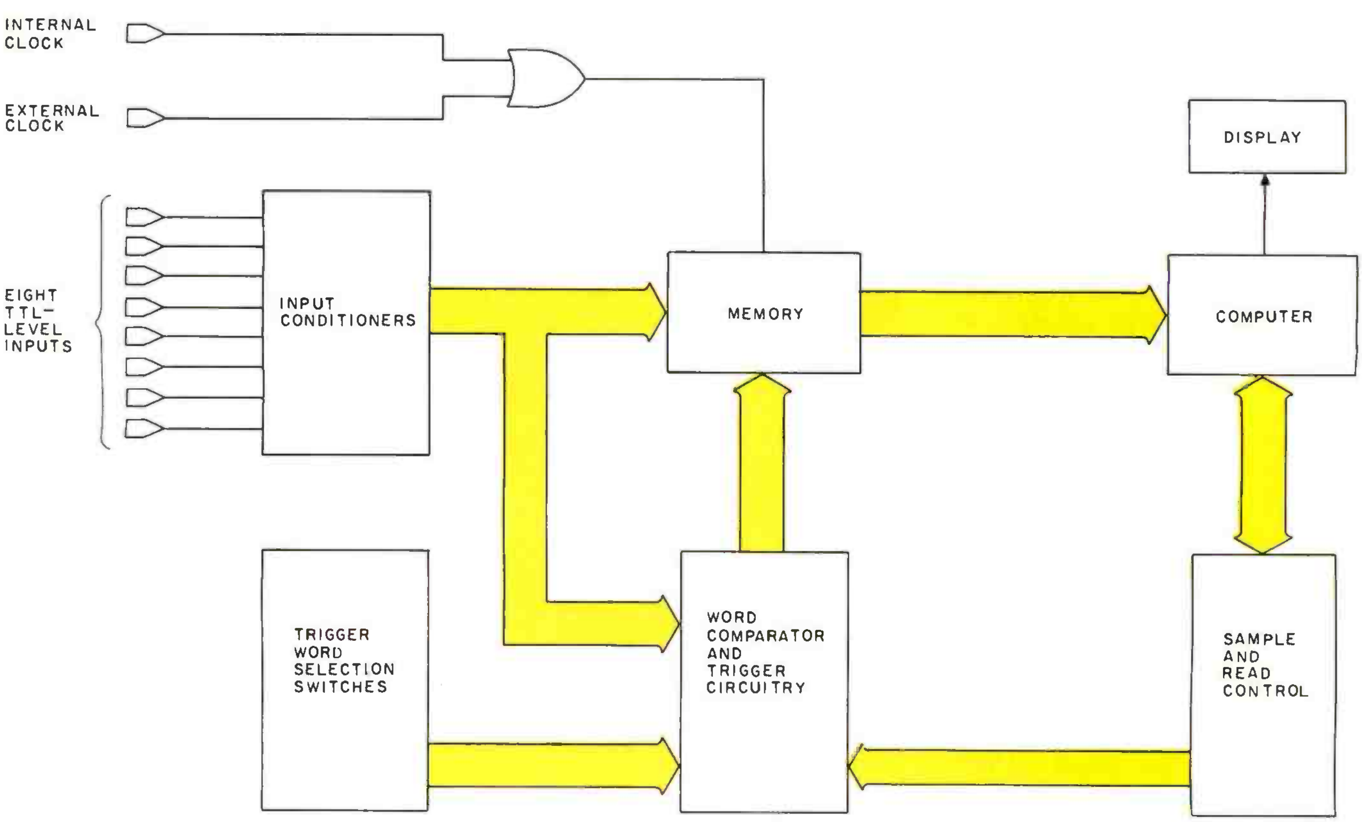



**Figure 3:** *Basic block diagram of the simple logic analyzer. In this case, the block labeled "computer" refers to an externally attached personal computer. In commercial units, the computer and display are integral components of the logic analyzer.*

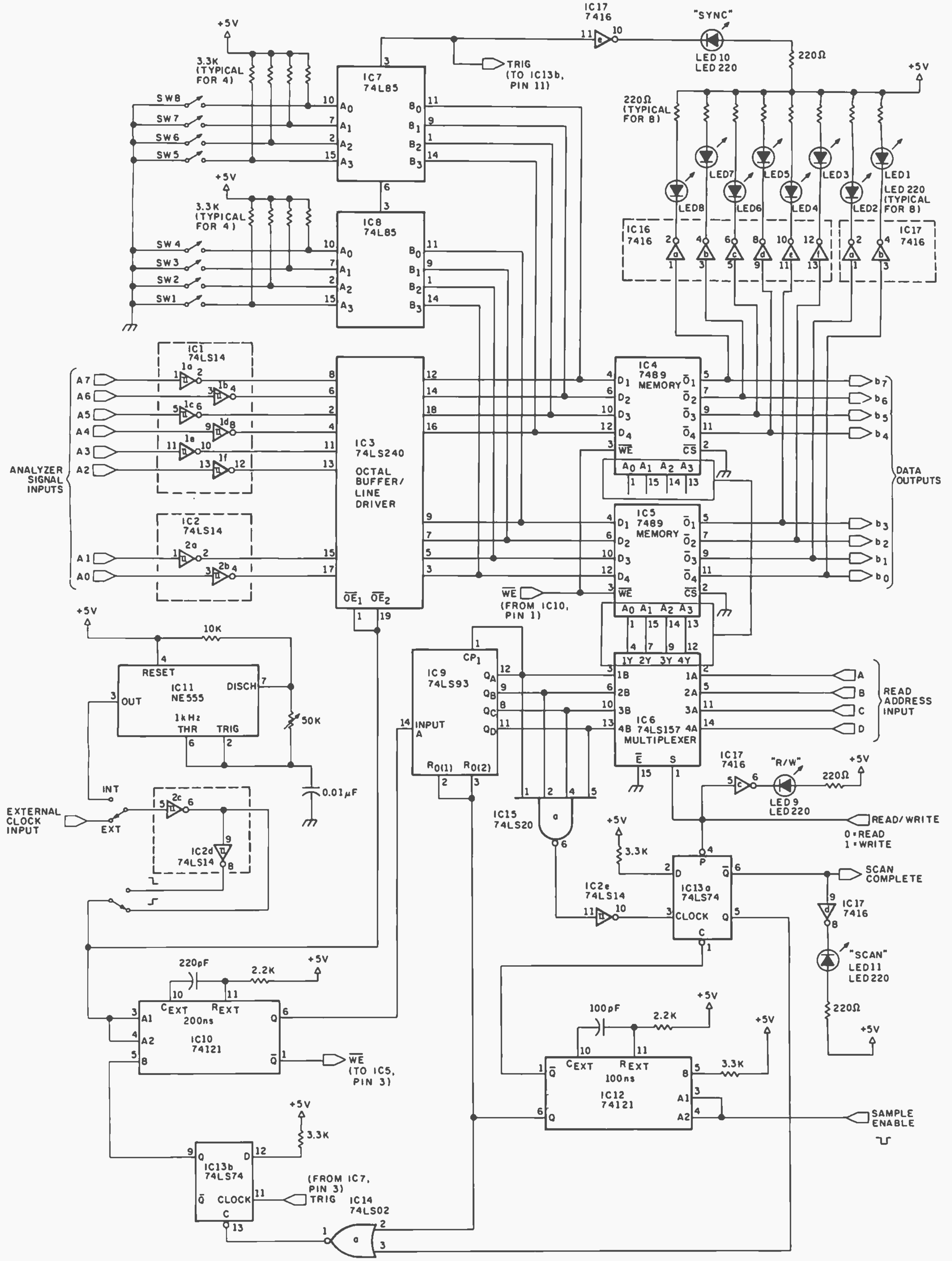


**Figure 4:** *Schematic diagram of an eight-input logic analyzer. One and a half parallel I/O ports are required for operation. Note that the 74L85 integrated circuits used here have a different pinout specification from the 74LS85. User connections are on the left; computer connections are on the right.*

| Number | Type | +5 V | GND |
|---|---|---|---|
| IC1 | 74LS14 | 14 | 7 |
| IC2 | 74LS14 | 14 | 7 |
| IC3 | 74LS240 | 20 | 10 |
| IC4 | 7489 | 16 | 8 |
| IC5 | 7489 | 16 | 8 |
| IC6 | 74LS157 | 16 | 8 |
| IC7 | 74L85 | 16 | 8 |
| IC8 | 74L85 | 16 | 8 |
| IC9 | 74LS93 | 5 | 10 |
| IC10 | 74121 | 14 | 7 |
| IC11 | NE555 | 8 | 1 |
| IC12 | 74121 | 14 | 7 |
| IC13 | 74LS74 | 14 | 7 |
| IC14 | 74LS02 | 14 | 7 |
| IC15 | 74LS20 | 14 | 7 |
| IC16 | 7416 | 14 | 7 |
| IC17 | 7416 | 14 | 7 |

**Table 1:** *Power connections for integrated circuits of figure 4, on page 41.*

*Text continued from page 39:*

When sixteen samples have been taken, the 4-bit memory address is binary 1111. IC13 and IC14 detect this condition and set the Scan Complete line to a logic 0. This also disables further storage until the interface is reset with a Sample Enable pulse to IC2.

Reading the contents is simply a matter of setting the Read/Write line to a logic 0 and placing an appropriate 4-bit address on the Read Address input lines. When an address is set on these lines, the data-output lines of the analyzer will contain the contents of that memory location. The eight LEDs will also display that value.

## Creating a Time-Domain Display

As previously mentioned, the display format available from this interface is generally a listing of 1s and 0s. This is quite useful under most circumstances but not as appealing to hardware buffs as a timing-diagram-type output. Even if your computer has graphics capability, writing a program to simulate a multi-trace oscilloscope display requires considerable software expertise.

The logic-analyzer interface can be converted to a time-domain display with relatively little extra hardware and only a single-line BASIC program. Figure 5 is the schematic diagram of the additional circuitry. Essentially, it consists of a dual 4-input digital multiplexer and 2-bit D/A (digital-to-analog) converter, which offsets each of the four channels when displayed. In effect, it

| Number | Type | +5 V | GND | −5 V |
|---|---|---|---|---|
| IC1 | NE555 | 8 | 1 | |
| IC2 | 74LS74 | 14 | 7 | |
| IC3 | 74LS151 | 16 | 8 | |
| IC4 | 74LS151 | 16 | 8 | |
| IC5 | LM741 | 7 | | 4 |
| IC6 | LM741 | 7 | | 4 |

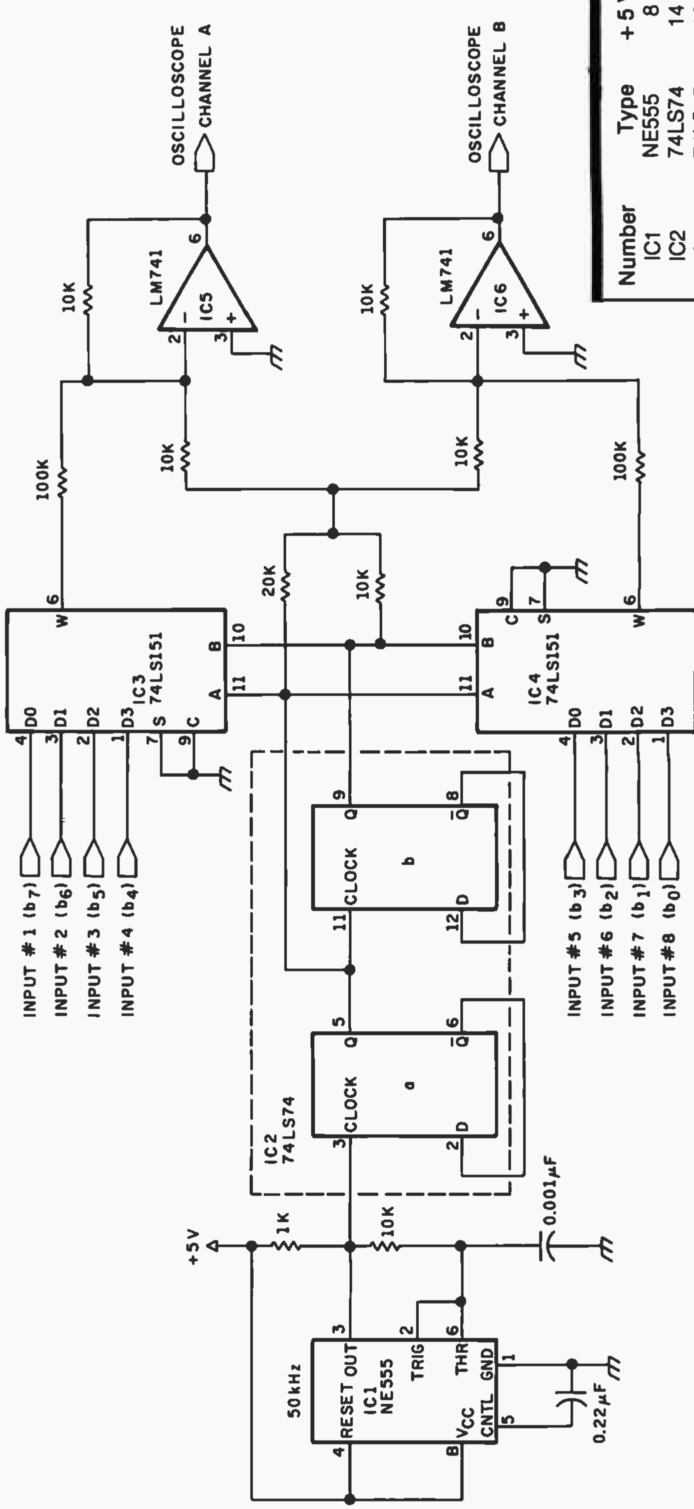



**Figure 5:** *Eight-channel display multiplexer, which facilitates display of eight TTL inputs on a standard dual-trace oscilloscope. Its intended use is to convert the data-domain output from the circuit of figure 4 into a time-domain display on an oscilloscope.*

allows a dual-trace oscilloscope to display eight channels simultaneously. Such a display appears in photo 5.

Conversion from data-domain to time-domain operation is not as difficult as it might seem. Consider the operation of the analyzer for a moment. Once the 16-word buffer is full, the data can be read out at any rate. If we cycle the read addresses very quickly, the outputs will form a repetitive pattern which can be easily viewed on an oscilloscope. The fast cycling can be accomplished using a 4-bit counter and oscillator source attached to the address-input lines or by using a simple program statement like:

```
100 FOR X = 0 TO 255:OUT 16,X:
    NEXT X:GOTO 100
```

Using a dual-trace oscilloscope, you can view two signals, or, with the circuit of figure 5, you can view all eight data channels simultaneously. Since there is no system clock to contend with and the pattern repeats every sixteen steps, triggering problems are reduced and the display is stationary. All other interface operations remain the same.

## Adding a Vector-Display Capability

If you are determined to hunt "wild vectors," the same technique employed to provide a timing plot lends itself to vector display. Using the same methods to cycle the buffer data on the output lines of the analyzer, substitute D/A converters for the multiplexer in figure 5. Typically, two 4-bit D/A converters are needed. One would be attached to the 4 high-order bits and the other to the 4 low-order bits. One D/A converter is attached to the *x*-axis scope input and the other to the *y*-axis input. When the buffer is cycled, a unique vector pattern will appear on the screen, describing the 16 data words stored in the analyzer's buffer. (A more informative discussion on this approach to troubleshooting was one of my previous articles, "A Penny Pinching Address State Analyzer," February 1978 BYTE, page 6. It has been reprinted in *Ciarcia's Circuit Cellar*, Volume I, available from BYTE Books.)

**Listing 1:** *A BASIC program that exercises the computer/logic analyzer interface, displaying output through the computer's normal output devices.*

```
100 REM Logic Analyzer Program
110 REM
120 REM data in on port 16, scan complete on bit 0 of port 17
130 REM read enable and sample enable are bits 6 and 7
140 REM of port 16
150 REM read address is bits 0 thru 3 of port 16
160 REM memory locations 25000 to 25015 is set aside as the data
170 REM buffer
180 PRINT"LOGIC ANALYZER"
190 PRINT:PRINT"Enable New Sample or List Analyzer Buffer";
200 PRINT" (E or L)";
210 INPUT A$
220 IF A$ ="E" THEN 250
230 IF A$ ="L" THEN 380
240 GOTO 190
250 REM Enable Logic Analyzer and take 16 readings
260 REM pulse sample enable line and set read/write line=0
270 OUT 16,255:OUT 16,0: OUT 16,255
280 REM
290 REM test scan complete line
300 IF INP(17) =255 THEN GOTO 300
310 REM when scan is completed store readings in table
320 FOR S=25000 TO 25015
330 N=S-25000
340 REM set read address and store analyzer output
350 OUT 16,N :A=INP(16):POKE S,A
360 NEXT S
370 GOSUB 380
380 REM Ones and zeros data-domain display routine
390 PRINT:PRINT
400 PRINT"D7 D6 D5 D4     D3 D2 D1 D0"
410 FOR S=25000 TO 25015 :X=PEEK(S)
420 FOR N=7 TO 0 STEP -1
430 W=X AND 2^N
440 IF W>0 THEN PRINT"1  "; ELSE PRINT"0  ";
450 IF N=4 THEN PRINT"    ";
460 NEXT N
470 PRINT"  SAMPLE #";S-24999
480 NEXT S
490 GOTO 190

READY
```

**Listing 2:** *Sample output produced by the program of listing 1.*

```
RUN
LOGIC ANALYZER

Enable New Sample or List Analyzer Buffer (E or L)? E


D7 D6 D5 D4     D3 D2 D1 D0
0  0  0  0      1  1  1  0    SAMPLE # 1
1  1  0  1      0  1  0  1    SAMPLE # 2
0  0  1  1      1  0  1  0    SAMPLE # 3
1  0  0  0      1  0  0  0    SAMPLE # 4
0  0  0  0      0  0  0  1    SAMPLE # 5
1  1  1  1      0  1  0  1    SAMPLE # 6
1  1  0  0      1  1  0  1    SAMPLE # 7
0  0  0  1      0  0  0  0    SAMPLE # 8
0  0  0  1      0  1  1  0    SAMPLE # 9
1  1  1  1      0  0  0  1    SAMPLE # 10
1  1  1  0      0  0  1  1    SAMPLE # 11
0  0  1  0      0  0  1  0    SAMPLE # 12
1  0  1  0      0  1  1  0    SAMPLE # 13
0  0  0  0      0  0  0  1    SAMPLE # 14
0  0  0  1      1  1  1  1    SAMPLE # 15
1  1  0  0      1  1  0  1    SAMPLE # 16

Enable New Sample or List Analyzer Buffer (E or L)?
```

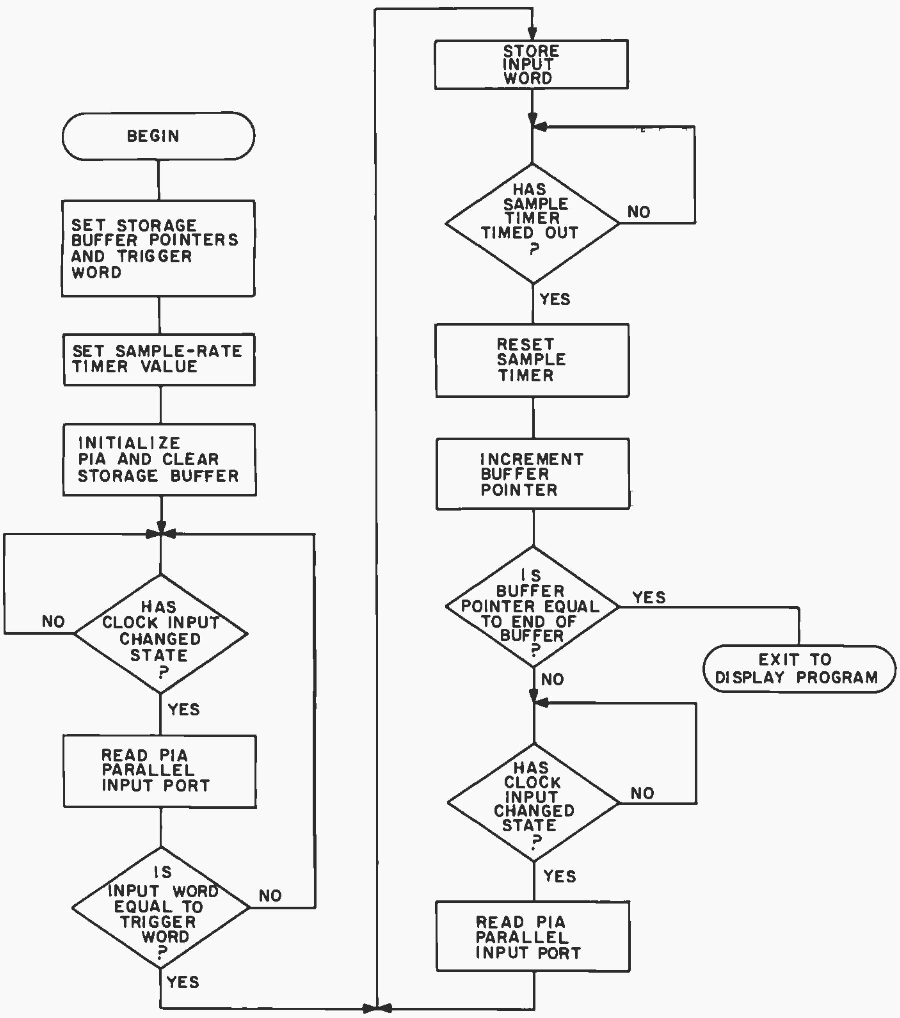



**Figure 6a:** *Flowchart of a software logic analyzer. Using a Motorola 6820 PIA (Peripheral Interface Adapter), this sequence of operations is all that is required to demonstrate logic-analyzer functions in software. This method is limited in speed of operation by the execution time of the program.*

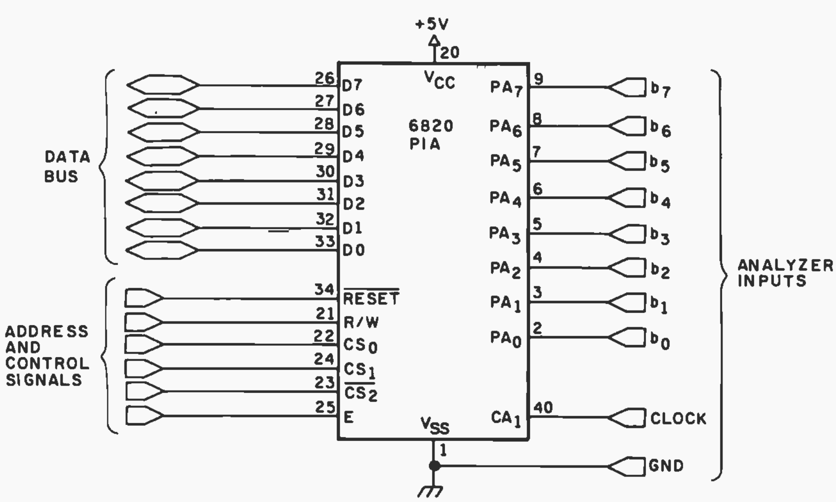



**Figure 6b:** *Pinout chart of the Motorola 6820 PIA used by the algorithm of figure 6a.*

## Logic-Analyzer Functions Created Through Software

While I generally prefer to demonstrate hardware interfaces in my articles, the functions of a logic analyzer can easily be simulated in software if data-acquisition speed (under 20 kHz) is not critical. While it may not be appropriate for testing microcomputer bus signals, it should work for slower applications.

Figure 6 is a flow diagram outlining the specific steps involved in accomplishing this function. While any existing parallel input port will suffice, the Motorola 6820 PIA (Peripheral Interface Adapter) shown has a separate clock input, which greatly facilitates proper timing.

## In Conclusion

As digital hardware becomes more complex, the instruments used in troubleshooting and debugging these circuits must themselves become more sophisticated. This sophistication, however, need not always be provided in the form of a commercially produced test instrument. Often the solution can be intelligent application of existing equipment with limited modifications.

The logic analyzer I have described can be used for all types of troubleshooting and testing of digital circuits. However, its true flexibility is revealed when the instrument captures the extremely fast data flowing in a microcomputer and generates a stationary timing diagram with the results. Built from scratch, combined with an oscilloscope, and exercised by a computer, this interface costs only a fraction of the price of commercial analyzers, yet approximates many of their features.

## Next Month:

*Build a remote-controlled motorized moving platform.* ■

**Editor's Note:** *Steve often refers to previous Circuit Cellar articles as reference material for the articles he presents each month. These articles are available in reprint books from BYTE Books, 70 Main St, Peterborough NH 03458.* Ciarcia's Circuit Cellar *covers articles appeating in BYTE from September 1977 thru November 1978.* Ciarcia's Circuit Cellar, Volume II *presents articles from December 1978 thru June 1980.*

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Tom Ochs
Assistant Research Professor
Desert Research Institute

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## System Review

# The MicroAce Computer

Delmar Searls, 1825 S Johnstone, Bartlesville OK 74003

**About the Author**
*Delmar Searls is a professor of mathematics at Bartlesville Wesleyan College, Bartlesville, Oklahoma. His interest in microcomputers is a result of both professional and personal experience: he learned BASIC programming by using a PET microcomputer on the job; at home, he taught himself electronics, beginning with the basics, and continuing through digital electronics and microprocessors. His interest in the MicroAce was sparked by the remarkably low price.*

The MicroAce is a small, Z80-based microcomputer in kit form. When completed it measures 23.2 cm by 18.8 cm by 4.1 cm ($9\frac{1}{8}$ inches deep, $7\frac{3}{8}$ inches wide, and $1\frac{5}{8}$ inches high). It features an integer BASIC in ROM (read-only memory), touch-sensitive keyboard input, cassette I/O (input/output), and video output through an on-board UHF modulator. The video display consists of 24 lines of 32 alphanumeric and graphics characters.

The kit comes in two forms, depending on the amount of user-programmable memory purchased. For $149 (including shipping) you get a unit with 1 K bytes of programmable memory, expandable to a maximum of 2 K bytes with the purchase of an upgrade kit for $29. You can save $9 by buying the second version of the kit for $169.

Depending on the sources available, you can save even more by buying the 1 K-byte kit and purchasing the extra components from local or mail retailers. You would need to buy three integrated-circuit sockets, two memory circuits, a 74LS32 integrated circuit, and one capacitor.

If my experience is typical, you can expect to wait about a month for your MicroAce to arrive if you mail your order; less if you order by phone.

### At a Glance

**Name**
MicroAce (kit)

**Manufacturer**
MicroAce
1348 E Edinger
Santa Ana CA 92705
(714) 547-2526

**Price**
$149 (with 1 K bytes of programmable memory)

**Dimensions**
23.2 cm by 18.8 cm by 4.1 cm ($9\frac{1}{8}$ inches by $7\frac{3}{8}$ inches by $1\frac{5}{8}$ inches)

**Processor**
Z80, 8-bit

**System Clock Frequency**
3.25 MHz

**Memory**
4096 bytes of ROM
1024 bytes of programmable memory

**Mass Storage**
Cassette tape recorder supplied by user

**Other Features**
Touch-sensitive keyboard, RF-modulated output (UHF channel 35), display of 24 lines by 32 characters

**Documentation**
Teach-yourself BASIC manual (67 pages)

**Audience**
Anyone who wants an inexpensive microcomputer

### Construction

The advertisement for the MicroAce (as it appeared in BYTE and in other magazines) states that you will receive a "teach-yourself BASIC manual" and that "a hardware manual is also included with every kit." This is not correct. There is no hardware manual supplied with the kit, only the BASIC manual which includes a section entitled "Construction," preceding the first chapter.

The assembly instructions are very general and, in my opinion, not quite sufficient for those who have no ex-


**Photo 1:** *The MicroAce kit as shipped. Starting at the bottom and moving clockwise around the main circuit board are: the discrete components, the integrated circuit sockets, the integrated circuits themselves, voltage regulator, power supply, UHF modulator, antenna switch box, cable materials, and black plastic case. The 8- by $11\frac{1}{2}$-inch instruction manual gives an indication of the size of this computer.*

perience in circuit-board kit construction. There are no guidelines for proper soldering techniques and no step-by-step instructions that are commonly found with kits from the larger kit manufacturers.

Component values are written in a rather unusual notation. For example, a resistance of 470 ohms is written 470R, 1000 ohms is written 1K0, 2200 ohms is written 2K2, 47,000 ohms is written 47K, and 1,000,000 ohms is written 1M0.

There is a logical pattern to the notation, but it is different from that which is normally used. I suspect that the notation is British, since the MicroAce is essentially the kit version of the Sinclair ZX80, which is made in England.

Another unusual practice is the frequent listing of capacitance in nanofarads rather than picofarads. While this notation may be unusual, it should not cause any real problem as color codes and identifying marks are also listed for the various components.

The smaller components are packaged in plastic bags, while the larger items are packed loose (see photo 1). There were no missing parts, and, in fact, I received three extra resistors and one extra capacitor. There was a moment of concern when I discovered that the parts list called for eleven diodes and only nine had been supplied. A close inspection of the circuit board, however, revealed that only nine were required.

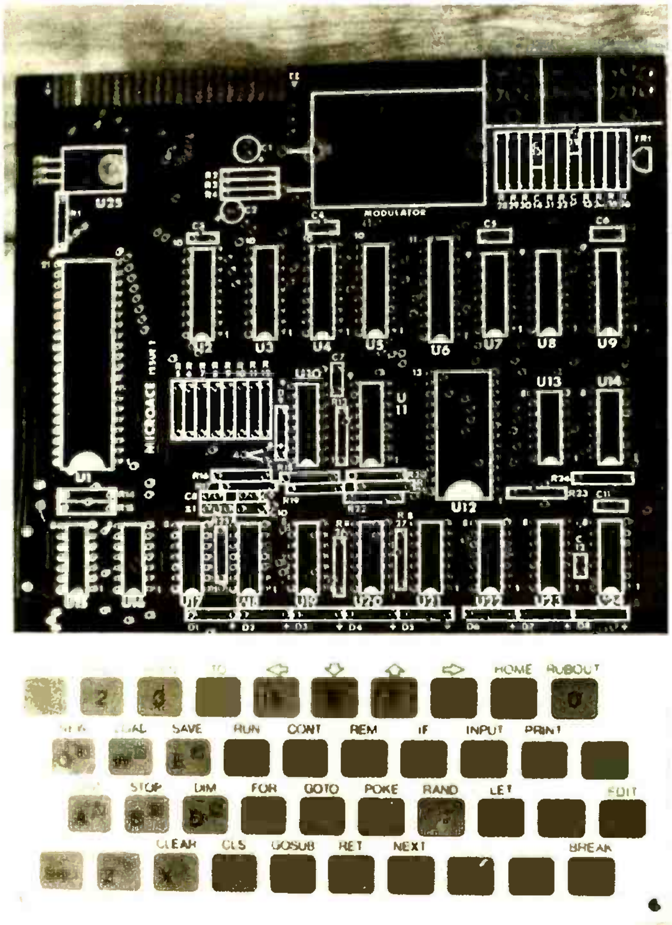


**Photo 2:** *Component side of the main circuit board. Note that component locations are clearly marked, and that the keyboard is an integral part of the printed-circuit board.*

The circuit board is double sided with holes soldered through. Component locations are indicated by white outlines and white identification labels on the component side of the board (see photo 2). Component type and value is determined by cross-referencing the identification label (R2, C12, U8, etc) with the parts list.

The actual assembly is straightforward and very easy, especially for those familiar with circuit-board projects. The construction notes suggest that components be soldered to the board in the following order: sockets for the integrated circuits, discrete components, cable sockets, voltage regulator, and the video modulator.

Next, the integrated circuits can be installed. Be sure to follow the appropriate precautions when handling the MOS (metal-oxide semiconductor) devices, which include the Z80, two programmable-memory chips, and the ROM circuit. At this point the unit can be tested for proper operation. The last stage in construction, following successful testing, is the installation of the unit in its case (see photo 3).

The 1 K-byte version of the kit does not provide the sockets for three circuit locations. (These are supplied with the upgrade kit.) I suggest that anyone building this version use masking tape to identify these locations prior to construction. Otherwise, it would be easy to install a socket in one of these locations, only to come up short later on. Once a socket is soldered in, it is practically impossible to remove.

There are no instructions given for the preparation of the cables that will attach your television and cassette recorder. You are provided with about 10½ feet of shielded cable, two phono plugs, and four mini-jacks. As simple as this task may appear, more instructions should


**Photo 3:** *Completed MicroAce with cables.*


**Photo 4:** *Sample program displayed on a standard color television set. The current program line is 180, as indicated by the reverse-video cursor.*


**Photo 5:** *Layout of the MicroAce keyboard. Note that each BASIC keyword is associated with a specific key.*

have been given to aid the inexperienced builder.

The fastenings provided for attaching the circuit board to the lower half of the case, and for fastening the upper half of the case to the lower, are plastic devices referred to as "rivets." In my opinion, these fasteners are inadequate. In fact, the rivet at one circuit-board location was useless and kept popping out. To remedy the problem, I used a fine round file to enlarge the holes in the plastic case, and substituted small nuts and screws for the rivets. Plastic washers were used to prevent the circuit board from becoming marred.

The keyboard appears to be built up with two layers. The bottom layer consists of the front one-third of the circuit board, while the second layer is laid on top and seems to be secured with some sort of adhesive. This is done by the manufacturer, not the kit-builder.

On my unit, this overlay was positioned slightly too far to the left, so that I had to press the right edge of the key, rather than the middle, to get a response to the keyboard entry. In addition, some keys require considerably more pressure than others. These factors, plus the fact that no audio or tactile feedback is given to indicate a successful keyboard entry, make the keyboard a little frustrating to use.

## Program Entry

The output of the modulator is received on or near channel 35 on a regular television set. I used an RCA 13-inch color set and had no trouble obtaining a good display. With the controls set for normal reception of commercial broadcasts, the display appears as white characters on a gray background. If desired, white letters on an almost black background can be obtained by adjusting the contrast and brightness controls (see photo 4).

On power-up, the display is blank with the exception of a reverse-video "K" at the lower-left corner of the screen. Whenever this reverse K appears, a nonshifted

keyboard entry from the bottom three rows of keys (see *photo 5) will result in* a BASIC *keyword* being printed on the screen.

Keywords (and thus the use of a reverse K) are BASIC commands which are stored in a single byte of memory but are spelled out on the screen. For a list of these keywords, as well as other BASIC commands and functions, see table 1.

Nonshifted keyboard entries from the top row are printed as numeric characters for the line numbers (which must be between 1 and 9999, inclusive). As a line number is entered, the reverse K will shift to the right, one space at a time. As long as the reverse K is on the screen, any shifted-key input (other than an editing command) will result in a syntax error. Commands entered without a preceding line number are executed immediately in the "command mode."

After entering a line number, press the key corresponding to the BASIC keyword with which your program line is to begin. Every program line must start with one of these keywords. For example, in some forms of BASIC, the LET keyword is optional, and "10 LET A=5" can be written "10 A=5". This is not possible with the MicroAce.

Following the entry of a keyword, the reverse K cursor changes to a reverse L, signifying that you are in the *letter* mode and that keyboard entries will be interpreted as regular alphanumeric or graphics characters. As you type in a program line, the system monitor checks for syntax errors after each character is entered. A line contains a syntax error if, in its present form, the line is incorrect or incomplete. Suppose you wish to enter the following line:

```
20 PRINT "THE FINAL SUM IS "; A
```

The PRINT command is entered by pressing one key (the letter O) because the machine is in its keyword mode at the start of each new line. Immediately following the entry of the first set of quotation marks, a reverse-video S (for syntax) appears to the right of the reverse-L program cursor. This does not indicate that an error has been made, but rather that the line is incomplete. As the literal

Keyword Commands

| Keyboard Abbreviation | Comments |
|---|---|
| CLEAR | Set all variables to zero |
| CLS | Clear the screen |
| CONT | Continue |
| DIM | Dimension (one-dimensional arrays) |
| FOR | |
| GOSUB | |
| GOTO | |
| IF | |
| INPUT | |
| LET | |
| LIST | |
| LOAD | Cassette input |
| NEW | |
| NEXT | |
| POKE | |
| PRINT | |
| RAND | Randomize |
| REM | Remark |
| RET | Return |
| RUN | |
| SAVE | Cassette output |
| STOP | |

String Functions

| Function | Comments |
|---|---|
| CHR$(*N*) | Return character or keyword string corresponding to decimal code *N*. |
| CODE(*S*) | Return decimal code number of first character in string *S* |
| STR$(*I*) | Convert the integer *I* into its corresponding string representation. |
| TL$(*S*) | Delete the first character from string *S*. |

Other Functions

| Function | Comments |
|---|---|
| ABS(*N*) | Return absolute value of *N*. |
| PEEK(*N*) | Return decimal value stored in memory at address *N*. |
| USR(*N*) | Start machine-language routine at address *N*. |
| RND(*N*) | Return a random number between 1 and *N* if *N* is positive. |

Logical Functions

| Function | Comments |
|---|---|
| AND | Check to see if two or more conditions are met simultaneously. |
| OR | Check to see whether any one of two or more conditions is met. |
| NOT | The opposite of a stated condition is tested. |

(These logical functions have additional uses which cannot be detailed here.)

Arithmetic Operations

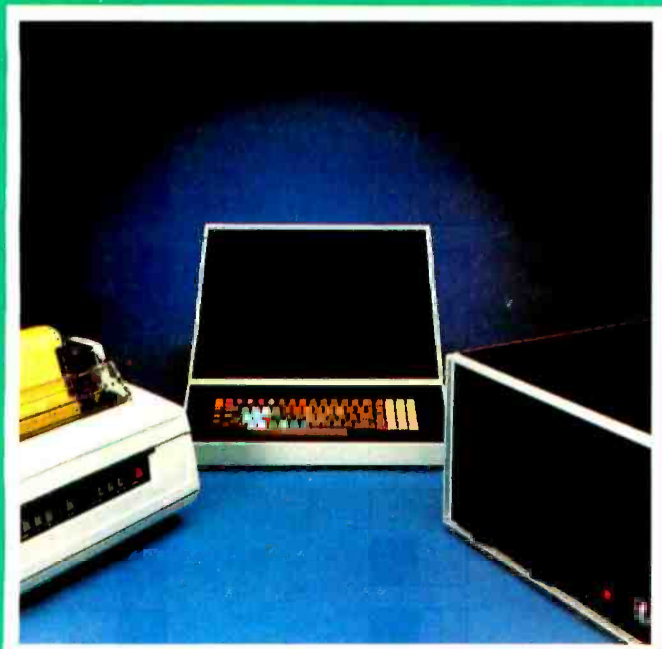
| | |
|---|---|
| + | Addition |
| − | Subtraction |
| * | Multiplication |
| / | Division |
| ** | Exponentiation (2**3 = 2*2*2 = 8) |

**Table 1:** *Commands and functions available in MicroAce integer BASIC, with comments at selected points. The manual supplied with the kit provides a more detailed explanation.*






Circle 33 on inquiry card. →



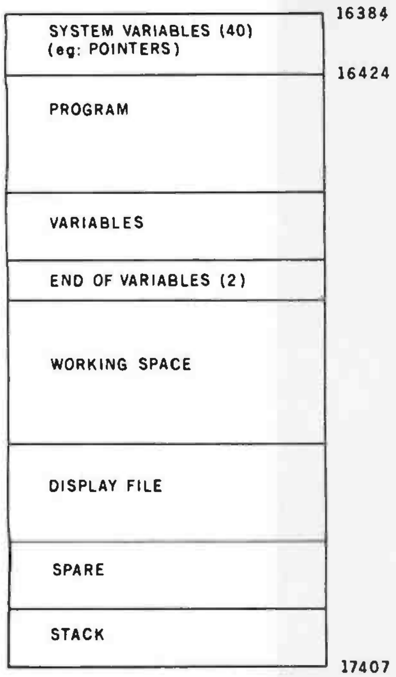



**Figure 1:** *Map of the programmable memory in the MicroAce computer. Fixed boundary addresses are given in decimal; the other boundaries are variable. Numbers in parentheses give the size of a fixed block in decimal bytes.*

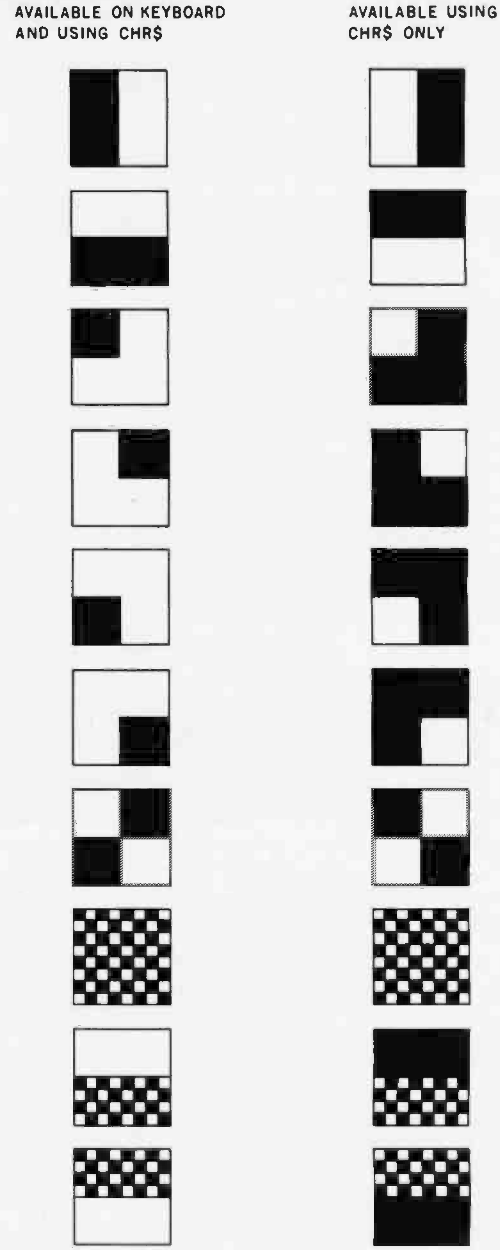



**Figure 2:** *Graphics symbols available with the MicroAce. Note that the first ten symbols are addressable from the keyboard, while the second ten are their reverse-video images, available only through the use of the CHR$ function in BASIC.*

string is entered, the reverse LS moves to the right as a double cursor. When the second set of quotation marks is entered, the reverse S disappears because the line now has the correct syntax.

Consider a second example. You wish to enter the line:

125 LET I=I+1

but inadvertently type:

125 LET I+1=I

This line would not be accepted because it contains a syntax error. The reverse S cursor would be located directly after the + symbol.

Notice that in this case the reverse S does not follow the reverse L cursor, but remains at the point where the error occurred. In the case of multiple errors, the reverse S will always be located at the first error contained in the line. When this error is corrected, the reverse S moves to the second error, and so on.

As indicated above, no line containing a syntax error will be accepted into a program. This guarantees that every line in your final program is complete and free of syntax errors. It does not, of course, prevent errors of logic. When a line is complete and correct, it can be entered into a program by pressing the NEWLINE key—the MicroAce equivalent of a RETURN key.

As a line is entered into a program it is placed into memory in two places. First, it is placed into the program storage area, which begins at decimal address 16424. (See figure 1 for a simplified map of the programmable memory.) It is also relocated in the display-file section of memory so that it appears on the upper portion of the screen.

Recall that on power-up the reverse K was at the lower left and that line entry was done at the bottom of the screen. As new lines are entered they appear in numerical order. The most recently entered line is identified by a line cursor (a reverse video >).

A line entered with a number between those of two previously entered lines is placed in the appropriate position on the display, and the line cursor is moved to its location. When the screen is full, the addition of new lines causes the program listing to scroll up, always leaving the most recently entered portion on the display.

This method of using programmable memory for both program storage and display storage leads to problems. In some systems, the video-display memory is dedicated, meaning that an advertised 1 K bytes of programmable



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memory are used for program storage only, and that additional memory is supplied for storing video data.

With the MicroAce, the programmable memory available to the user must perform both tasks. Thus, as program length increases, the area for displaying the program listing begins to shrink as less and less memory is available for display storage. As a result, the program line-entry "window" moves up from its bottom position on the screen. The advantage of this system is that when your line-entry window is near the top of the screen, you know you are close to filling the available program memory. The disadvantage is that shorter and shorter segments of a program can be listed at any one time. As you will see later, this dual use of memory causes similar difficulties when running a program.

Another feature of the MicroAce is that there is no limit (other than available memory) to the length of a program line. Thus, a large section of text can be printed using a single PRINT command. This can save time and memory if properly used.

A disadvantage of the system is that multiple statements on a single line are not allowed. For example:

```
230 LET A=5: LET B=9
```

would have to be written as:

```
230 LET A=5
235 LET B=9
```

In another example:

```
200 INPUT A,B,C
```

would have to be written as:

```
200 INPUT A
205 INPUT B
210 INPUT C
```

### Program Editing

As indicated earlier, new lines can be inserted anywhere in a program by entering them in the normal fashion. Entire lines can be deleted by entering the line number and pressing NEWLINE. If the line that is currently displayed needs editing, the following procedure is used: the up and down arrows (shifted 7 and shifted 6, respectively) are used to locate the line cursor at the proper line; then EDIT (shifted NEWLINE) is pressed to copy the desired line in the program-entry window at the bottom of the screen.

The left and right arrows (shifted 5 and shifted 8, respectively) are used to position the program cursor within the line. Deletions are made by placing the program cursor to the right of the desired character or keyword and pressing RUBOUT (shifted numeral 0).

Insertions are made by merely typing in the correct character or keyword. The portion of the line to the right of the insertion shifts to the right to accommodate the inserted text. You cannot over-type incorrect text; it must be deleted using the RUBOUT command.

A line that is not presently on display can be edited in one of two ways. The up or down arrows can be used to scroll the program listing down or up on the display until the desired line appears, or the LIST command can be used instead.

Normally, a LIST command will list the program starting with the line preceding the requested line. If, for example, the lines are numbered by tens, then a LIST 120 will result in a listing that begins with line 110 and continues as far as space and display memory permit. In either case, once the desired line is displayed on the screen, it can be edited as described above.

MicroAce has one disconcerting feature that affects the entering and editing of programs. The microprocessor performs only one function or task at a time. Thus, it either handles keyboard input *or* controls the video display, and as a result, every key closure during program entry and editing causes the display to roll. This makes it difficult to use the editing arrows, as it is hard to follow a moving cursor on a rolling display.

### Running a Program

A program is executed by entering the RUN keyword command followed by NEWLINE. During program execution, the display remains blank until a STOP or INPUT command is executed, a BREAK or an error occurs, or the program completes its run. At that point, the microprocessor is free to devote its attention to the video display. This means that a PRINT command in a program merely loads the data into the display memory for future use. It will not appear on the display until active execution of the program ceases. For this reason, animated graphics are not possible.

As mentioned earlier, there are some problems related to running programs, because the available program-

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mable memory is used for both program and display storage. Program memory is given priority, so if, for example, a PRINT command giving some instructions contains more characters than the available display memory can accommodate, the displayed message terminates at the point where display memory was filled, program execution stops, and an error message appears at the lower-left portion of the screen.

This clearly limits the amount of displayable text that can be included in a program. In the worst possible situation, where the entire screen is filled, 768 bytes of memory ($32 \times 24 = 768$) would be required for the display alone. Only 256 bytes remain in which to store system pointers, program lines, variables, and so on.

Furthermore, the display will not scroll during program execution. If a PRINT command results in a line of text beyond line 24, program execution ceases and a different error message is displayed. The PRINT and CLS (clear screen) commands must be used judiciously in order to avoid printing too many lines, on the one hand, and clearing text before it can be read, on the other.

### MicroAce Integer BASIC

Integer BASIC is limited in its computational capabilities. All numbers used in computation must be integers in the range −32768 to 32767, inclusive. Results of arithmetic operations are truncated (ie: all fractions are dropped). Thus, 99 divided by 100 would come out 0, because the division normally yields a quotient of 0.99. But integer BASIC drops all fractions, leaving 0.

Only the fundamental operations of addition, subtraction, multiplication, division, and exponentiation (using positive integral exponents) are implemented. This is true not only for MicroAce integer BASIC, but for any form of integer BASIC. The purpose of integer BASIC is to provide the user with a high-level programming language in as little memory as possible. This should be kept in mind when evaluating the capabilities of an integer BASIC.

While the features of MicroAce BASIC are given in table 1, a few points should be emphasized. Note that string manipulation, a feature not always included in integer BASIC, is possible. Also, a USR function is provided which allows the user to run machine-language programs. I have not yet experimented with this feature, but should point out that the manual does not teach you any machine-language programming. It merely suggests that you write a monitor in BASIC to enter machine-language programs, and use the USR function to run them.

The use of keywords was discussed earlier. This greatly simplifies program entry because entire commands are entered with a single keystroke. Memory is conserved because each keyword occupies only a single byte of memory. Any keyword command can appear in an executable program line including LIST, LOAD, SAVE, RUN, and NEW.

You have to be very careful with some of these commands. Program execution terminates following a LIST. The NEW command executed in a program, or in command mode (executed directly from the keyboard), would wipe out everything in memory, including the program itself. The LOAD and SAVE commands would be of little value in a program since the cassette recorder

would have to be turned on at just the right moment in order to complete the command execution.

The MicroAce BASIC provides an error message whenever program execution ceases. The number of different messages is limited, but remember that all program lines must have correct syntax before they are accepted into a program. The error messages are given in the format c:nnn where c is an error code, and, in most cases, nnn is the last program line executed. Here are some examples:

0:400 This could mean one of two things. Either the program has come to a successful end at line 400, or a BREAK was executed and line 400 would have been the next line executed in the program.
5:40 This indicates that a PRINT command in line 40 attempted to print beyond the twenty-fourth line on the display, which, as noted above, is not possible.
4:40 This might indicate that a LET command was used when there was no more memory available for variables storage. (The error code indicates there is not enough memory to perform the given line.)

The system of error messages, together with the syntax checking feature, make program debugging quite easy. This is definitely one of the strong points of MicroAce BASIC.

One negative aspect of the MicroAce BASIC is the inability to halt program execution at an INPUT command. When executing an INPUT command, the BREAK key is, in effect, ignored. This is not that unusual as other computers exhibit the same property. However, any key entry, including NEWLINE (and that is a bit unusual), that is not a valid response to the INPUT command results in the appearance of the reverse-video S syntax error cursor, which means that the response will not be accepted. It must be deleted using the RUBOUT command, and a correct response must be entered before program execution resumes.

I entered a relatively simple game program which involved locating a submarine within a three-dimensional region. The player is allowed seven trials, and must input three coordinates during each trial. Thus, a maximum of twenty-one INPUT commands will be executed. Unless a STOP command or an escape routine is included in the program (or you disconnect the power), there is no obvious way to terminate execution of the program until all twenty-one INPUTs are responded to properly. This could make debugging of highly interactive programs a time-consuming process. By the way, even though this program was quite short, the instructions for playing the game could not be displayed without overflowing the available display memory. Consequently, they had to be omitted from the program.

## Graphics

There are twenty graphics symbols available, as shown in figure 2. Note that only ten are available from the keyboard. The remaining ten are reverse-video graphics available by using the CHR$ function.

In fact, any alphanumeric character, graphics symbol, or keyword string can be printed using the CHR$ func-

tion. Most characters can be printed in reverse-video as well. The BASIC manual provides a complete list of all available characters and strings, along with their decimal codes. The code is unique to MicroAce and thus not compatible with standard computer codes.

Since each character position on the 24 by 32 display is divided into four parts by the graphics symbols, a resolution of 48 by 64 dots is possible. Remember though, that an extensive graphics display greatly limits the amount of memory available for program storage.

### Cassette Input and Output

I had to try two tape recorders before I could successfully load a program from tape. The first recorder I tried lacked a tone control and could not load a program, regardless of the volume setting. The second recorder had a tone control and loaded properly with the control set at maximum treble.

The proper volume level seems to vary from tape to tape, even when they are made by the same company. Before saving a program, the program name is recorded on the tape by voice.

A cable is attached between the microphone output of the computer and the microphone input of the recorder. The recorder is placed in its record mode and the SAVE command is entered followed by NEWLINE. The television screen goes blank for about five seconds, followed by a jumpy display of horizontal white lines. This indicates that the data is being output to the recorder. When the display returns to normal, the save is complete.

Loading a program involves a similar series of steps. In this case, however, you cannot be certain that the program is being input until the screen resumes its normal display, giving a listing of the tail end of the successfully loaded program.

If, after a reasonable interval of time, the display does not return to normal, the BREAK key may be used to reset the computer. Occasionally, you may have to disconnect the power momentarily to recover from an unsuccessful load. Once the proper volume setting is found, however, loading can be done quite reliably.

### The Teach-Yourself Manual

The manual supplied with the MicroAce, entitled *The Teach-Yourself BASIC Manual*, is shown in photo 1. The title may be slightly misleading. It brings to mind a tutorial text complete with exercises for the reader, but it is not that kind of text. It merely introduces the BASIC commands, one at a time, illustrating their proper use and perhaps some typical applications.

At the same time, the processes of program entry, program editing, and program execution are taught. Token coverage is given to the art of programming, but in all fairness it might be unreasonable to expect a more detailed explanation. As an introduction to the use and syntax of fundamental BASIC commands, the manual is quite adequate.

While typing errors (or misprints) are inevitable, I do think that special care should be given to printing sample programs. One program in the manual has two lines which read "GO TO 7000" when the program contains no line numbered 7000. Those two lines should have read "GO TO 1000". As written, the sample program would not run successfully.

### Other Considerations

I believe that any product's value is partially determined by the manufacturer's willingness to respond to the consumer's request for aid or assistance. Nine weeks prior to the writing of this review, I sent a letter to MicroAce requesting answers to specific questions related to the MicroAce and to future plans for upgrading and expansion. That letter was never answered. This, to me, indicates a lack of interest in serving the customer.

At the same time that the letter was sent to MicroAce, a similar letter was sent to Sinclair Research Limited, the company that markets the Sinclair ZX80. (The MicroAce is essentially a kit version of Sinclair's machine and is manufactured under a license from Sinclair Research Limited.)

Sinclair's response to my letter left many questions unanswered (especially in regard to future plans), but they did say that the MicroAce operates in the same manner as the ZX80. Consequently, the comments made in this review concerning the operation of the MicroAce would apply to the Sinclair ZX80 as well.

I was also told by Sinclair that while the unit operates like the ZX80, it is not identical to it, and that peripherals marketed for the ZX80 might not work with the MicroAce. They did not elaborate, and, as noted above, MicroAce had no comment at all.

### Conclusions

The MicroAce kit is a very inexpensive introduction to the world of microcomputers. Kit construction is easy





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MicroAce BASIC contains several nice features. The use of keyword commands simplifies program entry and reduces the amount of memory required for program storage. Because line syntax is checked before the line is entered into a program, fewer programming errors can occur. This feature is especially useful for those just learning how to use BASIC.

The machine's compact size and light weight make storage and transportation very easy. The unit is simple to attach to a home television set, and the cassette input and output operations are reliable, once the proper settings are found.

The largest drawback is the severely limited amount of programmable memory. This disadvantage is most apparent when you try to write any but the shortest programs utilizing a significant amount of video display. I would strongly encourage any prospective buyer to purchase the 2 K-byte version of the MicroAce. Another drawback is that the screen is blank during active program execution. This limits the types of possible graphic displays, and can be somewhat annoying.

If you recognize the limitations of the machine and don't expect too much, then I think you can buy the MicroAce kit with confidence. It is most appropriate for someone who wants an inexpensive unit as a teaching tool in order to learn the fundamentals of BASIC programming. It might also appeal to hobbyists who want to "tinker around" with microcomputers but don't want to risk their more expensive equipment. ■

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# Digital Minicassette Controller

James Kahn
2284 Ellena Dr
Santa Clara CA 95050

The microcomputer-system designer has had a difficult time finding low-cost storage devices. Frequently, the choices have been limited to either standard Phillips audio cassettes or floppy disks. Although these are relatively inexpensive storage media, the transport mechanisms, or drives, are not. In addition to the transport, a controller and data formatter is required to interface the transport to the microcomputer system. The controller may either be a dedicated LSI (large-scale integration) device or be built up discretely from SSI (small-scale integration) logic consisting of TTL (transistor-transistor logic) gates and flip-flops.

**Commonly used mass-storage mechanisms and associated controllers are often quite expensive.**

There is now another choice besides the floppy disk and the Phillips cassette: the digital minicassette. Not only is the storage medium inexpensive, so is the transport (about $140, versus $400 for a floppy-disk drive). As a bonus, the transport is extremely compact (only 23 cubic inches) and requires little power (1 watt). This makes it suitable for a wide range of low-end applications ranging from experimental systems to data logging for test instrumentation.

There *is* one problem with designs using a minicassette: controlling it. There are several choices for the transport controller. One choice is to design a controller of discrete SSI logic. Although this choice will provide good performance, it requires a handful of discrete components. The SSI controller will use much circuit-board space, compromising the advantage of a compact transport. A better design would use a minimal number of components and take advantage of current LSI technology.

One such controller-design solution is to use the Intel 8255A Programmable Peripheral Interface IC (integrated circuit) to interface the transport to a microcomputer system. Although this design provides a simple solution to the problem, the processor would be burdened with providing the low-level control needed by the transport, in addition to supporting its normal real-time I/O (input/output) tasks. Examples of these low-level tasks are transport start-up, data formatting, and transport shutdown.

There is, however, a better LSI solution available: distribute the system intelligence from the micro-

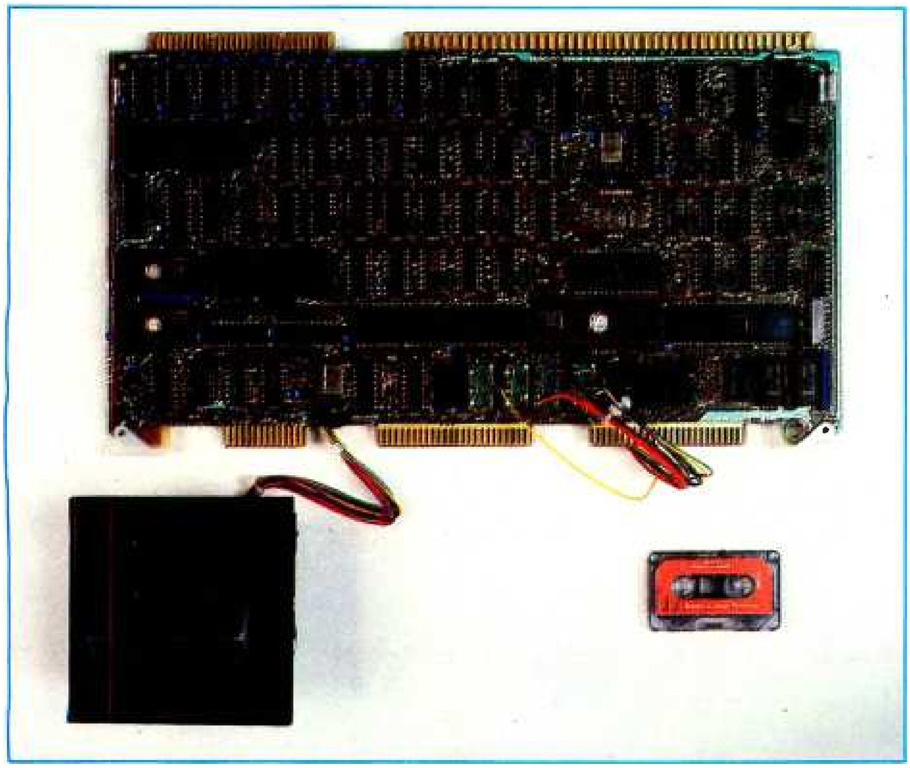

**Photo 1:** *The author's minicassette system includes an Intel iSBC 80/30 single-board computer and a Braemar CM-600 Mini-Dek transport.*

processor to its peripheral devices by using an intelligent peripheral controller to carry the burden of low-level peripheral interface requirements. The processor now interfaces at a higher level, issuing the appropriate command to the controller and transferring the data to and from the controller in response to its I/O requests.

The controller provides a buffer between the processor and the transport. For example, the cassette transport expects data in a serial format, while the microprocessor is designed for handling data in either 8-bit words or 16-bit words. The controller performs data conversion from serial to parallel and buffers the data. This buffering is necessary to compensate for the I/O-service latency caused by other time-critical tasks handled by the microprocessor (ie: the data is held until the computer can devote itself to the controller). As a direct result, the system's work load is reduced, allowing it to utilize this savings in time to support other tasks, yielding a higher-performance microprocessor system.

Applying this to the minicassette design, we look through the available literature for dedicated single-device cassette controllers. Unfortunately, there are no devices of this caliber for minicassettes. There is, however, another solution: use the Intel UPI-41 Universal Peripheral Interface (UPI) integrated circuit. Two versions are available; we can use one of them, the 8741A, and design software, customizing it to control the minicassette transport.

The 8741A, shown in figure 1, is a complete, single-chip microcomputer containing 1024 bytes of EPROM (erasable programmable read-only memory), 64 bytes of programmable memory, 18 programmable I/O lines (providing a direct interface to the peripheral device), and a timer/event counter with an 8-bit prescaler for real-time I/O. In addition, it contains a complete slave-microprocessor bus interface, including both interrupt and direct-memory-access capabilities. A pin- and function-compatible factory-mask ROM (ie: programmed only at the factory) version of the UPI-41, the 8041A, is also available.

The 8243 I/O-port expander completes the system and interfaces directly to the I/O port of either of


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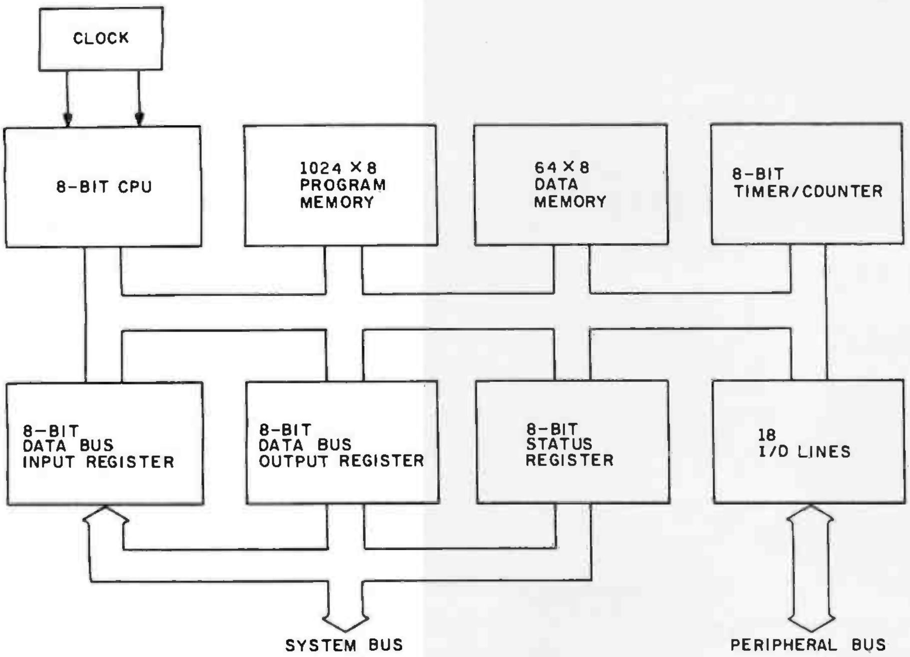


**Figure 1:** *Internal block diagram of the 8741A/8041A Universal Peripheral Interface. I/O lines can be programmed as inputs or outputs; 8041A control-program memory must be factory programmed; 8741A memory is user-programmed.*

the two slave microcomputers. Each 8243 provides 16 programmable, bidirectional I/O lines.

Using the 8741A allows the designer to develop a custom peripheral interface for particular I/O problems. These devices have found applications in such diverse areas as character-printer control, data encryption, keyboard control, and intelligent displays. Developing an 8741A design is straightforward. The designer develops a control algorithm using the UPI-41A cross assembler and programs the on-board EPROM of the 8741A. Testing may be accomplished using either an ICE-41A in-circuit emulator or the single-step mode of the 8741A.

## The Hardware

The complete microcomputer system is shown in photo 1, including the CM-600 minicassette transport. The microcomputer system for this design consists of an Intel iSBC 80/30 single-board computer. It supports an 8085A microprocessor, 8 K bytes of EPROM, and 16 K bytes of programmable memory. In addition to an 8255A parallel interface and an 8251A serial interface, it contains a Multibus system bus connector allowing expansion beyond the board's local resources. Incidentally, there is an 8741A socket built into the board as well.

Let us examine the microcomputer-to-8741A hardware interface. The computer sees the 8741A as three registers in its I/O address space: the data register, the command register, and the status register. The decoding of these registers is shown in figure 2. Within the 8741A, both the data and commands are written into the same physical register, the Data Bus Buffer Input register (DBBIN). The state of the register-select input, $A_0$, determines whether a command or data has been written ($A_0 = 0$ for data). All output to the microprocessor is read from the Data Bus Buffer Output register (DBBOUT).

The status register is composed of 4 software-programmable bits and 4 reserved bits reflecting the state of the 8741A slave microcomputer (see figure 3 on page 78). The Input Buffer Full (IBF) bit and Output Buffer Full (OBF) bit reflect the state of the DBBIN and DBBOUT registers, respectively. Flag 0 ($F_0$) and Flag 1 ($F_1$) can be set and complemented via the

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internal software. The remaining 4 bits are used to indicate the status of the transport.

The TTL-compatible I/O lines of the 8741A provide an uncomplicated interface to the CM-600 Mini-Dek minicassette transport (Mini-Dek is a registered trademark of Braemar Computer Devices Inc). The I/O lines can be divided into three groups: motor control, data control, and cassette status. These I/O port lines are shown in the 8741A interface schematic in figure 4 on page 78. The motor-group controls are go/stop, fast/slow, and forward/reverse. The data controls are read/write, data-in, and data-out. The remaining group of outputs reflects the CM-600's status: clear leader, cassette present, file protected, and cassette side.

The Braemar CM-600 Mini-Dek transport is representative of digital minicassette transports. The transport is compact, requiring only 3 by 3 by 2½ inches for mounting. It has a single read/write head and uses only one drive motor. Operating from a 5 V supply, it has modest power-supply requirements, needing only 200 mA during a read or write. Tape speeds are 3 ips (inches per second) during read/write, 5 ips for fast forward, and 15 ips during rewind. Calculating the data-transfer rate based on the read/write speed and the maximum recording density of 800 bpi (bits per inch) yields a maximum data-transfer rate of 2400 bps (bits per second). A more useful representation illustrating the significance of this number is obtained by inverting it. This yields the bit-cell period: 416 μs. This control requirement is easily met by the 8741A, its timer having a minimum resolution of 80 μs. If finer resolution were required, software-timing loops would have to be used. The maximum resolution is limited to the instruction-cycle time of the 8741A, 2.5 μs, necessary for transfer rates of 8000 bps.

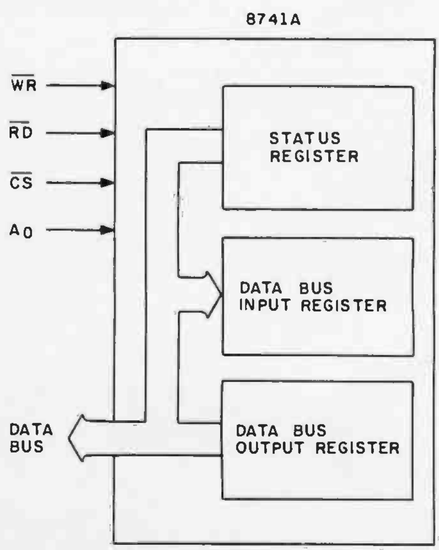
## Recording Format

Since the CM-600 does not provide any data formatting, the 8741A must perform this additional low-level task. A multitude of encoding techniques are available from which the user may choose [ie: NRZ1 (Non-return to Zero, change if 1), Phase, GCR (Group Code Recording)]. For this application, a "self-clocking" phase-encoding scheme similar to that used in floppy disks was selected. Phase encoding provides easy encoding and decoding of the serial data, embedding the timing information and data bits together in the recorded bit cells on the tape. This is an effective means of compensating for speed variations of the drive. Reading the data is accomplished by using the clocking information of the bit cell to synchronize the sampling of the data bit coming from the transport.

Figure 5 on page 78 illustrates this encoding technique as applied to the hexadecimal character 3A (all characters referenced in this article are hexadecimal). Notice that each bit cell begins with a transition to a logic level opposite the level of the preceding bit-cell level. Decoding the data is simply a matter of starting a timer on this "clocking" transition of the cell, waiting 3/4 of a bit-cell period, and determining whether a mid-cell transition occurred. Cells with no mid-cell transitions are 0s; cells with transitions are 1s. Besides the encoding

*Text continued on page 80*






| $\overline{CS}$ | $\overline{RD}$ | $\overline{WR}$ | $A_0$ | REGISTER |
|---|---|---|---|---|
| 0 | 0 | 1 | 0 | DBBOUT |
| 0 | 0 | 1 | 1 | STATUS |
| 0 | 1 | 0 | 0 | DBBIN (DATA) |
| 0 | 1 | 0 | 1 | DBBIN (COMMAND) |
| 1 | X | X | X | NONE |

**Figure 2:** *8741A system-bus interface and register decoding as seen by the host processor.*

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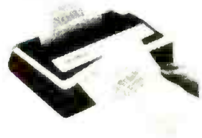

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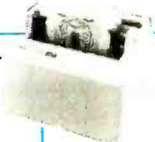

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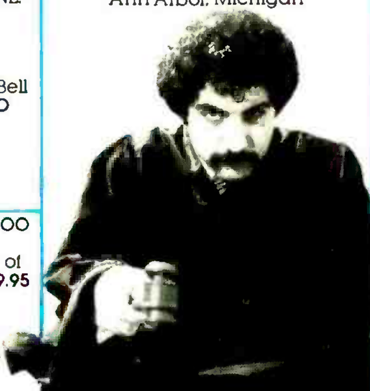

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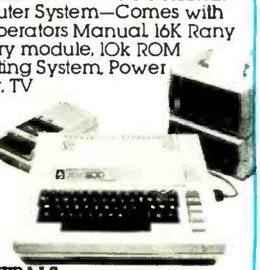

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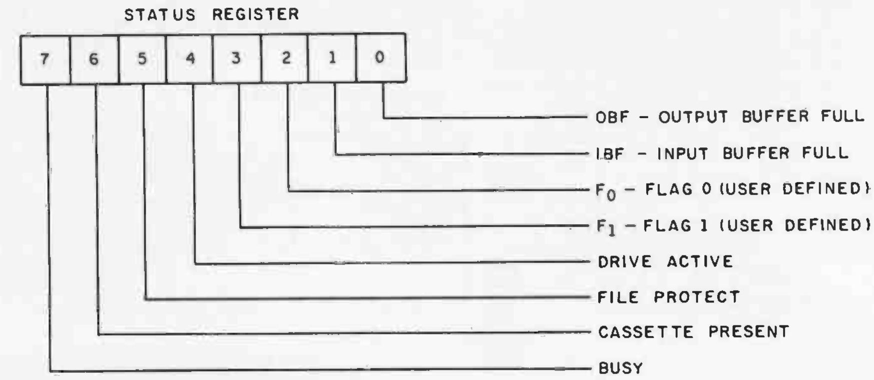


**Figure 3:** *Definitions of the status-register bits; Flag 0 and Flag 1 may be controlled by the user via the internal software.*

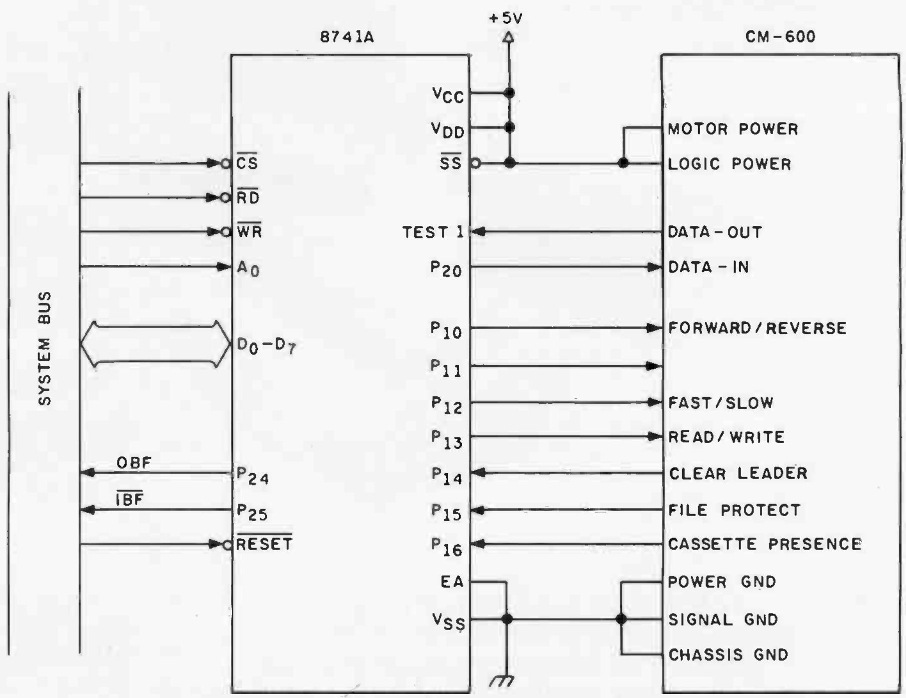


**Figure 4:** *The interface between the CM-600 Mini-Dek, the 8741A, and the host system.*

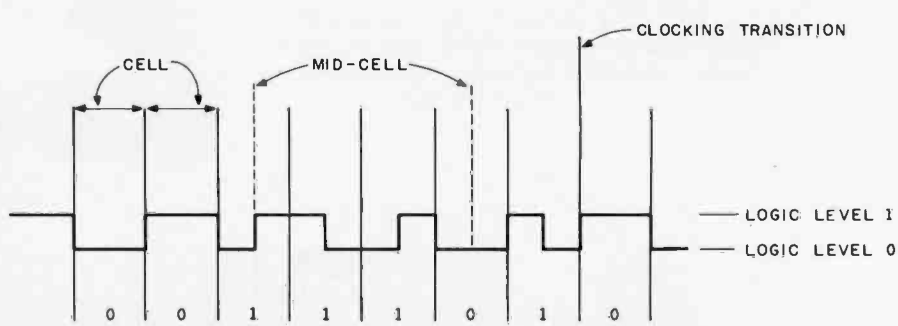


**Figure 5:** *The hexadecimal character 3A phase-encoded. This is the algorithm used with the minicassette controller. It is not the logic level of a bit cell that determines its value, but the presence or absence of a mid-cell transition.*

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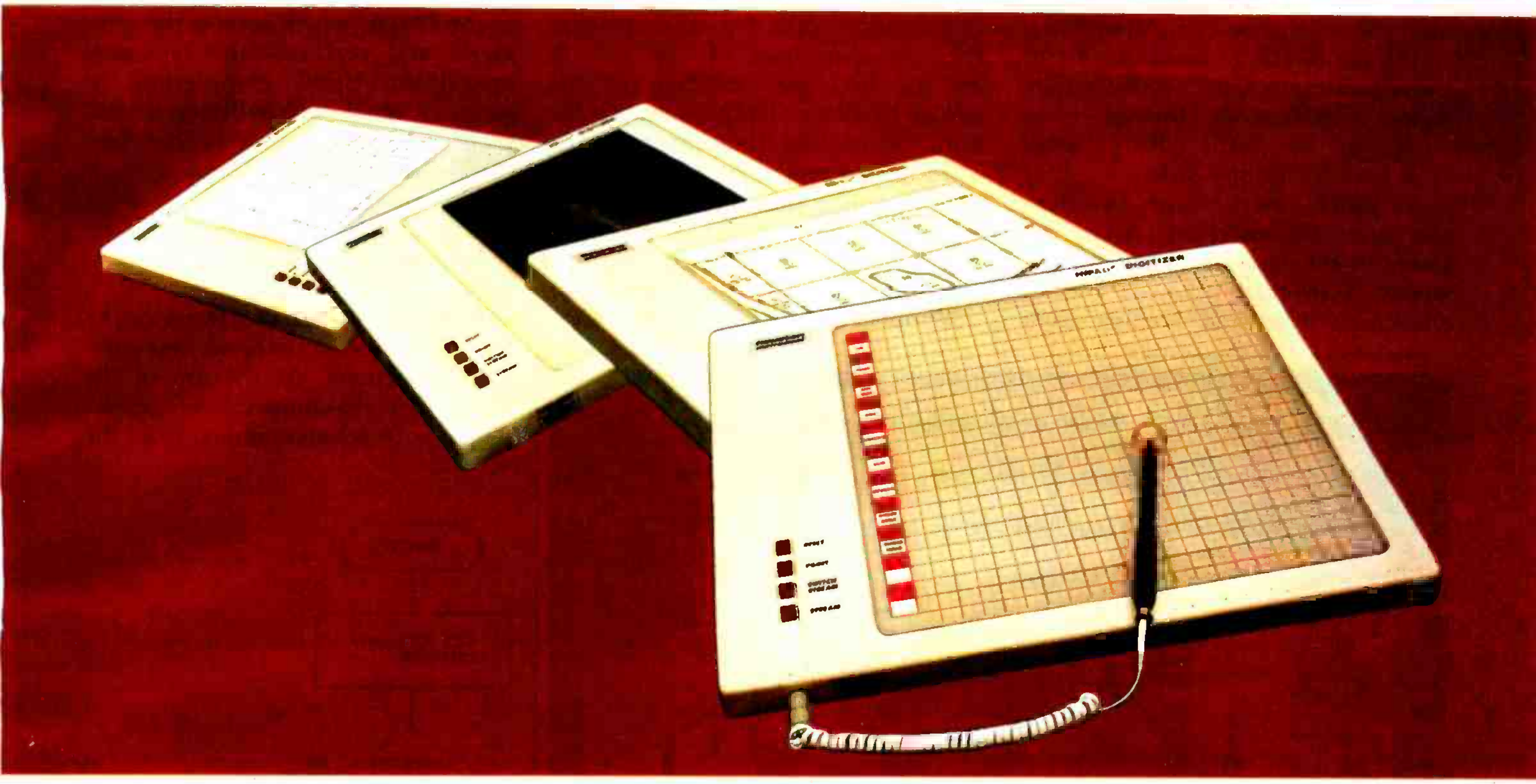

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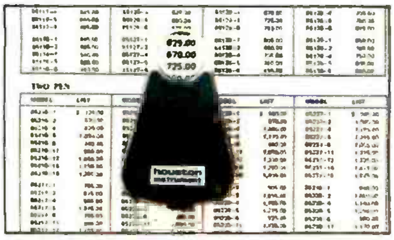

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*Text continued from page 72:*
scheme, the data format is also up to the user. The 8741A reads and writes blocks of variable length with an 8-bit checksum for error detection automatically appended. An option is to use the 8741A to check for errors by generating a CRC (cyclic redundancy check) code instead of a checksum, as in the CRC-16 error code used for floppy disks.

A block starts with a Sync character (hexadecimal AA), followed by the data (up to 64 K bytes), which is in turn followed by the checksum byte and trailing Sync character. Blocks of data are separated by an IRG (inter-record gap). The IRG is such a length that the transport can stop and start within an IRG. The CM-600 drive specification calls for a worst-case start or stop time of 150 ms. A 450 ms IRG was selected for the 8741A to allow plenty of margin for both controlling the transport (ie: starting and stopping) and detecting an IRG during the SKIP operation.

### The 8741A Controller Software

The goal of the software design for this application was to make the UPI-41A microcomputer into an intelligent cassette-control processor. The host microprocessor (8085A, 8080A, 8088, etc) issues a high-level command such as READ or WRITE to the 8741A, which accepts the command and performs the requested operation. Upon completion, it returns a result code notifying the microprocessor of the outcome (eg: Good-Completion, Sync Error, etc). Table 1 on page 92 lists the high-level command and result codes for the functions performed by the minicassette controller.

The internal 8741A software can be roughly divided into the various command functions. At the top of the hierarchy is the command recognizer. Its job is to get a command from the



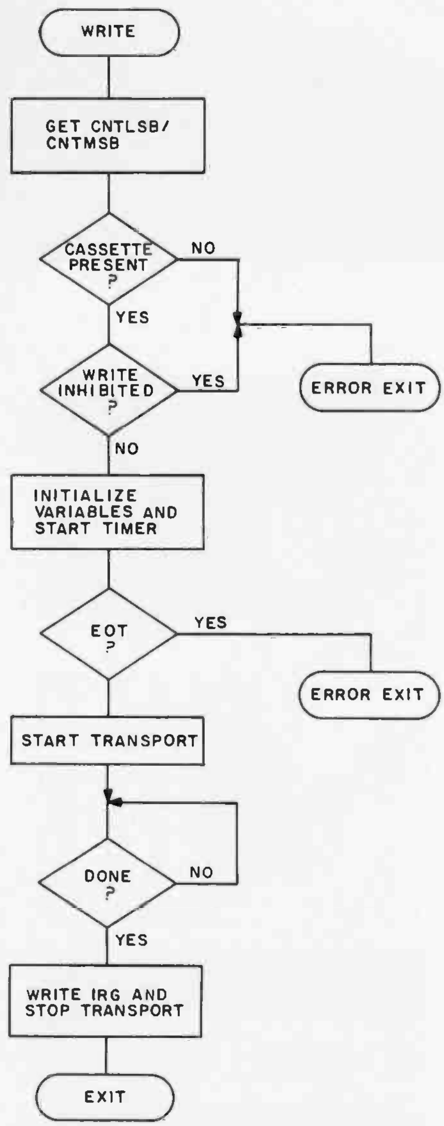
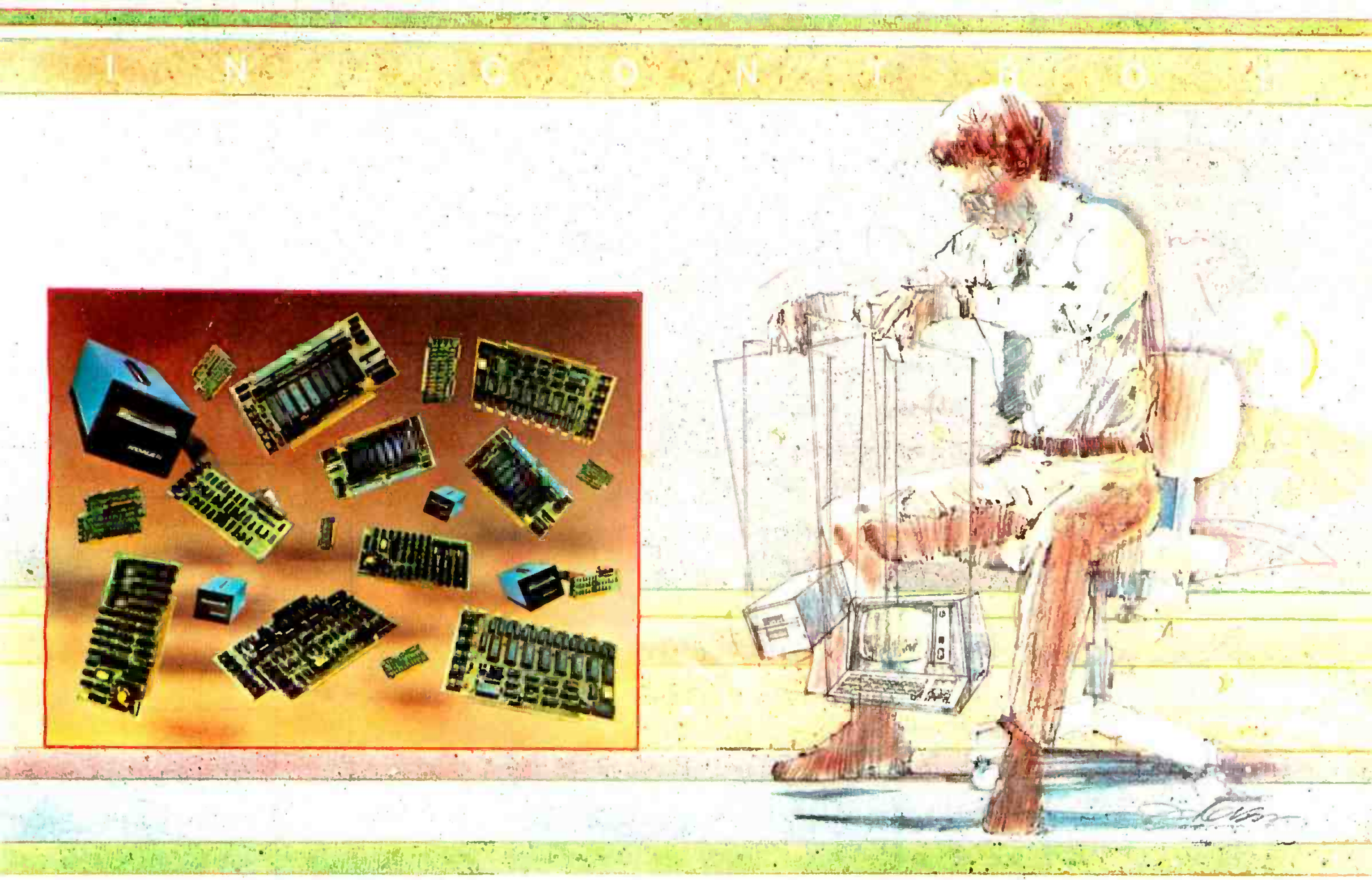



**Figure 6:** *Flowchart of the WRITE command sequence.*



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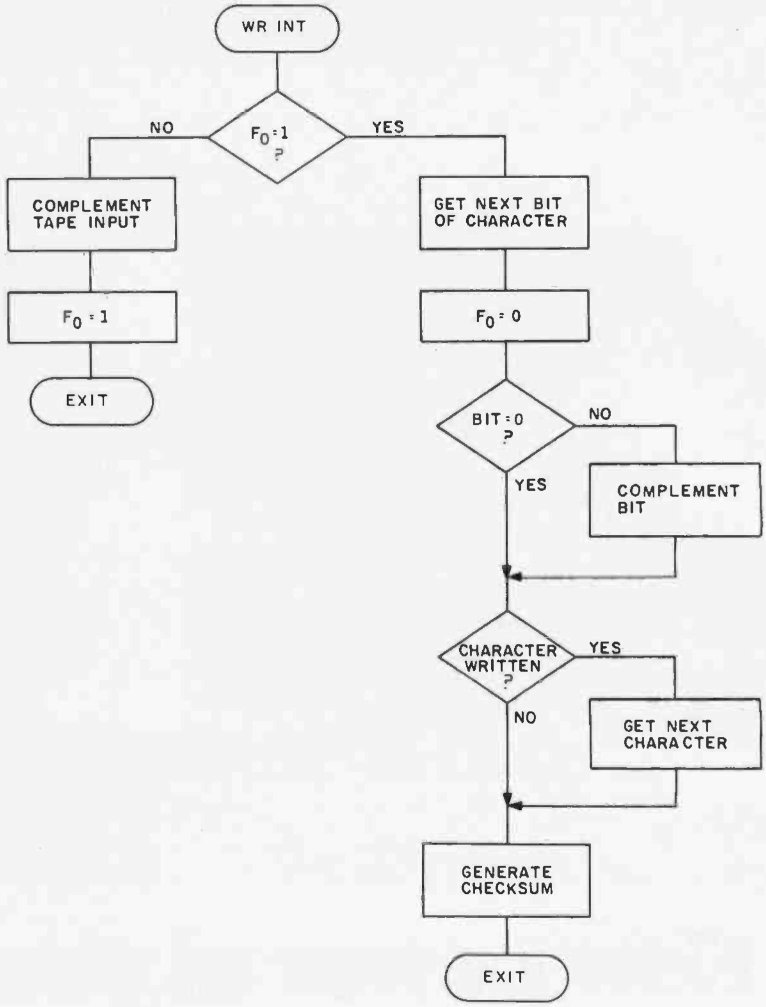


**Figure 7:** *Flowchart of the WRITE interrupt routine.*

microprocessor and branch to the appropriate command routine, executing until either the operation specified by the command is complete or aborted by the microcomputer or CM-600. The command routine then returns to the command recognizer to await the next command. Since only one command routine can be in execution at any one time, the working registers can change function based upon which command is active. These register names were assigned according to their function to aid program clarity. To understand the operation of the controller, let us examine the flow of the various commands in greater detail.

## WRITE Command

When the WRITE command is issued by the microprocessor, the 8741A expects a 16-bit unsigned number specifying the number of bytes to be written onto the tape to follow immediately. The controller requests only the desired number of data bytes by keeping track of the transfer count internally. All data transfers to and from the computer are double buffered. Before starting the transport, the 8741A checks the transport's status, verifying that the cassette is present and writing to the tape is not inhibited. If the drive is not ready for the data transfer, an appropriate error code will be returned; otherwise, the transfer will commence. The flowchart of this function is diagrammed in figures 6 and 7.

The controller begins the block transfer by writing a 450 ms IRG, followed by the leading Sync character, the data, the checksum character, and the final Sync character. The data is encoded with the phase-encoding algorithm described earlier before being written onto the tape. The internal timer is

*Text continued on page 86*

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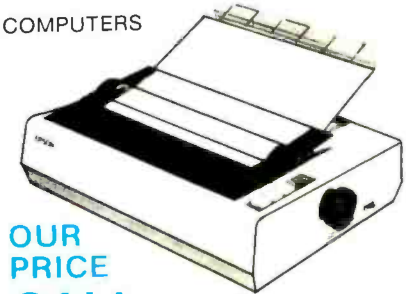

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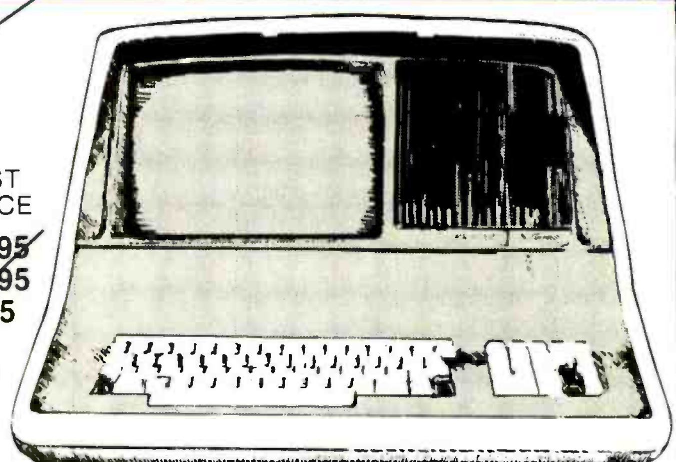

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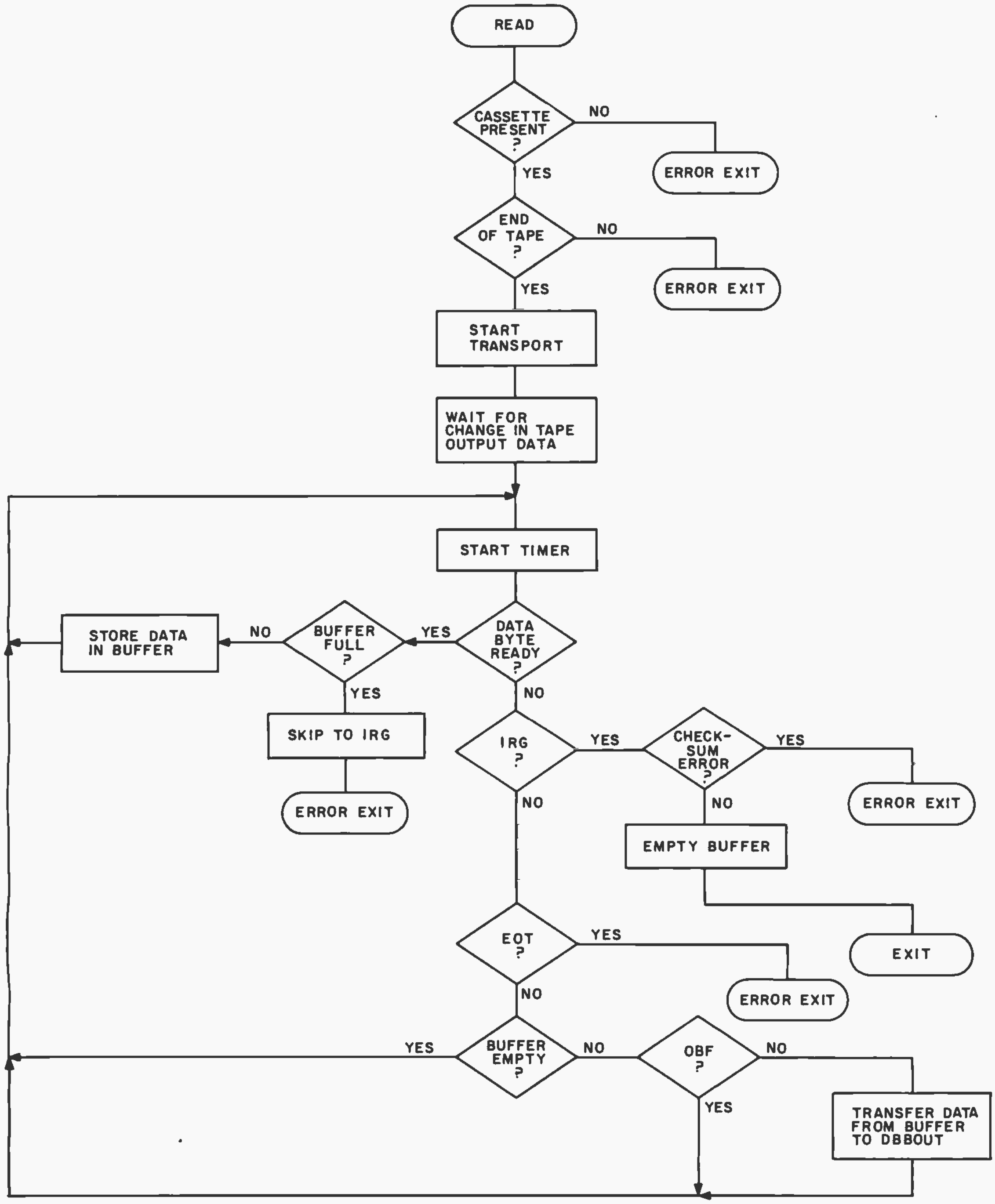


**Figure 8:** *Flowchart of the READ command sequence.*

*Text continued from page 82:*
used to signal both the initial cell transition and the mid-cell transition, generating an internal interrupt every 208 $\mu$s. Thus, a byte is written every sixteen timer interrupts, or 3.3 ms. If nothing unusual happens during the operation, it returns a Good-Completion result code (hexadecimal 00) to the host.

If an error occurs, the 8741A mini-cassette controller provides error wrap-up facilities, protecting the information on the tape from being corrupted. For example, if the clear leader of the tape is found during a write operation, the transport is halted immediately. Another error results from the processor being late in supplying data to the controller, causing a data-underrun error and aborting the data transfer. A 450 ms IRG is then written onto the tape before the transport is halted.

## READ Command

The READ command provides error checking similar to the WRITE command. Once the READ command is issued by the microprocessor, the controller checks for cassette presence and starts the transport. The data output from the transport is then examined and decoded continuously. This function is shown in the flowcharts of figures 8 and 9. The first character must be a Sync, or the

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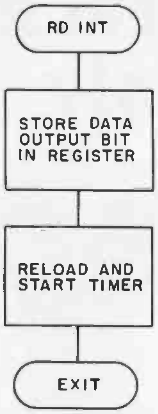


**Figure 9:** *Flowchart of the READ interrupt routine.*

controller will abort the read operation, return a Bad-First-Sync result code (hexadecimal 42), and advance to the next IRG of the tape. If the Sync character is correct, succeeding characters are read into an internal 30-character FIFO (first-in, first-out) buffer, allowing the processor over 99 ms of service latency before a data-overrun condition occurs. Whenever the DBBOUT register is empty, data is transferred to it from the FIFO buffer. This continues until an IRG is encountered, at which point the transport is stopped. The controller then tests the last character. If it is a Sync, the controller compares the ac-

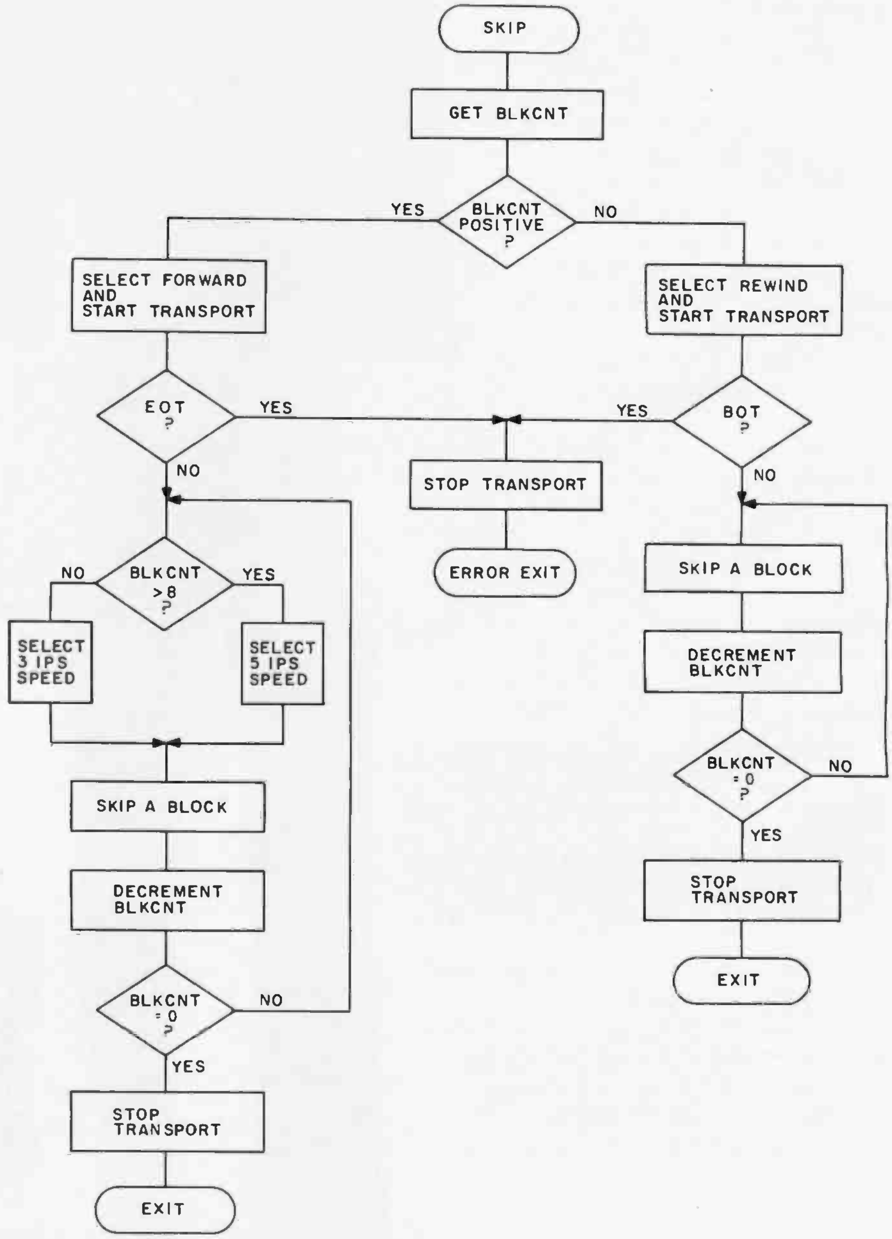


**Figure 10:** *Flowchart of the SKIP command sequence.*

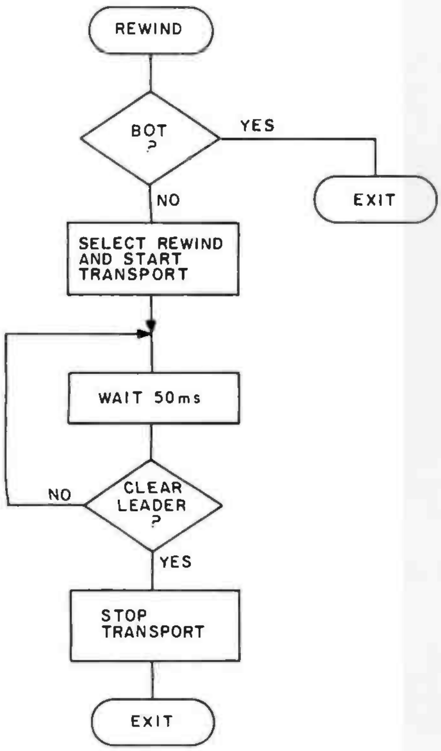


**Figure 11:** *Flowchart of the REWIND command sequence.*

cumulated internal checksum to the block's checksum, the last character of the block. If they match, a Good-Completion result code (hexadecimal 00) is returned to the host. Otherwise, the appropriate error-result code is returned (ie: Bad Sync2 or Checksum error). The READ command also checks continuously for the End-of-Tape (EOT) clear leader and returns the appropriate error code if it is found before the read operation is complete.

### SKIP Command

The SKIP command (see figure 10) allows the host to skip up to 127 blocks forward or backward. Immediately following the command byte, the controller expects an 8-bit signed-magnitude byte specifying the number of blocks to skip. The most significant bit of this byte selects the direction of the skip (0=forward, 1=reverse). SKIP provides two search speeds in the forward direction. If the number of blocks to skip is greater than 8, the controller uses fast forward (5 ips) until it is within 8 blocks of the desired location, then switches to the normal read speed of 3 ips to allow accurate placement of the tape.

The reverse SKIP uses only the rewind speed (15 ips). Like the READ and WRITE commands, SKIP also checks for EOT and Beginning-of-Tape (BOT) depending upon the tape's direction, returning an error code if either is encountered before the specified number of blocks have been skipped.

### REWIND Command

The REWIND command routine, figure 11, sets the transport to fast rewind of 15 ips and waits until the clear-leader status input of the transport is active for more than 50 ms. (There is a hole at each end of the tape. It is guaranteed not to cause the clear-leader input to be active for more than 50 ms.) Once the clear leader is found, the CM-600 is stopped and a Good-Completion result code is loaded into DBBOUT.

### ABORT Command

The final command, ABORT, is not a stand-alone command like the

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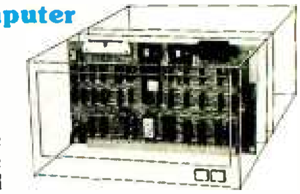

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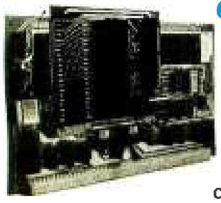

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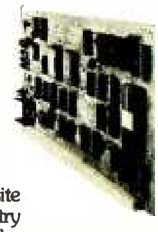

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others. Instead, the ABORT function is part of each of the other commands, allowing the microcomputer to abort the current operation. If a command is found in DBBIN register during the operation of one of the other commands, the command is compared to the ABORT command code. If it matches, the routine in execution is terminated. The Abort-Complete result code is then placed in DBBOUT to acknowledge the abort. The aborted routine will, however, exit gracefully. An aborted READ or SKIP advances to the next IRG before terminating. An aborted WRITE command will record an IRG before terminating execution. This protection helps insure the integrity of data stored on the minicassette tape.

| Command | Hexadecimal Representation | Result-Codes Returned | Hexadecimal Representation |
|---|---|---|---|
| READ | 01 | Good-Completion | 00 |
| | | Buffer Overrun Error | 41 |
| | | Bad Sync1 Error | 42 |
| | | Bad Sync2 Error | 43 |
| | | Checksum Error | 44 |
| | | Command Error | 45 |
| | | End-of-Tape Error | 46 |
| REWIND | 04 | Good-Completion | 00 |
| SKIP | 03 | Good-Completion | 00 |
| | | End-of-Tape Error | 47 |
| | | Beginning-of-Tape Error | 48 |
| WRITE | 02 | Good-Completion | 00 |
| | | Buffer Underrun Error | 81 |
| | | Command Error | 82 |
| | | End-of-Tape Error | 83 |

**Table 1:** *Commands issued by the host processor and possible resultant codes returned to it when the EPROM in the 8741A is programmed with the software described in this article.*

## Conclusion

This application illustrates how the 8741A device can provide intelligent peripheral interfaces between a computer and a peripheral device such as the CM-600 Mini-Dek transport. This benefits the microprocessor system by divorcing it from the close management required by the peripheral. It interfaces to the 8741A controller producing a high-level I/O interface. The 8741A provides all the low-level peripheral-control functions. Another benefit of this task modularity is that it allows the software to be modified and upgraded without affecting the computer system software. In fact, the 8741A software could be adapted to control other cassette transports without affecting the microprocessor. ■

# A Reformatter for CP/M and IBM Floppy Disks

John A Lehman, 716 Hutchins #2, Ann Arbor MI 48013

In the "old" days of personal computing (ie: five years ago), the transfer of programs or data between large and small computers was not a major problem. You simply turned on the paper-tape punch in your Teletype ASR33 terminal and listed the program on the source computer. You then took the paper tape to the second computer, inserted it in the paper-tape reader, and read it in. This was slow, noisy, and did not encourage transfer of long programs, which microprocessor-based computers didn't have enough memory to run anyway.

The situation has changed quite a bit. Small computers are no longer mere experimenter's toys, but serious tools for science and business. Instead of being programmed only in machine language or BASIC, they are now programmed in FORTRAN, Pascal, PL/I, COBOL, and many other popular high-level languages. The fact that small machines can now run the same programs as the larger ones has increased the demand for program transfer between machines. For example, it is not uncommon for me to take a 1000-line FORTRAN program from a large timesharing system and run it (virtually unchanged) on my CP/M system. However, a program of that size is too large to dump to paper tape, even *if* any of the systems I use still had a Teletype terminal with a paper-tape reader.

This is where Microtech Exports' Reformatter for floppy disks comes in. IBM originally intended the floppy disk to be a replacement for punched-card data entry. The IBM 3740 Data-Entry System Basic Exchange Format (BEF) is a fixed-field, uncomplicated standard for data transfer between IBM equipment. Many machines that use floppy disks do not use BEF for normal use, because it is inefficient. However, almost all IBM equipment can use it to transfer files. Reformatter allows the transfer of data both ways between CP/M and BEF files.

Reformatter is a useful product for anyone who wants to take programs developed on one system and run them on another. For example, I have put a number of published FORTRAN packages onto my CP/M system. Going the other way, to avoid being charged for development time, I use my system to develop FORTRAN and PL/I programs to run on larger systems.

Another group who will find Reformatter useful are people with access to large computers that have peripherals they would like to use on a smaller system. For example, my CP/M system has neither 9-track magnetic tape nor a high-speed line printer, but I have access to an IBM Series/1 system that does.

So much for the motivation for using the Reformatter package. How does it work? Surprisingly well. It allows

## At a Glance

**Name**
Reformatter

**Type**
Translates between CP/M and IBM Basic-Exchange-Format floppy disks.

**Manufacturer**
Microtech Exports
912 Cowper St
Palo Alto CA 94301
(415) 324-9114

**Price**
$195

**Format**
8-inch floppy disk

**Computer**
Any CP/M system *and* any IBM system. Requires two 8-inch disk drives.

**Audience**
Anyone with access to both CP/M and IBM systems.





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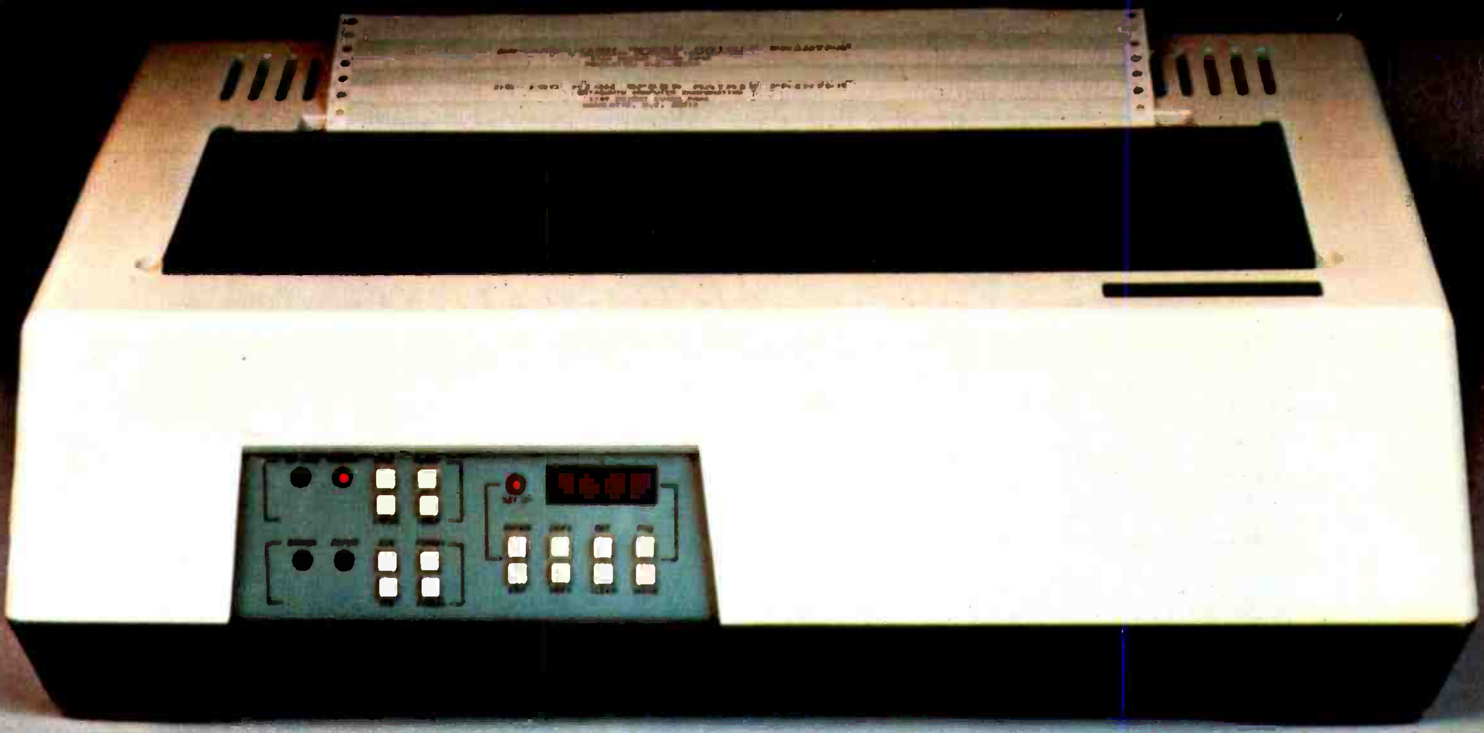

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**Non-volatile Format Retention**—a unique programming keypad featuring a non-volatile memory allows the user to configure the DS180 for virtually any application. Top of form, horizontal and vertical tabs, perforation skipover, communications parameters and many other features may be programmed and stored from the keypad.When your system is powered down, the format is retained in memory. The DS180 even remembers the line where you stopped printing. There is no need to reset the top of form, margins, baud rate, etc.... it's all stored in the memory. If you need to reconfigure for another application, simply load a new format into the memory.

**Communications Versatility**—The DS180 offers three interfaces including RS232, current loop and 8-bit parallel. Baud rates from 110-9600 may be selected. A 1K buffer and X-on, X-off handshaking ensure optimum throughput.

**Forms Handling Flexibility**—Adjustable tractors accommodate forms from 3"-15". The adjustable head can print 6-part forms crisply and clearly making the DS180 ideal for printing multipart invoices and shipping documents. Forms can be fed from the front or the bottom.

If you would like more information on how the DS180's low-cost total printer package can fill your application, give us a call at Datasouth. The DS180 is available for 30-day delivery from our sales/service distributors throughout the U.S.

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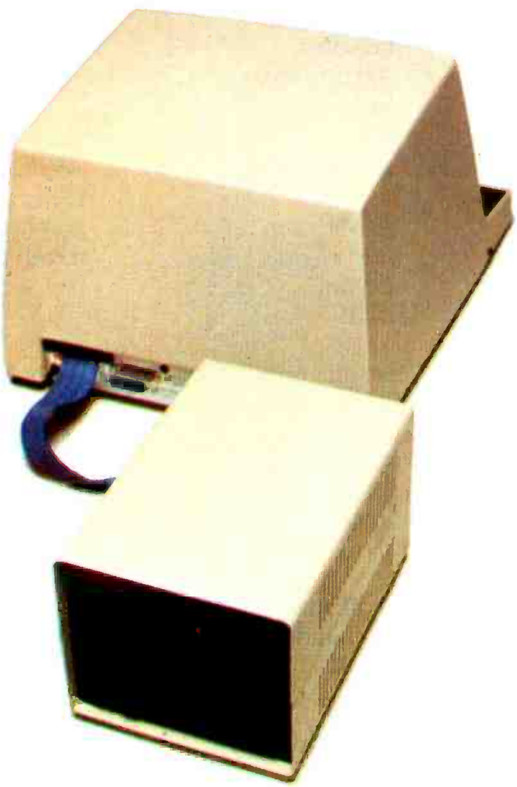
4740 Dwight Evans Road • Charlotte, North Carolina 28210 • 704/523-8500 you to initialize Basic-Exchange-Format floppy disks, list their directories, change the file definitions, dump, display, edit, or delete the files, and to transfer data to and from CP/M files. Automatic character-set conversion and proper handling of conversion between fixed- and variable-record formats can be used or disabled. All of these functions work well and rapidly. Reformatter can transfer a file between CP/M and BEF twice as fast as an IBM Series/1 can transfer that same file to hard disk. Its file-manipulation facilities are also considerably more flexible than are the IBM-supplied versions.

Reformatter is also easy to use. It is menu driven, and entering a carriage return at any point backs you up one level in the menu. In terms of ease of use, it ranks in the top quarter of the CP/M software that I have used, and in the top 1% of IBM software.

In fact, any problems I had using this package stemmed from IBM's tendency to do things the hard way from the user's standpoint. With any IBM software that I have used, you are required to specify the size of a file at the time you create it. On the other hand, CP/M can dynamically expand a file; moreover, it uses variable-length records, as opposed to IBM's fixed-length. The result is that you must specify the size of the IBM file without knowing the size of the CP/M file. There are a number of ways around this. You can set up your IBM disks with only one file per disk, which is not as wasteful as it sounds, since a BEF disk holds about 50 K bytes of text or programs (each line takes a full 128 bytes). The second solution is to purposely create overlapping files, copy them, check the directory for the resulting sizes, and repeat the process again. Finally, you can write a program that counts the lines in a CP/M file and tells you how many tracks and sectors the IBM disk will require.

In summary, if you have access to an IBM or an IBM-compatible computer system and you want your file- and data-transfer problems solved, Reformatter is probably what you've been looking for.

If you have a TRS-80 or access to DEC machines, Microtech Exports has another version for you.■



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# MicroShakespeare Revisited
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Andrew Kalnik, 3201 Wamath Dr, Charlotte NC 28210

William Shakespeare would have made a first-rate computer analyst. He had all the qualifications: superb powers of observation, capacity to deal with complex problems, imagination, and a fair ability to express himself.

Looking at his writings, you can easily recognize the vocabulary of a systems consultant making his pitch to land an installation contract. Presented in a conference room against a backdrop of easel charts, with gold-stamped proposal binders on the broad walnut table, some of his phrases would be right in place:

"...I'll teach you how to flow..."
(*The Tempest*, Act II, scene i)

"What is written shall be executed..."
(*Titus Andronicus*, Act V, scene ii)

"I will execute, and it shall go hard,
but I will better the instruction..."
(*Merchant of Venice*, Act III, scene i)

"...Our interpreter does it well..."
(*All's Well That Ends Well*, Act IV, scene iii)

From other lines, you can feel the sympathy the Programmer of Avon would give wretches like you and me sentenced to a debugging session:

"O hateful error, melancholy's child
Why dost thou show to the apt thoughts of man
The things that are not? O, error, soon conceived
Thou never comest into a happy birth..."
(*Julius Caesar*, Act V, scene iii)

Here's another short quiz to test how well you can match Master Will's golden words against the shiny silicon jargon of our art. (Try your hand at the other quiz in the April 1980 BYTE, page 104.) What we've done is to make free translations from Shakespearean phrases into terms familiar in computing.

Simply match the letter of the most pertinent modern phrase against the quotations. No prizes, just the satisfaction of puzzling out the answers. The answers and ratings are on page 184. [**Editor's note:** *Each of the items 1 thru 20 will match to one of the answers "a" thru "t," so read through all the answers before you try to make a match.* ...**GW**]

| | |
|---|---|
| 1. ( ) We'll evaluate your purpose, and put on a form... *Troilus and Cressida*, Act III, scene iii | a. "And *that* crashed the whole program!" |
| 2. ( ) ...an adder did it... *A Midsummer Night's Dream*, III/ii | b. "We'll have the function graphed on screen in a few seconds." |
| 3. ( ) That one error fills him with faults. *Two Gentlemen of Verona*, V/iv | c. "I wish I could check the register flags." |
| 4. ( ) ...shall run in a new channel fair and evenly... *I Henry IV*, I/i | d. "There isn't much time to convert the analog readings between interrupts." |
| 5. ( ) ...unpleasantest words that ever blotted paper... *The Merchant of Venice*, III/ii | e. "Put a scope on it to check those big input spikes." |
| 6. ( ) ...inferreth arguments of mighty strength... *III Henry VI*, V/ii | f. "With the new I/O board, it should just perk right along." |
| 7. ( ) ...the minute of their plot is almost come... *The Tempest*, IV/i | g. "That frosts me—we're not getting any output from those ANDs." |

| | | | |
|---|---|---|---|
| 8. ( ) | This fierce abridgement hath to it circumstantial branches.<br>*Cymbeline,* V/v | h. | "We regret to inform you that we can no longer supply replacement parts for your system." |
| 9. ( ) | Look, what thy memory cannot contain/ Commit to these waste blanks.<br>*Sonnet lxxvii* | i. | NOP |
| 10. ( ) | ...full charactered, lasting memory...<br>*Sonnet cxxii* | j. | "It was in accumulator A." |
| 11. ( ) | ...the very cipher of a function...<br>*Measure for Measure,* II/ii | k. | "Looks like you're getting a hard-copy memory dump." |
| 12. ( ) | ...Would I were assured of my condition...<br>*King Lear,* IV/vii | l. | "If you have no more memory left, you store everything on a scratch disk." |
| 13. ( ) | ...Is it ended then...?<br>*Coriolanus,* IV/iii | m. | "Let's work up a high-level flowchart." |
| 14. ( ) | ...The gates made fast! Brother, I like not this.<br>*III Henry VI,* IV/vii | n. | "We can't be any worse off." |
| 15. ( ) | O'erbearing interruption...<br>*King John,* III/iv | o. | "It seems you can call a macro that inverts a 99 by 99 matrix." |
| 16. ( ) | ...mark the high noises...<br>*King Lear,* III/vi | p. | "It's unmaskable." |
| 17. ( ) | What should that alphabetical position portend?<br>*Twelfth Night,* II/v | q. | "That IF-THEN-ELSE decision sequence cut the program down by at least 40%." |
| 18. ( ) | Thou hast caused printing to be used...<br>*III Henry VI,* IV/ii | r. | "Are we at step 9999?" |
| 19. ( ) | What I can do can do no hurt to try...<br>*All's Well That Ends Well,* II/i | s. | "ROM with complete ASCII set." |
| 20. ( ) | If it were done when 'tis done, then 'twere well/ It were done quickly...<br>*Macbeth,* I/vii | t. | "Can you tell me what this string is doing in position FFCA?" |

See answers on page 184.■

# Programming the Game of Go

Jonathan K Millen
661 Main St
Concord MA 01742

Go is a board game. Like chess, it is a game of pure skill; moreover, a considerable body of literature has been devoted to it. Go was invented in China around 2000 BC. Since its introduction into Japan around 700 AD, it has flourished there to the extent that the most accomplished masters of the game are now Japanese. However, the game has spread world-wide. In the United States, one can find Go clubs in the vicinity of large cities and universities, and most large bookstores have at least one substantial book on the game.

Go is played on a 19 by 19 square grid having black spots on nine intersections, as illustrated in figure 1. The traditional board, called a *Go Ban*, is a wooden block about 17 inches square and several inches thick, with four short feet. It stands alone as a table at just the correct height for players sitting on floor cushions.

One player has a supply of black stones; the other, white stones. The stones are disks about the same size as the grid spacing; they are approximately three-eighths of an inch thick in the middle and almost sharp around the edge. The black stones traditionally are made of slate, and the white stones of clam shell.

Players move alternately, each placing a stone on the point of intersection of a pair of grid lines. The object of the game is to enclose the most area, measured by the number of unoccupied points enclosed by stones of a given color. A point is enclosed by, say, black, if no path along the grid from the point runs into a white stone. Figure 2 shows some enclosed areas. Note that the edge of the board can form one boundary of an area.

A player can increase his area by capturing the opponent's stones. Stones are captured a connected group at a time. A set of stones forms a connected group if there are paths along the grid from any stone to any other stone in the set, such that all points on the path are occupied by stones in the set. This criterion is easy to visualize because the stones, being as large as the grid spacing, actually touch along paths of connection. The phrase "connected group" also implies that the stones in the group are all of the same color, and that the group is not merely a part of some larger connected group.

A group of stones is captured when it has no *liberties*. A liberty of a connected group is an unoccupied point adjacent (vertically or horizontally) to a stone in the group. If a group has just one liberty, the opponent may capture it by placing one of his stones on the liberty. The opponent then picks up the captured stones and keeps them as prisoners. At the end of the game, a player's point count of area is augmented by the number of prisoners he has captured. Figure 3 shows a group having one liberty.

The game ends when both players pass consecutively, because they both see no further advantage in playing more stones. Usually, when this happens, there are white stones within areas enclosed by black, and vice versa. These stones have been given up because the owner can predict that they will be captured. They are removed as prisoners at the end of the game before counting the score.

The remaining rules are technicalities. Two that have a significant effect on the game, concerning "ko" and "suicide," will be mentioned later on. The rest involve details of ending the game and scoring, and are rarely invoked.

## A Go-Playing Program

A Go opponent, called Wally, was programmed on a KIM-1 within its approximately 1 K bytes of memory. Wally's algorithm is based on essentially two capabilities: finding the liberties of a connected group, and matching a few common patterns. Moves take less than a second.

A 15 by 15 board was used because

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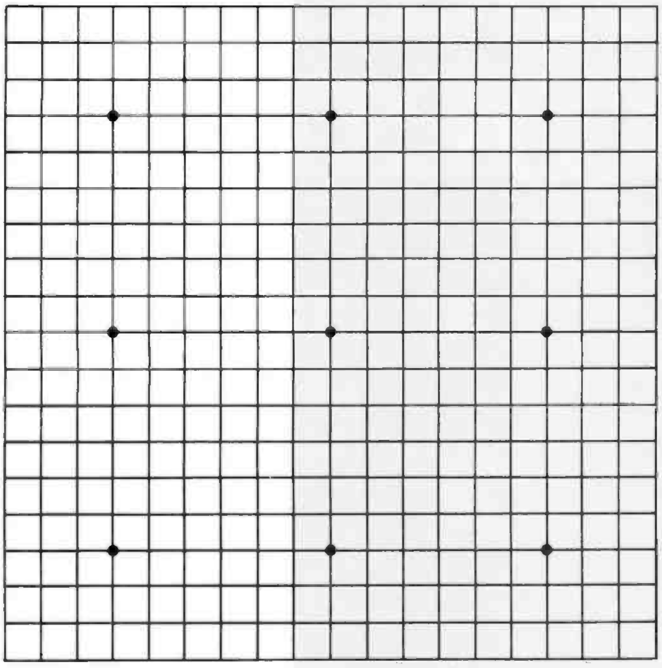

**Figure 1:** *The Go board. Players move alternately, placing stones on the points of intersection of the lines, rather than in the spaces. The nine dots are handicap-stone locations. The line spacing is about 2.2 cm (seven-eighths of an inch).*

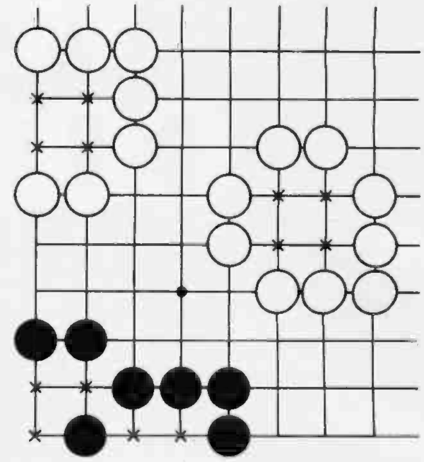

**Figure 2:** *Enclosed areas. Points marked x are in areas enclosed by one player or the other. The figure shows five black points and eight white points.*

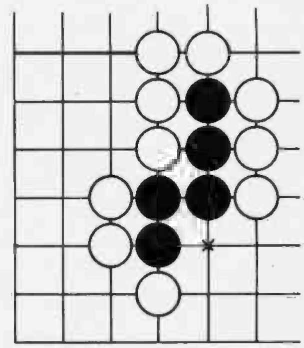

**Figure 3:** *A black group with exactly one liberty, marked x. If it is white's turn, he can capture the black group by placing a stone at x and removing the black group as his prisoners.*



it was convenient for addressing reasons to represent it internally within a single 256-byte page, using one byte per point. Although there would be room for a 16 by 16 board, a Go board ought to have a center point. Rows and columns were numbered from 1 to F (in hexadecimal) so that the coordinates of a move could be entered on the KIM keyboard.

When a move is entered, Wally responds with the coordinates of his move on the KIM display, and the complete board is also output on a video terminal. The display of a game in progress is shown in photo 1.

Once the board representation and the input and output routines were set up, the first major component of the

program to be written was the routine that walks through a connected group of stones, marking the members of the group, and both marking and counting its liberties. Called COUNT, this routine is a variety of the maze-search algorithm. It was programmed recursively in machine language.

What COUNT does for each board location it looks at is based on the "invariant assertion" that any point it looks at is one of the following:

- a stone in the connected group
- a liberty of the connected group
- a stone of the other color adjacent to the connected group

If it is looking at a stone in the group, it checks to see whether that stone has previously been marked. If not, it marks the stone and calls itself to repeat the same process, starting with each of the four locations north, east, south, and west of the present stone.

*Marking* a stone or point, of course, means to set a particular bit in the byte corresponding to that point in the board representation. Other bits encode whether the point is

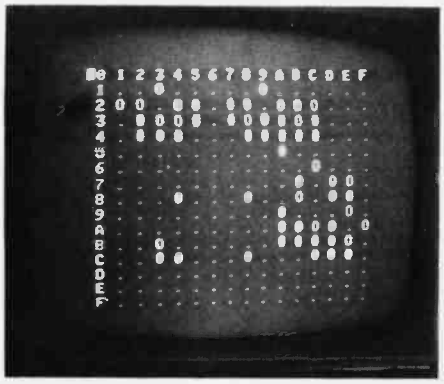

Photo 1: *A game in progress. Wally (the computer) is playing black, represented by the solid-looking crosshatches (#). The author is playing white, represented by 0s. The computer uses a 15 by 15 board; the points of play are indicated by periods. In this game, black was given a nine-stone handicap.*

occupied and, if so, by what color stone.

If COUNT is looking at an unoccupied point, it marks the point as a liberty and increments the count of liberties, unless the point has already been marked and counted.

If COUNT is looking at a stone of the other color, it does nothing, and just returns.

If a stone is on the edge, or first line, of the board, then one (or, in a corner, two) of its neighbors will be off the board. If COUNT is called for an off-board location, it returns immediately.

Note that, if COUNT starts on a stone and operates as described above, the recursive calls to COUNT will carry the center of attention all over the group and onto all neighboring points. The invariant assertion is satisfied because COUNT progresses one step each time only from stones in the group, as sketched in figure 4.

The algorithm for COUNT is specified concisely in listing 1 using a kind of "structured English." The rest of the Go-playing program will be specified similarly, as a collection of modules like COUNT.

Recursion is not difficult to implement; COUNT just calls itself with the usual jump-to-subroutine instruction for each of the neighboring points. The current board location is in a register; it is saved on the KIM stack before it is replaced by the location of each neighboring point, and then restored upon return from each call. The size of the connected group

is limited by the size of the stack; one byte of board location plus two bytes of return address are pushed for each call, and the calls are nested as the algorithm "walks" around the group. A 100-byte stack can handle a 33-stone group. A group of that size would occur, if at all, only near the end of the game, when Wally's play deteriorates for other reasons anyway.

### Main Loop

After COUNT was coded, a reasonable overall structure for a program to use it followed quickly. The main loop is specified in listing 2. The "consequences" of counting a group of stones include removing it from the board (zero out the board locations) if it has no liberties; other consequences have to do with suggesting tentative moves for Wally. Wally always plays black, in accordance with the Go tradition of giving the black stones to the weaker player.

The pattern-matching facility was not implemented immediately. In fact, the first version of the program chose black moves randomly, trying again if it hit upon an occupied point. At least the capturing of black groups could be tested, and, for the most part, it was playing legal Go.

### Tactics and Priorities

The next step in the design of the program was the decision that Wally would make contact moves, adjacent to white stones. In this way, the program would appear to be attempting to capture white groups, and would eventually fill up the liberties of each white group and capture it, if no defensive action were taken.

At the same time, it was clear that Wally also should take some defensive moves to avoid capture. This brought up the question of priorities: when is a black group threatened enough so that Wally should stop attacking white and make a defensive move instead? The answer had to be based on the number of liberties remaining in the black and white groups. It was decided that threats would be ignored until a black group had been reduced down to one or two liberties. Otherwise, Wally attacks whichever white group has the least number of liberties, because that group promises the best chance of being captured.

This strategy was implemented by associating a number of liberties with each suggested black move—namely, the number of liberties remaining for the group contacted by the stone. When a move is suggested, such as some liberty of a white group being

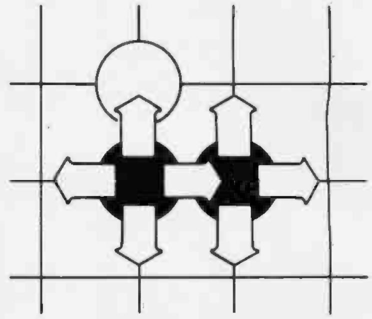

**Figure 4:** *How the procedure COUNT works. When tracing a black group, COUNT begins on a stone in the group and calls itself recursively to look at the four neighboring locations. If a neighbor is a black stone, the process is repeated until all stones in the connected group have been found. All unoccupied points adjacent to stones in the groups (ie: liberties) are also found and counted.*

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**Listing 1:** *Structured English specification of COUNT module to find and count the liberties of a connected group containing a stone at point "x" of color "color." COUNT calls itself recursively, saving x on the push-down stack during each call.*

```
COUNT(x, color):
  IF x is not off the edge
  THEN
    IF there is a stone at x AND
      it is the given color AND
      it is not marked
    THEN
        mark it
        CALL COUNT(NORTH(x), color)
        CALL COUNT(EAST(x), color)
        CALL COUNT(SOUTH(x), color)
        CALL COUNT(WEST(x), color)
    ELSE IF there is no stone at x
    THEN
        mark the point as a liberty
        increment the liberty count
    END
  END
```

counted, a best (move, liberties) pair is updated if the new move is adjacent to a group of a smaller or equal number of liberties. Since black groups are counted after the phase in which white groups are counted, a move by black in contact with a black group with one or two liberties is automatically preferred to a move adjacent to a white group with the same number of liberties. An exception was put in later: when Wally finds a chance to capture a white group on the next move, he always takes it, even if some black group also has only one liberty. There is some doubt whether this exception was wise, however.

## Ko and Illegal Moves

There are two situations in which a move on an unoccupied point is illegal. A move that leaves one's own group with no liberties is illegal. Figure 5a shows a move by black that would be illegal because the resulting black group would have no liberties. A move resulting in the capture of an opponent's group, as in figure 5b, is permissible because removing the captured group creates at least one liberty.

The second type of illegal move arises from a *ko*, illustrated in figure 6a. If white captures the central black stone on his next move, the position will look as in figure 6b. Now black can capture the white stone and reproduce the original position in figure 6a. This could go on forever. To prevent such infinite repetition, the *Rule of Ko* was introduced: no

**Listing 2:** *Module specification for the main loop of the Go-playing program and two of its called modules.*

```
MAIN:
  place black handicap stones
  LOOP
    display the board
    get white's move from keyboard
    CALL WEFFECT for the effect of white's move
    CALL BEFFECT to obtain a tentative black move
    CALL PATS to check for a pattern match
    place black stone
  END

WEFFECT:
  FOR each point x with a black stone DO
    CALL COUNT(x,black)
    IF the group has no liberties
    THEN remove its stones
    ELSE IF the group has at least one liberty
    THEN
      choose a liberty not on edge line
      IF the group has 1 or 2 liberties
      THEN CALL EVAL for the chosen liberty
    END
  END

BEFFECT:
  FOR each point x with a white stone DO
    CALL COUNT(x,white)
    IF the group has exactly 1 liberty
    THEN
      designate it as the black move
      remove the white stones
      EXIT
    ELSE IF the group has 2 or more liberties
    THEN
      choose a liberty
      CALL EVAL for the chosen liberty
    END
  END
```

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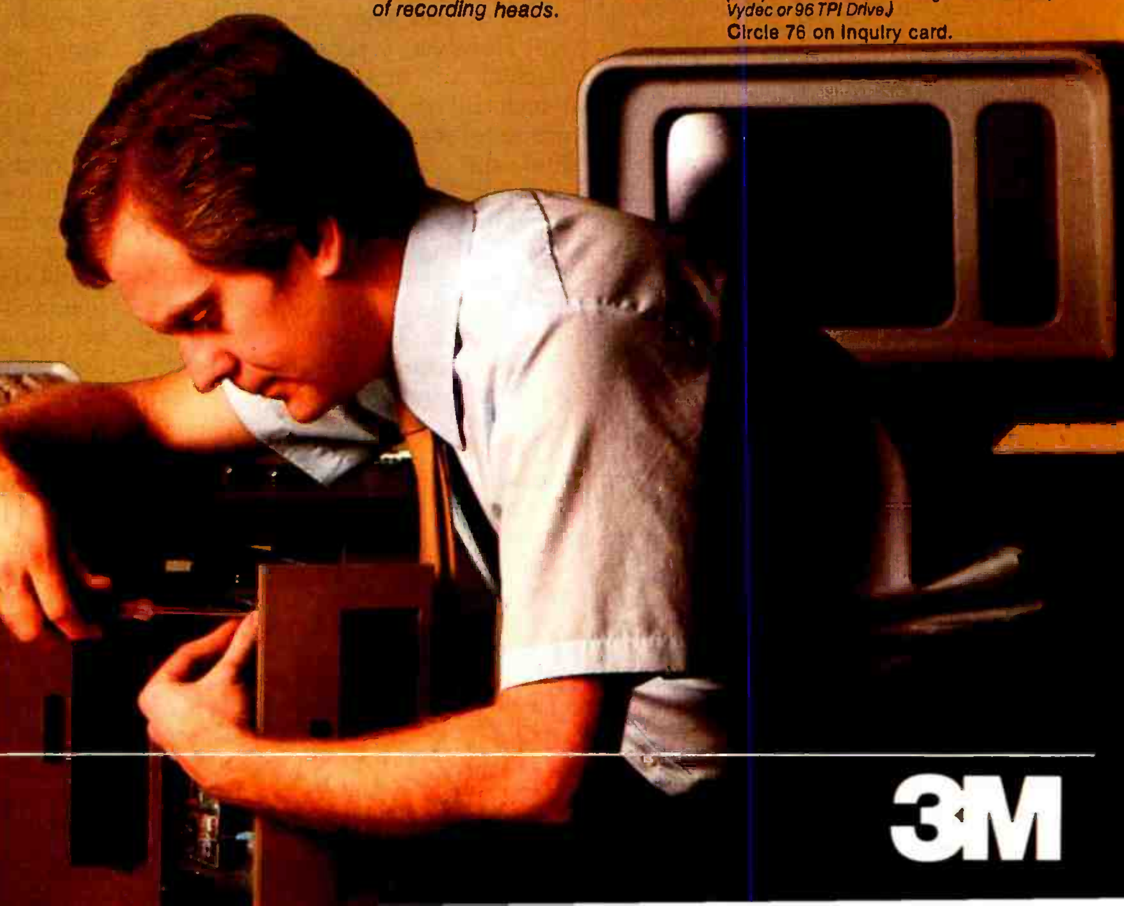

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(a)

(b)

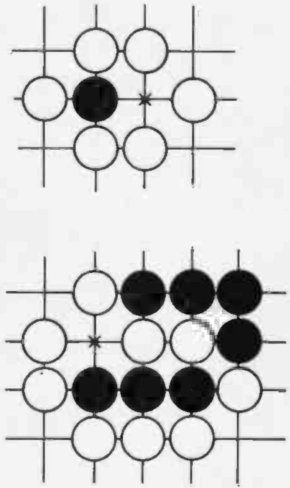

**Figure 5:** *Illegal moves. The point marked x in 5a is illegal for black because it would result in a black group with no liberties. The point marked x in 5b is permissible, however, because it captures the two white stones, leaving the inner black group with two liberties.*

(a)

(b)

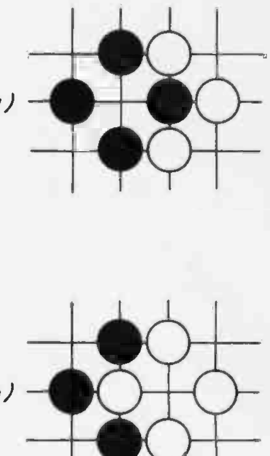

**Figure 6:** *Ko. In 6a, white can capture the black stone, resulting in 6b. It is illegal for black to restore 6a immediately by recapturing the white stone; he must wait a turn.*

player may move so as to reproduce the board position existing just prior to his opponent's last move. A move must be made elsewhere to change the board position before the ko capture is allowed.

### Lookahead

Kos are common and often critical in master games, but at Wally's level it was simpler to leave out the Rule of Ko. However, it is essential to avoid suicidal or totally wasted moves which fill in the last liberty of a group, or leave it only one liberty, so that the group will be captured anyway. Hence a limited lookahead capability was adopted. The last step in evaluating a suggested black move is to put the stone down tentatively and count the liberties of the resulting black group. This is done by calling COUNT. The move is rejected if the resulting group does not have at least two liberties.

The complete move evaluation module, EVAL, is shown in listing 3. The module LOOKAHEAD saves the current (move, liberties) pair before COUNT is called with the tentative black stone in place.

### Pattern Matching

Wally's most intelligent-looking moves are pattern matches. There are common configurations of stones which suggest an obvious next move to a good player. Wally has a table of patterns of this sort; these patterns are illustrated in figure 7. Each pattern includes one white stone and two black stones, with a third black move indicated. Patterns 7a thru 7e represent responses to threatened connections. Patterns 7f and 7g create good "shape."

In Go, as in other spheres, there is truth to the motto, "In unity there is strength." The first step in capturing a group of stones is to cut it off from any other large groups nearby. Two weak groups, when connected into a single large group, often have a much better chance of survival. That is why defensive moves like figures 7a thru 7e are important.

Good *shape* in Go is a local positional strength. It is characterized by diamond-shaped configurations, or box-like shapes with at least two solid walls. These patterns enclose an area in an easily defended way, and serve as a basis for expansion. Moves like those in figures 7f and 7g are aggressive moves that take area while expanding against the opponent's outposts.

The program looks at each white stone, trying to find two black stones near it in the same relative positions as in one of the patterns. The table entry for a pattern contains the vertical and horizontal displacements of the two black stones relative to the white stone, and that of the suggested black move. If the two black stones

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are found and the point for the black move is unoccupied, the black move is returned for evaluation.

Each pattern must be considered in all possible orientations around the white stone. Three-stone patterns have either four or eight orientations, depending on their lateral symmetry. The program trades table space against program space by performing 180° rotations automatically. Thus, two or four table entries representing different orientations of each pattern are needed to account for all possibilities.

**Listing 3:** *Module specifications for move evaluation, lookahead, and pattern matching.*

```
EVAL(move,liberties):
  GLOBAL (best-move, best-liberties)
  IF liberties ≤ best-liberties AND
    LOOKAHEAD(move) ≥ 2
  THEN
      best-move = move
      best-liberties = liberties
  END

LOOKAHEAD(move):
  place black stone at move
  CALL COUNT(move,black)
  remove black stone
  RETURN count of liberties

PATS:
  FOR each white stone DO
    IF there is a pattern in the table
       centered on that white stone
    THEN
      get suggested black move y
      CALL EVAL(y,2)
      EXIT
    END
  END
```

Pattern matches are checked last, because they almost always take priority over moves arising from the earlier phase of counting the liberties of groups. Pattern-match moves are associated with an artificial figure of two liberties to set their priority. Thus, if Wally can capture a white group, or avoid the capture of a black group having one liberty, he will do so despite any pattern matches. The priorities of the patterns are determined by the order in which they are checked, since the first match found is returned.

## Ghost Stones

The edge of the Go board is strategically important because it helps to wall off areas. An attempt by white, for example, to invade between a black stone and the edge of the board should be defended against. The first five patterns in figure 7 already defend against threatened connections; why not use them to protect the connection between a stone and the edge of the board? Imagine that there is an additional row of black "ghost" stones all around the board. As figure 8 shows, a white move near the edge can then invoke a pattern. This idea was implemented in the pattern match by allowing off-board positions to count as black stones tested for in each pattern.

## Edge Moves

One of the most startling improvements in Wally's performance resulted from a simple observation in the first few games. Groups on the edge of the board, when attacked, often extended fruitlessly along the edge, as in figure 9. A prohibition against edge moves, except to capture or on a pattern match, was added. Wally's play began at that moment to take on the character of an opponent to be reckoned with.

## Handicaps

Go has a handicap system that allows an expert to play an even and interesting game with a novice. Black is given a head start of two to nine stones on designated points—the ones marked with black spots on the board (see figure 1). The handicap stones are placed symmetrically like die spots, except that a handicap of three stones is placed on three corners. Additional handicap points, for a total of up to seventeen stones, were added for Wally's benefit, since it was not expected that he would be a strong player. Each additional handicap stone accounts for roughly 10 points difference in score.

The handicap stones help to make up for Wally's lack of overall strategy. The handicap points are good points to occupy early in the game, so a large handicap solves much of the strategy problem.

## Eyes and Life

Wally has a blind spot that costs him dearly against experienced players: he does not understand that any group, no matter how large, will be captured unless it has two "eyes," or sufficient space to make them. An eye is an unoccupied point or connected group of points. A group enclosing two eyes is immune from

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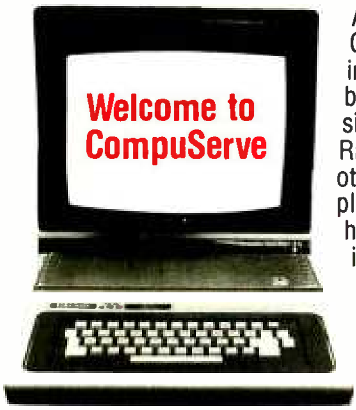


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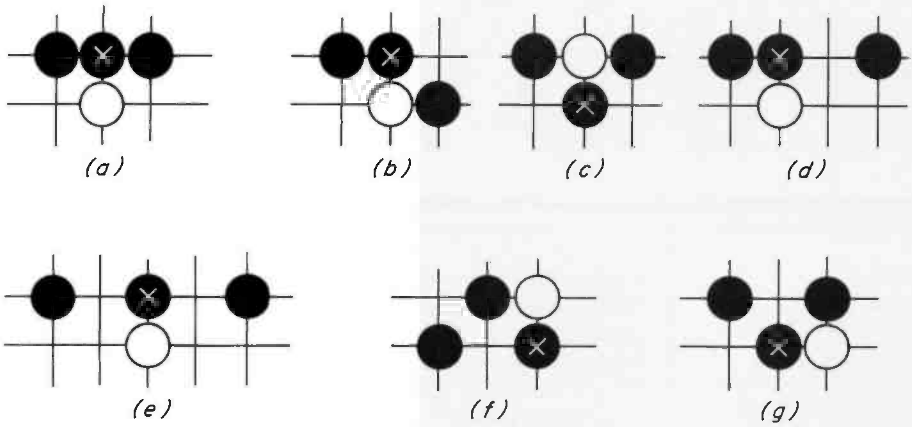


**Figure 7:** *Patterns. In each of these seven configurations, the black move marked x is suggested when the white stone and the two other black stones are already present. These patterns are applied in all orientations.*

capture, because a group cannot be captured unless it can be brought down to only one liberty. A group with two eyes will always have at least two liberties. The opponent cannot fill either eye because such a move would fill all the liberties of his invading stone, and hence is illegal. Figure 10 illustrates this.

Wally does surprisingly well despite a fundamental ignorance of the facts of life. Captures and pattern-matching moves tend to create eyes more or less automatically.

## Play Experience and Improvements

Wally plays like a beginner; however, he does play better than people just introduced to the game. Experienced players are surprised by the reasonableness and apparent skill of some of Wally's moves but are quick to discover that he does not know about forming two eyes.

Along the present lines, there is no room for significantly improving Wally within the 1 K-byte memory that my KIM-1 has. With a memory extension, the first improvement that springs to mind for the future is a full-sized board. The Rule of Ko is not hard to implement and should be included. Many more patterns ought to be added, and the pattern-matching mechanism could be more general.

Wally should be taught something about *ladders*, if only to avoid them. A ladder, illustrated in figure 11, is a sequence of moves that ends in disaster for one side or the other, depending on conditions several moves ahead.

The most challenging problem for a Go-playing program is how to recognize when a group does or does not have the potential to form two eyes.

Looking ahead down the move tree as a general approach, as is done in chess-playing programs, has two obstacles: the sheer number of possible moves at each turn, and the need to first develop a way to evaluate the board configuration. The best candidate for an evaluation function is

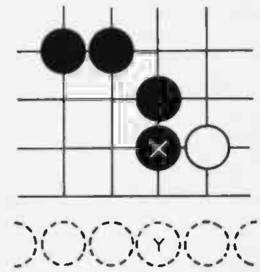


**Figure 8:** *Ghost stones. The black move at x is suggested by the pattern in figure 7d because there is an imaginary black stone at point Y, off the edge of the board, for purposes of pattern matching.*

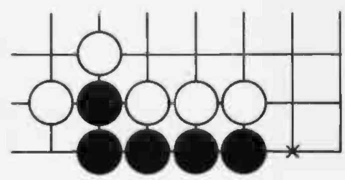

**Figure 9:** *Running along the edge. Before the program was modified, black would move at x, white could respond just above x, and the process would be repeated until the black "worm" reached the edge of the board and was captured. Edge moves are now prohibited except for captures and pattern matches.*

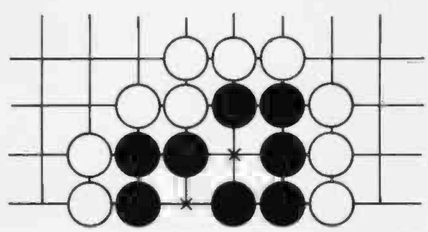

**Figure 10:** *A safe group with two eyes. White cannot capture black because both eyes, marked x, would have to be filled. But white can make only one move at a time, and a move in either point is illegal.*

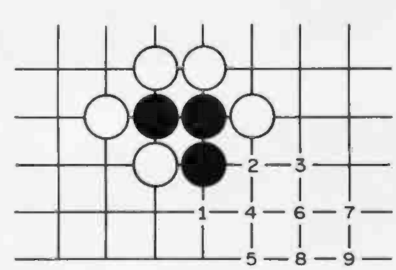


**Figure 11:** *A ladder. White threatens to capture black by moving at 1. When black attempts to escape at 2, white moves at 3, and so on. The black stones form a staircase that eventually reaches the edge of the board and is captured by white 9. If there were a black stone at 6, however, black would escape, and white would be left in a vulnerable position.*

an estimate of the area controlled by each player. When an area is only loosely surrounded, however, or an invasion is in progress, it is very difficult to determine the ownership of many points. A possible approach is the perceptual-grouping heuristic method developed by Zobrist (reference 3). Move tree searching is probably the only way to find the best move in confined tactical situations, like those that appear in Go problem books.

Another improvement suggested by chess programs is to include some of the countless known corner openings, or "joseki." Joseki are useful anywhere in the board, and should be implemented as an extension of the pattern matching.

After a move that leaves an opponent's group with only one liberty, one is supposed to say "atari" to warn him that his group is about to be captured. Wally says nothing, and I have lost large groups by failing to notice an impending capture. "Atari" goes in next.■

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1. Ryder, J. "Heuristic Analysis of Large Trees as Generated in the Game of Go." Stanford University: Ph D Thesis, 1971.
2. Wilcox, B. "Computer Go." *American Go Journal*, 1979.
3. Zobrist, A. "A Model of Visual Organization for the Game of Go." AFIPS Spring Joint Computer Conference, 1969, pages 103 thru 112.

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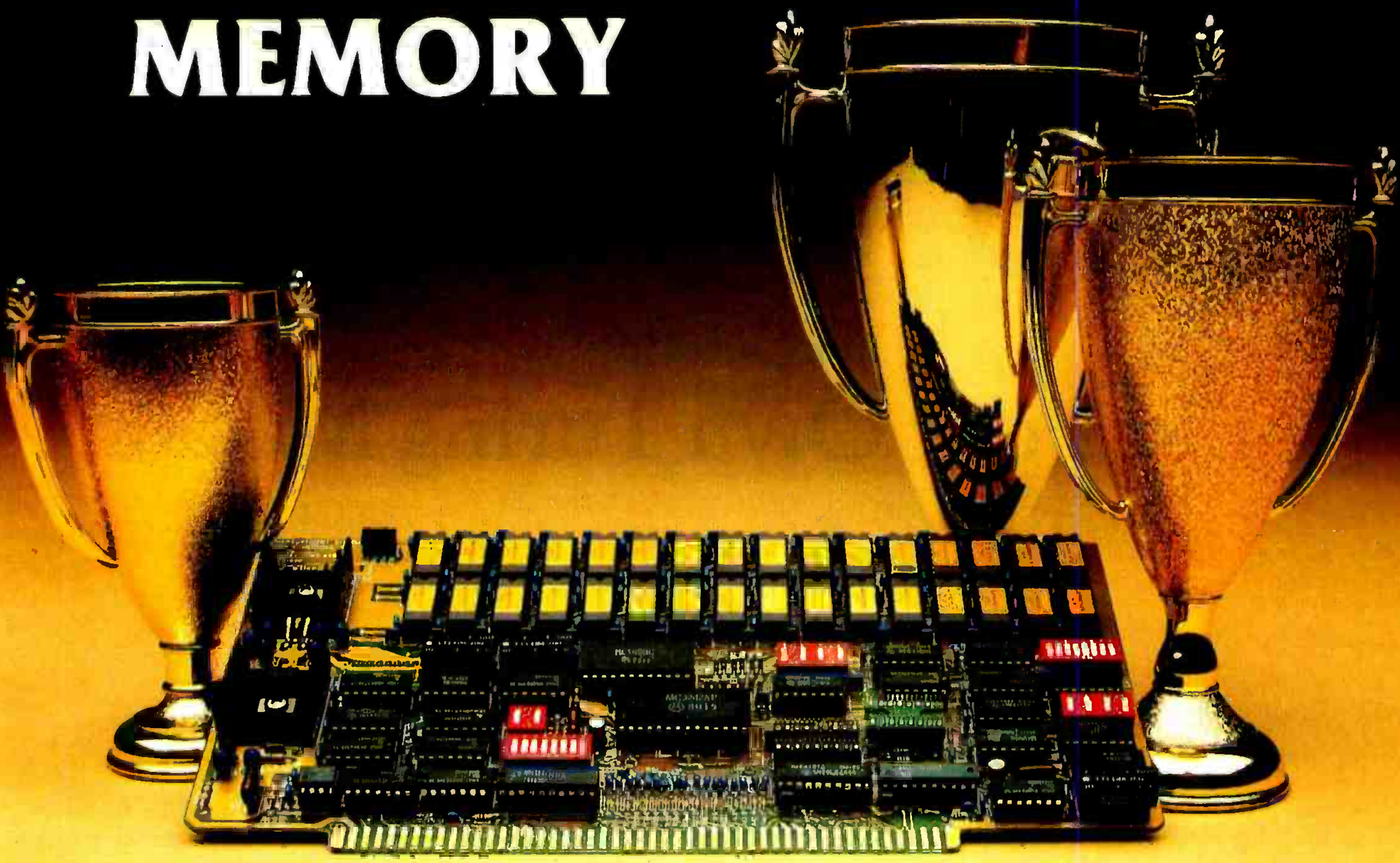

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In 1936, Alan M Turing gave the following description of a computing machine:

> The machine is supplied with a "tape" (the analog of paper) running through it, and divided into sections (called "squares"), each capable of bearing a "symbol." At any one moment there is only one square, say the *r*th, bearing the symbol G(*r*) which is "in the machine." We may call this square the "scanned square." The "scanned symbol" is the only one of which the machine is, so to speak, "directly aware." However, by altering its m-configuration, the machine can effectively remember some of the symbols which it has "seen" (scanned) previously. The possible behavior of the machine at any moment is determined by the m-configuration g(*n*) and the scanned symbol G(*r*). This pair g(*n*), G(*r*) will be called the "configuration." Thus, the configuration determines the possible behavior of the machine. In some configurations in which the scanned square is blank (ie: bears no symbol) the machine writes down a new symbol on the square; in other configurations, it erases the scanned symbol. The machine may also change the square which is being scanned, but only by shifting it one space to right or left.

**A Turing Machine consists of three parts: a tape, a program, and a device.**

Turing's description has become the definition of computability. That is, if a Turing Machine can work the problem, then the problem is said to be *computable*. If no Turing Machine can eventually find an answer to the problem, then the problem is not computable. John von Neumann and others have tried to establish a relationship between a Turing Machine and human neural networks. (See Michael Arbib's book, listed in the references at the end of this article.) An overview of these concepts along with some history of the problem is given in an article by Jeremy Bernstein (reference 2). An example of a hardwired version may be found in Jonathan K Millen's article (reference 3).

As with other problems involving computing machines, the first step is to carefully define the problem or task. Once a careful definition has been given that defines and limits the scope of the project, we may then attempt a solution. The solution may take on many forms depending on the intended use of the project.

In this article, I will describe a finite (theoretical) Turing Machine (TM) and the implementation of a Practical Turing Machine (PTM) in hardware, in a program for the 6800 microprocessor, and in a FORTRAN program. These implementations are equivalent in that they accept the same input and, for that input, produce the same output.

## Turing Machines—a Definition

A Turing Machine consists of three parts: a *tape*, a *program*, and a *device*. The tape consists of an infinite array of 1s and 0s. The device writes on the tape and moves the tape according to the program. (See figure 1a.)

*Text continued on page 128*

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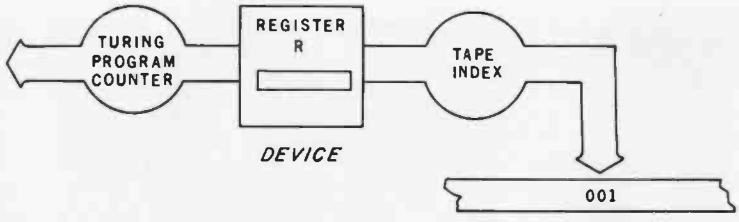
(1a)

| STM. NUMBER | R=0 W | R=0 D | R=0 ADR | R=1 W | R=1 D | R=1 ADR | COMMENTS | |
|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 1 | 1 | 1 | 1 | 2 | CHECK FIRST BIT | |
| 1 | 0 | 1 | 3 | 1 | 1 | 4 | CHECK SECOND BIT | |
| 2 | 0 | 1 | 4 | 1 | 1 | 3 | | |
| 3 | 1 | 1 | 5 | 1 | 1 | 5 | WRITE A 1 | |
| 4 | 0 | 1 | 5 | 0 | 1 | 5 | WRITE A 0 | |
| 5 | 0 | 0 | 6 | 1 | 0 | 6 | LOOP TO 6 | (HALT) |
| 6 | 0 | 1 | 5 | 1 | 1 | 5 | LOOP TO 5 | |

PROGRAM




(1b)

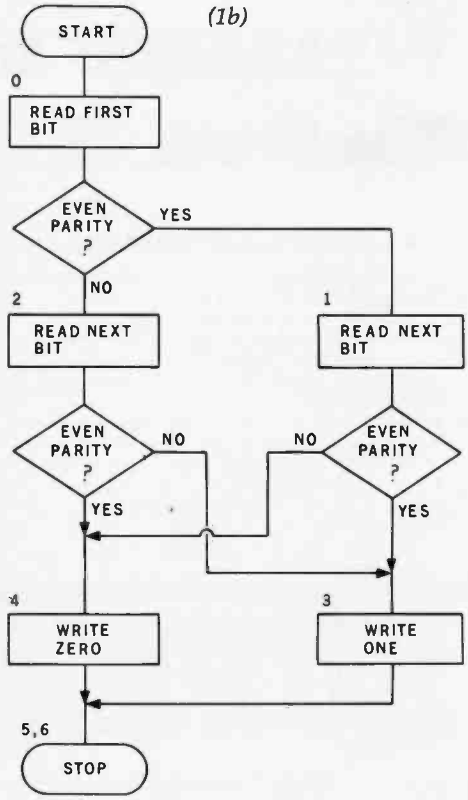



**Figure 1:** *Model of a Turing Machine and an example. Figure 1a presents a symbolic representation of a Turing Machine divided into three principal components: a program, a tape, and a mechanism or device for executing the program. The current instruction being executed is pointed to by the Turing program counter (TPC), the register R holds the contents of current tape position. The index I points to the character that is currently under the tape head. The program given in figure 1a reads 2 bits from the tape and writes a third bit to give the three characters odd parity (an odd number of 1s among them). The program has an initial state given by statement 0 and a final or halting state given by the infinite loop of statements 5 and 6. The flowchart in figure 1b shows the logic of this program, with the numbers beside each box being the statement number associated with that position within the flowchart.*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*Text continued from page 122:*

The device first reads position *I* of the tape through the tape head, then places the value it finds into its register, R. If R contains a zero, the device executes the left side of program statement number Turing Program Counter (TPC). If R contains a 1, the device executes the right side of program statement number Turing Program Counter.

Each side of each program statement contains a value for the variables W, D, and ADR. The symbol W indicates what is to be written on the tape. The symbol D indicates the direction to move the tape head: if D=0, the tape head is moved one space to the left; if D=1, the tape head is moved one space to the right. The symbol ADR is the address of the next program statement to be executed. Briefly, the device reads the tape, writes on the tape, moves the tape head, and transfers control to another program statement. The program presented in figure 1b is a parity checker—that is, the machine reads two binary digits and writes a third to give the total 3 bits an odd number of 1s—that is, odd parity.

[*It should be noted that the previously mentioned notation for a Turning Machine is not the one usually encountered in classrooms and textbooks. A more formal definition defines a Turning Machine with the program expressed as a set of 5-tuples of the following form;*

*(current state, character being read, character to write over current character, next state, direction to move tape)*

*where the particular 5-tuple to be applied is the one that is given by the current state and the character being read. It can be seen that each line of the notation used in this article can be rewritten as two 5-tuples of the above form; therefore, the two notations are equivalent . . . .* GW]

The operation of a Turing Machine may be represented by a flowchart, as in figure 2. Suppose that the variables W, D, and ADR are contained in three arrays, each two-dimensional: W(R,TPC), D(R,TPC) and ADR (R,TPC). The first subscript corresponds to the value contained in register R, while the second subscript refers to the program statement number. (In the example of figure 1, W(1,3)=0, D(1,3)=1, and ADR(1,3)=3.) The variable *I* refers to the position of the tape. Hence, the tape is represented by a one-dimensional array, TAPE(*I*). The variable TPC represents the Turing program counter—that is, the line of the Turing program being referenced. These variables, along with the description of the operation of a Turing Machine, are utilized in the flowchart of figure 2.

So far, no restrictions have been placed on the values of TPC or the tape index *I*. Turing assumed that the program and tape were indefinitely large. In a practical Turing machine, the variable TPC takes on values up to and including the maximum number of program statements. The tape index *I* may take on values up to and including the number of spaces on the tape. It is usual to assume that when the value of *I* exceeds the length of the tape, it returns to the first position on the tape, so that the tape then becomes finite and connected to form a loop. We call such a restricted machine a *practical Turing Machine* (PTM). With these restrictions it is possible to construct a PTM from discrete digital components.

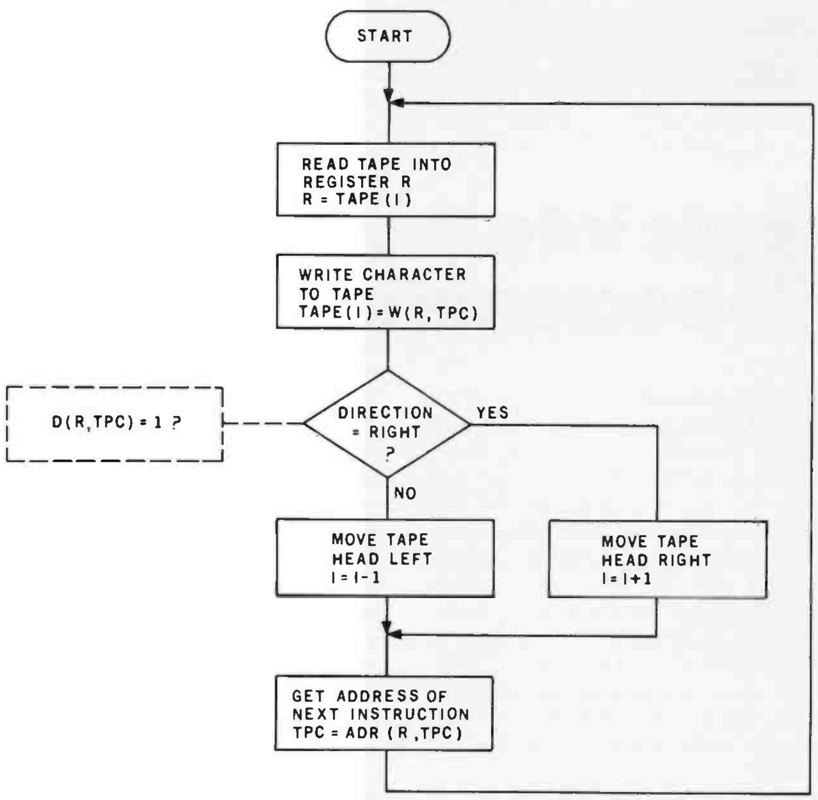


**Figure 2:** *Flowchart for the Turing Machine algorithm. In this algorithm, written primarily for a hardwired or assembly-language implementation, the only allowable characters that can be written are 0 and 1. The only allowable movements for the tape head are left and right. The algorithm does not end as such, but a final or halting state can be implemented by the addition of two program lines that unconditionally loop to each other, denoting the end of the algorithm. This is done in the example of figure 1a.*

## A Hardware Version

A hardwired version of a PTM utilizing integrated circuits can be readily constructed as described in the Millen article (see reference 3). In the present implementation, the program is stored in a 128 by 8-bit programmable memory circuit. (See figure 3.) The variables are the same as those used in the flowchart. The temporary register holds the value of ADR(R,TPC). Register TPC points to a program statement. Register R selects the left or right side of the program statement. The value of *I* is held in a 12-bit binary up-down counter. The tape is represented by 4096 bits of programmable memory. The boxes labeled "address selector" operate like double-throw switches and facilitate loading and execution of programs. A maximum of sixty-four program statements may be

*Text continued on page 136*

(3a)

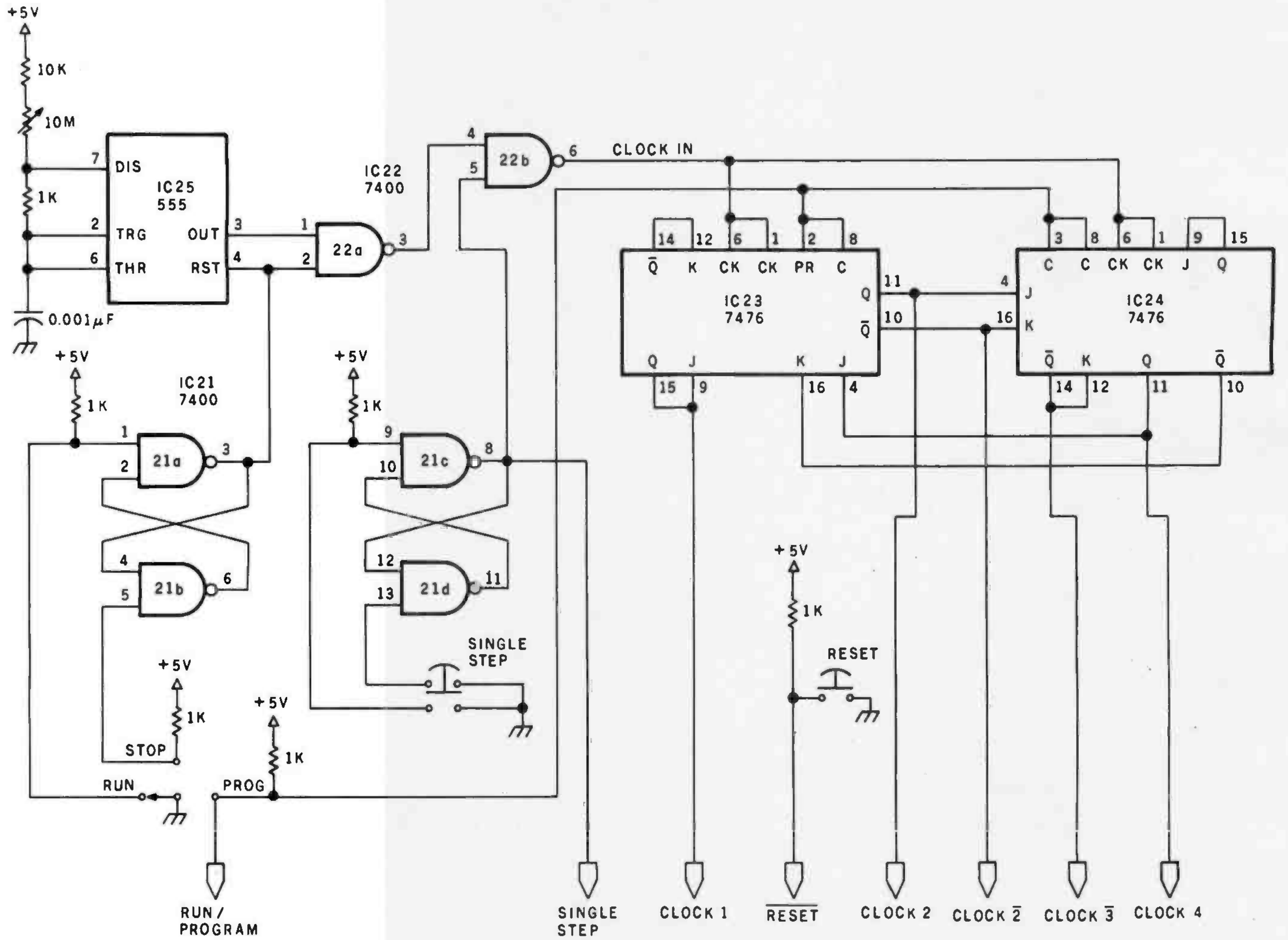


**Figure 3:** *Schematic diagram for the hardwired Practical Turing Machine. The device is designed to be built on three small circuit cards, figures 3a thru 3c. In figure 3a, the clock board, IC23 and IC24 produce a four-phase clock used by the other boards.*

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(3b)

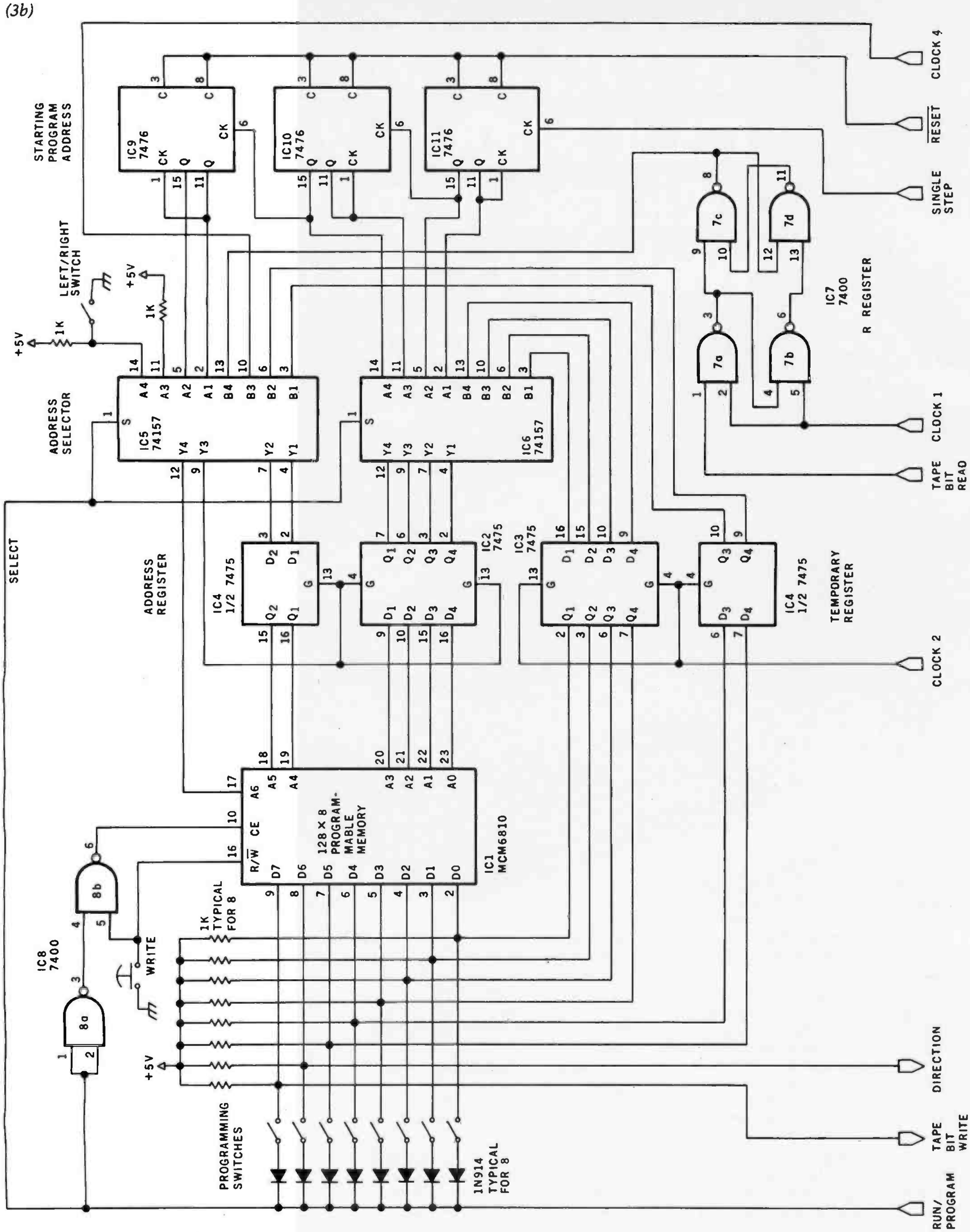


**Figure 3b:** *The processor card. IC1 is the Turing program memory; the lines coming into A0 thru A6 of IC1 are the Turing Program Counter (TPC). IC7 stores the R (direction) bit, and IC9, IC10, and IC11 store the Turing program address at which the program will start execution. The left/right switch designates which half of the Turing program word is written (switch open = left half) when the RUN/PROGRAM bit is set to PROGRAM.*

(3c)

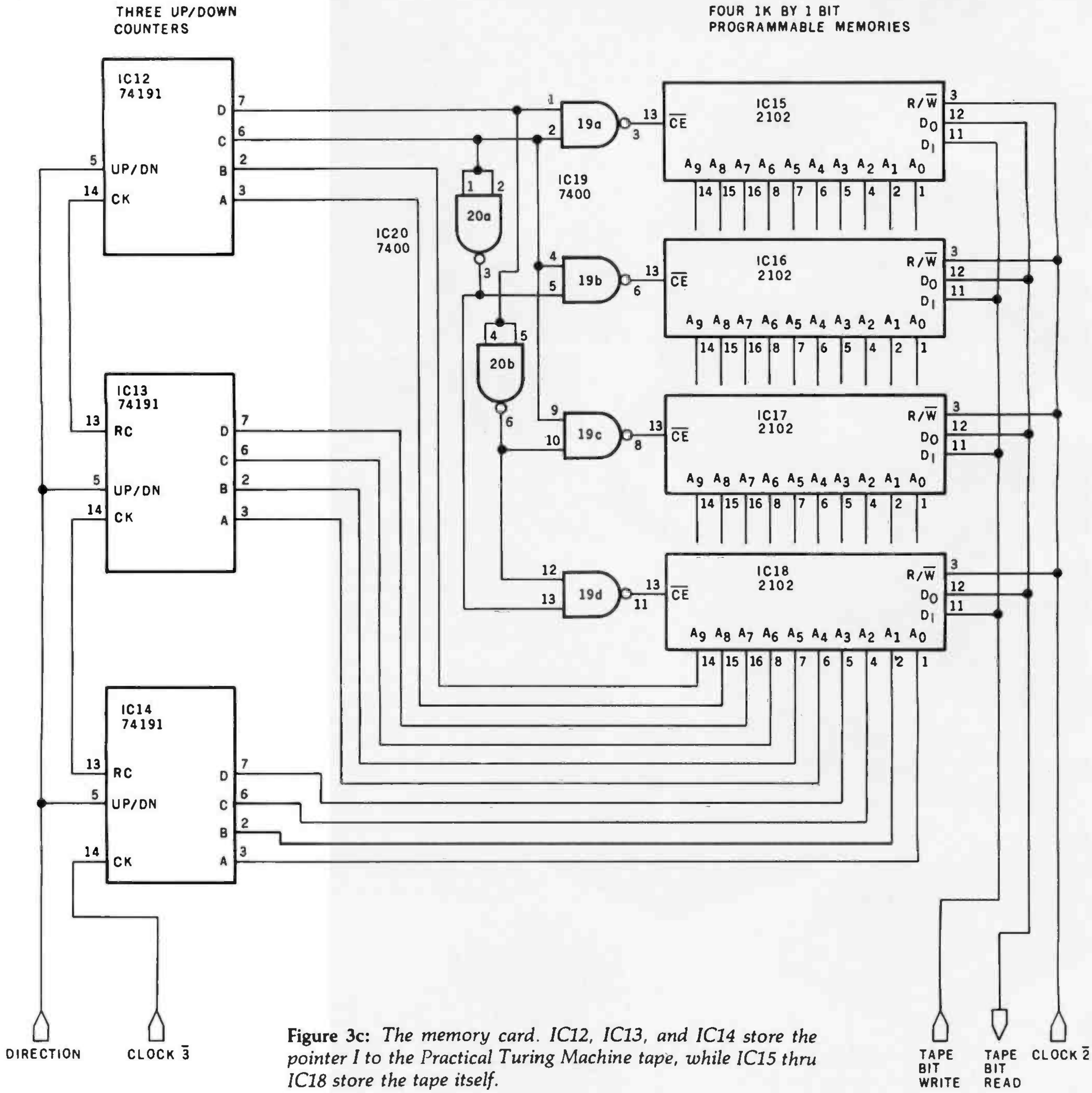


**Figure 3c:** *The memory card. IC12, IC13, and IC14 store the pointer I to the Practical Turing Machine tape, while IC15 thru IC18 store the tape itself.*

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(3d)

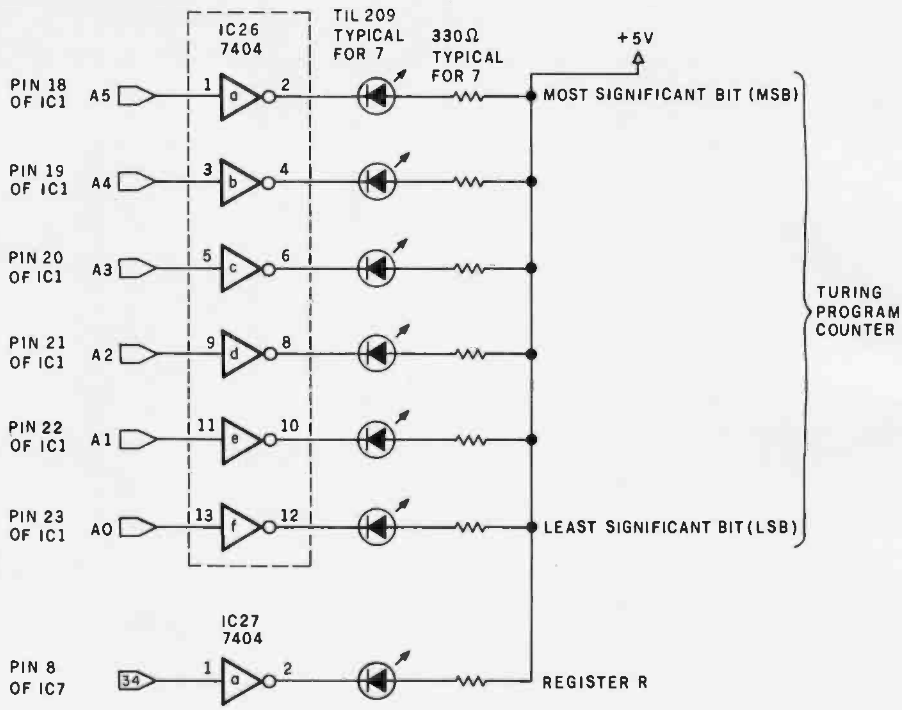


**Figure 3d:** *This simple front panel for the PTM displays the address being pointed to by the Turing Program Counter and the value in the R register.*

*Text continued from page 128:*

stored in 128 8-bit locations.

Programs are stored by:

| Number | Type | +5 V | GND |
|---|---|---|---|
| IC1 | MCM6810 | 24 | 1 |
| IC2 | 7475 | 5 | 12 |
| IC3 | 7475 | 5 | 12 |
| IC4 | 7475 | 5 | 12 |
| IC5 | 74157 | 16 | 8 |
| IC6 | 74157 | 16 | 8 |
| IC7 | 7400 | 14 | 7 |
| IC8 | 7400 | 14 | 7 |
| IC9 | 7476 | 5 | 13 |
| IC10 | 7476 | 5 | 13 |
| IC11 | 7476 | 5 | 13 |
| IC12 | 74191 | 16 | 8 |
| IC13 | 74191 | 16 | 8 |
| IC14 | 74191 | 16 | 8 |
| IC15 | 2102 | 9 | 10 |
| IC16 | 2102 | 9 | 10 |
| IC17 | 2102 | 9 | 10 |
| IC18 | 2102 | 9 | 10 |
| IC19 | 7400 | 14 | 7 |
| IC20 | 7400 | 14 | 7 |
| IC21 | 7400 | 14 | 7 |
| IC22 | 7400 | 14 | 7 |
| IC23 | 7476 | 5 | 13 |
| IC24 | 7476 | 5 | 13 |
| IC25 | 555 | 8 | 1 |
| IC26 | 7404 | 14 | 7 |
| IC27 | 7404 | 14 | 7 |

**Table 1:** *Power-wiring table for figures 3a, 3b, and 3c.*

- single-stepping the programming counter to the desired statement number,
- selecting the proper side of the statement with the L/R switch,
- loading the values for W, D, and ADR via the programming switches, and
- depressing the "write" button.

This sequence is repeated until all of the program has been entered.

Execution is initiated by:

- single-stepping the starting location of the Turing program into register TPC, and
- switching to RUN mode.

Timing signals are provided by a 4-phase clock through the inputs labeled clock 1 thru clock 4.

This representation offers a relatively fast execution time of about 2 μs per cycle. Changes in the length of the tape or in the maximum number of program statements are extremely difficult to make. Output is limited only by the imagination and

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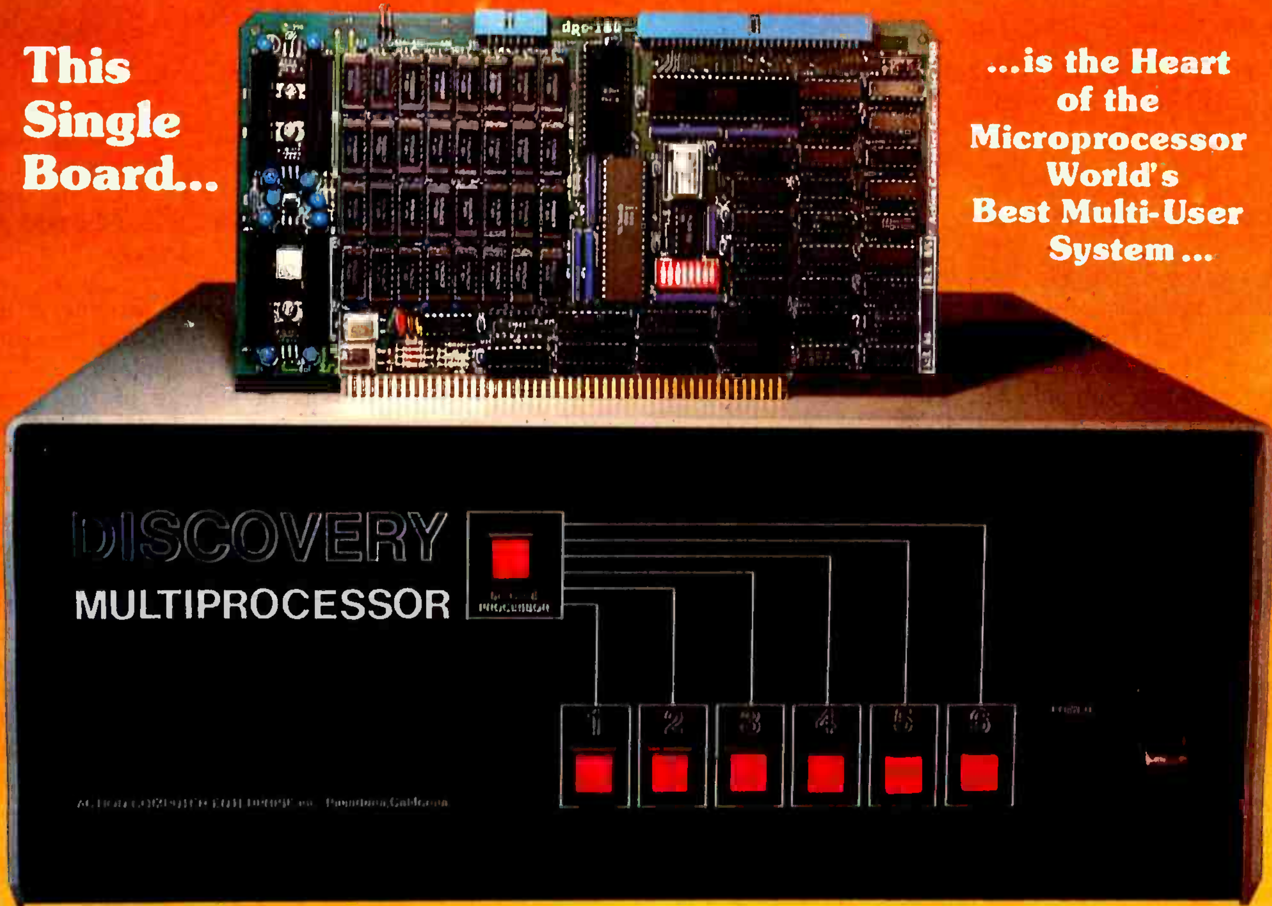


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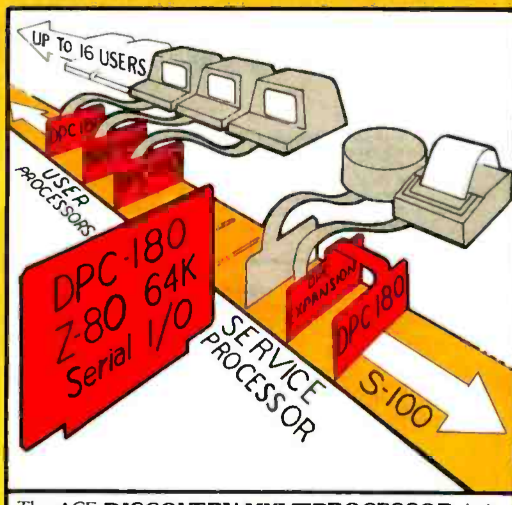


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means of the user. In my prototype, a row of light-emitting diodes (LEDs) displays the contents of register R and register TPC (see figure 5). Components for this hardwired representation of a PTM cost about $80.

## An Assembly-Language Version

Another implementation of a Practical Turing Machine is with a microprocessor. The code given in listing 1 is designed to run with only 512 bytes of memory and a Motorola 6800 microprocessor. The main program, as written, uses monitor routines available on the Heathkit ET-3400 Trainer. The tape index *I* is represented by the contents of locations I2 and I1. The variable I1 points to an 8-bit word in the tape array. The 3 least significant bits of the contents of the location I2 point to a bit within that word. A maximum of thirty-two program statements may be stored in 64 bytes of memory.

Subroutine RUN is divided into five parts:

- statements 0000 thru 0016 (hexadecimal) load R with the value of TAPE (*I*)
- statements 0017 thru 001C (hexadecimal) establish an offset for finding the proper half of a Turing program statement
- statements 001D thru 002F (hexadecimal) print W(R,TPC) on the TAPE
- statements 0030 thru 0044 (hexadecimal) increment or decrement *I*
- statements 0045 thru 0049 (hexadecimal) restore TPC to the next program statement number

| STM # | R=0 | R=1 |
|---|---|---|
| 0 | 0080 | 00A0 |
| 1 | 0081 | 00A1 |
| 2 | 0082 | 00A2 |
| 3 | 0083 | 00A3 |
| • | • | • |
| • | • | • |
| • | • | • |
| 31 | 009F | 00BF |

W D — A D R —
7 6 5 4 3 2 1 0
Bit locations

**Figure 4:** *Memory map of assembly-language implementation of a Practical Turing Machine. Memory locations hexadecimal 0080 thru 00BF are used to store a program of up to thirty-two steps, with 2 bytes being used to store each statement line. The character to be written, W, is in bit 7 of a given byte. The direction of tape head movement, D, is in bit 6. The statement number of the next statement to be executed is stored in bits 4 thru 0 of the byte. Bit 5 is unused.*

The main program provides output through the ET-3400 monitor routines and LED displays.

Details of storage of the Turing program appear in figure 4. Each side of each program statement is stored in a separate memory location. The value of W occupies the most significant bit and the value of D occupies the next most significant bit. The value of ADR is stored in the 5 least significant bits of a Turing program statement location.

Program statements are entered directly into memory locations using monitor routines available on the trainer.

Execution is initiated by:

- entering the starting location of the Turing program into the location TPC,

*Text continued on page 146*

**Listing 1:** *Listing for implementation of the Practical Turing Machine in 6800 machine code. The program uses routines from the Heathkit ET-3400 microprocessor trainer at hexadecimal locations 0058 and 005B.*

```
"                              MICRO-TURING
"      PRACTICAL TURING MACHINE SIMULATOR FOR USE WITH A 6800 MPU
"      AND AT LEAST 512 BYTES OF RAM.THE MAIN PROGRAM USES MONITOR
"      ROUTINES AVAILABLE ON HEATHKIT'S MODEL ET-3400 MICROPROCESSOR
"      TRAINER.WRITTEN BY JIM WILLIS PHYSICS DEPT. UNC CHAPEL HILL.
"      CHAPEL HILL , NC. 27514.
"                              MICRO-TURING
MEM.
LOC. OP. CODE LABEL MNEMOMIC                COMMENTS
                                            " READ TAPE
                                            " SET UP TAPE MASK FROM (I2)
0000 86 01     RUN    LDA A # $01           A=00000001
0002 D6 4A            LDA B I2              B=I2
0004 C4 07            AND B # $07           B=00000111 .AND. B
0006 27 04     FIRST  BEQ NEXT              IF (B=0) GO TO NEXT
0008 48               ASL A                 A=2*A
0009 5A               DEC B                 B=B-1
000A 20 FA            BRA FIRST             GO TO FIRST
000C D7 4F     NEXT   STA B R               R=B(=0)
                                            " LOAD R WITH TAPE(I2,I1)
000E DE 4B            LDX I1                X=I1
0010 A5 00            BIT A $00,X           IF ((A.AND.TAPE(I1)).EQ.0) Z=1,ELSE Z=0
0012 27 09            BEQ ENDR              IF (Z=1) GO TO ENDR
0014 5C               INC B                 B=B+1
0015 D7 4F            STA B R               R=B(=1)
                                            " LOAD B WITH TURING PROGRAM STM(R,TPC)
0017 D6 4E            LDA B TPC             B=TPC
0019 CB 20            ADD B # $20           B=B+$20
001B D7 4E            STA B TPC             TPC=B
001D DE 4D     ENDR   LDX TPC               X=TPC
001F E6 80            LDA B $80,X           B=TURING PROGRAM STM(R,TPC)
0021 DE 4B            LDX I1                X=I1
                                            " WRITE ON TAPE
0023 C5 80            BIT B # $80           IF((B.AND.10000000).EQ.0) Z=1,ELSE Z=0
0025 27 04            BEQ WZERO             IF (Z=1) GO TO WZERO
0027 AA 00            ORA A $00,X           A=A.OR.TAPE(I1)
0029 20 03            BRA ENDW              GO TO ENDW
002B 43        WZERO  COM A                 A=.NOT.A
002C A4 00            AND A $00,X           A=A.AND.TAPE(I1)
002E A7 00     ENDW   STA A $00,X           TAPE(I1)=A
                                            " MOVE TAPE POINTER
0030 CE 00 4A         LDX # $004A           X=$004A
0033 C5 40            BIT B # $40           IF((B.AND.01000000).EQ.0) Z=1,ELSE Z=0
0035 27 08            BEQ DEC1              IF (Z=1) GO TO DEC1
                                            " INCREMENT (I2,I1)
0037 6C 02            INC $02,X             I1=I1+1
0039 28 0A            BVC ENDD              IF(I1.NE.-128) GO TO ENDR
003B 6C 00            INC $00,X             I2=I2+1
003D 20 06            BRA ENDD              GO TO ENDD
                                            " DECREMENT (I2,I1)
003F 6A 02     DEC1   DEC $02,X             I1=I1-1
0041 28 02            BVC ENDD              IF(I1.NE.127) GO TO ENDD
0043 6A 00            DEC $00,X             I2=I2-1
                                            " TPC=ADR(R,TPC)
0045 C4 1F     ENDD   AND B # $1F           B=B.AND.00011111
0047 E7 04            STA B $04,X           TPC=B
0049 39               RTS                   RETURN

                                            " VARIABLES

004A XX        I2     (I2)                  I2
004B 01               $01
004C XX        I1     (I1)                  I1
004D 00               $00
```

*Listing 1 continued on page 142*

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| Heath H89 + Lifeboat CP/M | P4 |
| Heath H89 + Magnolia CP/M | P7 |
| Helios II | B2 |
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| ICOM 3812 | A1 |
| ICOM 4511 5440 Cartridge CP/M | D1 |
| ICOM 4511 5440 Cartridge CP/M | D2 |
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| IMS 8000 | A1 |
| IMSAI VDP-40 | R4 |
| IMSAI VDP-42 | R4 |
| IMSAI VDP-44 | R5 |
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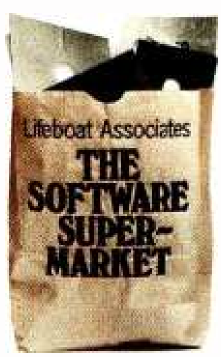


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*Listing 1 continued:*

```
004E XX        TPC    (TPC)              TPC
004F XX        R      (R)                R

                                         " MAIN

0054 8D AA     MAIN   BSR RUN            BRANCH TO SUBROUTINE RUN
0056 96 4F            LDA A # R          A=R
0058 BD FC BC         JSR REDIS          " SET UP DISPLAY ADDRESS
005B BD FE 3C         JSR OUTHEX         " DISPLAY CONTENTS OF A
005E 01 01 01         NOP                " SPACE FOR ANOTHER JSR
0061 20 F0            BRA MAIN           GO TO MAIN

                                         " END MAIN

0080 00        (0,0)                     " LOCATIONS $0080 THRU $00BF
0081 81        (0,1)                     " RESERVED FOR TURING PROGRAM
00A0 81        (1,0)                     " STATEMENTS
00A1 00        (1,1)                     " (1,0)=(R,TPC)

0100 XX                                  " TAPE
THRU XX                                  " TAPE
01FF XX                                  " TAPE

                                         " XX= LOCATION FILLED JUST PRIOR TO
                                         " EXECUTION
```

**Listing 2:** *Listing for implementation of the Practical Turing Machine in FORTRAN.*

```
"                                  TURING
"       UNIVERSAL TURING MACHINE SIMULATOR.JIM WILLIS , PHYSICS DEPARTMENT
"       UNIVERSITY OF NORTH CAROLINA , CHAPEL HILL  NORTH CAROLINA.
"       DESIGNED TO RUN ON UNCCC'S VERSION OF IBM'S 360/370 CALL-OS
"                                  TURING
        DIMENSION ITAPE(128)
        INTEGER *2 W(2,64),D(2,64),ADR(2,64),TAPE(128),TPC,WI,DI,ADRI,T
        DATA Y/'Y'/
 1000       WRITE(3,100)
  100       FORMAT(' HOW MANY SPACES IN THE TAPE? 128 MAX. ')
            READ(1,*) MTAPE
        IF(MTAPE.GT.128) MTAPE=128
 1001       WRITE(3,102)
  102       FORMAT(' INPUT TURING PROGRAM.W0,D0,ADR0,W1,D1,ADR1.W0=2 TO END')
        NSTM=0
    1     NDEX=NSTM+1
        WRITE (3,103)NSTM
  103       FORMAT(' STM.NO. ',I2)
        READ(1,*)W(1,NDEX),D(1,NDEX),ADR(1,NDEX),W(2,NDEX),D(2,NDEX),ADR(2,NDEX)
        IF(NSTM.EQ.64)GOTO 2
        IF(W(1,NDEX).GT.1)GOTO 2
        NSTM=NSTM+1
        GOTO 1
    2     WRITE(3,104)
  104       FORMAT('  NO. W0  D0  ADR0  W1  D1  ADR1')
        DO 3 I=1,NSTM
        N=I-1
        WRITE(3,105)N,W(1,I),D(1,I),ADR(1,I),W(2,I),D(2,I),ADR(2,I)
  105       FORMAT(' ',4I4,'\',3I4)
    3       CONTINUE
        WRITE(3,106)
  106       FORMAT(' INPUT FIRST TURING PROGRAM STM. NO.')
        READ(1,*)TPC
```

*Listing 2 continued on page 144*

*Listing 2 continued:*

```
      WRITE(3,107)
107      FORMAT(' HOW MANY TIMES THROUGH THE TAPE?')
      READ(1,*)MIT
      WRITE(3,119)
119      FORMAT(' INPUT CHARACTER FOR ZERO.')
      READ(1,120)IZERO
120      FORMAT(A1)
      WRITE(3,121)
121      FORMAT(' INPUT CHARACTER FOR ONE.')
      READ(1,120)IONE
"
"     INITIALIZE TAPE TO ZERO
"
      DO 4 I=1,MTAPE
      TAPE(I)=0
4        CONTINUE
      KIT=0
"
"     TAPE LIST ROUTINE
"
      KTAPE=1
9        KIT=KIT+1
      DO 32 N=1,MTAPE
      ITAPE(N)=IZERO
      IF(TAPE(N).EQ.0)GOTO 32
      ITAPE(N)=IONE
32       CONTINUE
      WRITE(3,118)(ITAPE(I),I=1,MTAPE)
118      FORMAT(128A1)
      IF(KIT.EQ.MIT)GOTO 99
"
"      RUN
"
200      CONTINUE
      TPC=TPC+1
      T=TAPE(KTAPE)+1
      DI=D(T,TPC)
      TAPE(KTAPE)=W(T,TPC)
      IF(DI.EQ.1)GOTO 201
      KTAPE=KTAPE-1
      IF(KTAPE.LT.1)KTAPE=MTAPE
      GOTO 202
201      KTAPE=KTAPE+1
      IF(KTAPE.GT.MTAPE)KTAPE=1
202      TPC=ADR(T,TPC)
        IF(KTAPE.EQ.MTAPE)GOTO 9
      GOTO 200
99       WRITE(3,108)
108      FORMAT( ' WANT TO CHANGE THE TAPE LENGTH?')
      READ(1,109)ANSWER
      IF(ANSWER.EQ.Y)GOTO 1000
109      FORMAT(A1)
      WRITE(3,110)
110      FORMAT(' WANT TO REPROGRAM?')
       READ(1,109)ANSWER
       IF(ANSWER.EQ.Y)GOTO 1001
      GOTO 2
      END
```

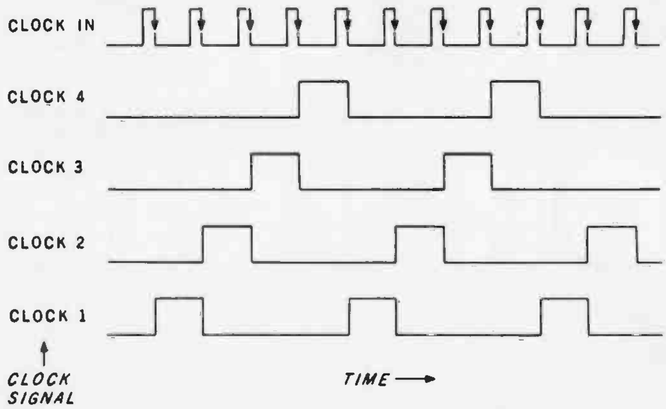


**Figure 5:** *Timing diagram for the four-phase clock. The signals shown here are generated by IC23 and IC24 in figure 3a. Note that within the schematic of figure 3c, the inverted counterparts of clock 2 and clock 3 are also used.*

*Text continued from page 138:*

- entering the DO-0054 command into the trainer (this begins program execution at hexadecimal location 0054).

The value of R is displayed continuously on the leftmost LED of the trainer.

The microprocessor representation of the PTM is easier to implement than the hardwired version. Changes in the length of the tape or the maximum number of program statements are relatively easy to make, but the microprocessor is very slow compared with the hardwired version. Subroutine RUN requires about 150 μs per cycle as compared with 2 μs for the hardwired version.

## A FORTRAN Version

One of the most useful and comprehendable representations of a PTM is one written as a high-level language program. Listing 2 is a source listing for an interactive FORTRAN program that can be used to simulate a PTM. The run section of this program follows the flowchart in figure 2.

The program is stored in three arrays dimensioned W(2,64), D(2,64), and ADR(2,64). The maximum length of the tape is 128 characters. A shift is made in the subscripts to allow R=0 and TPC=0. Output characters for the tape are chosen by the user rather than being restricted to 0 and 1. Program statements are entered as six-component vectors and can be readily changed. The most important variables are available interactively to the user.

## Summary

We have implemented the Practical Turing Machine in three forms—as a hardwired circuit, a 6800 machine code program, and a FORTRAN program. We have found that the hardwire version is the fastest but the most difficult to run or modify, and that the FORTRAN version is the easiest to modify but the slowest in execution. The microprocessor version is a compromise in both speed and utility. ■

**Acknowledgments**

*I would like to thank Tom Ainsworth for his help in the design of the hardwired version, Dr W J Thompson for his guidance during the project, and Alice Glenn for her help in the preparation of the manuscript. The research for this article was supported in part by the United States Department of Energy.*

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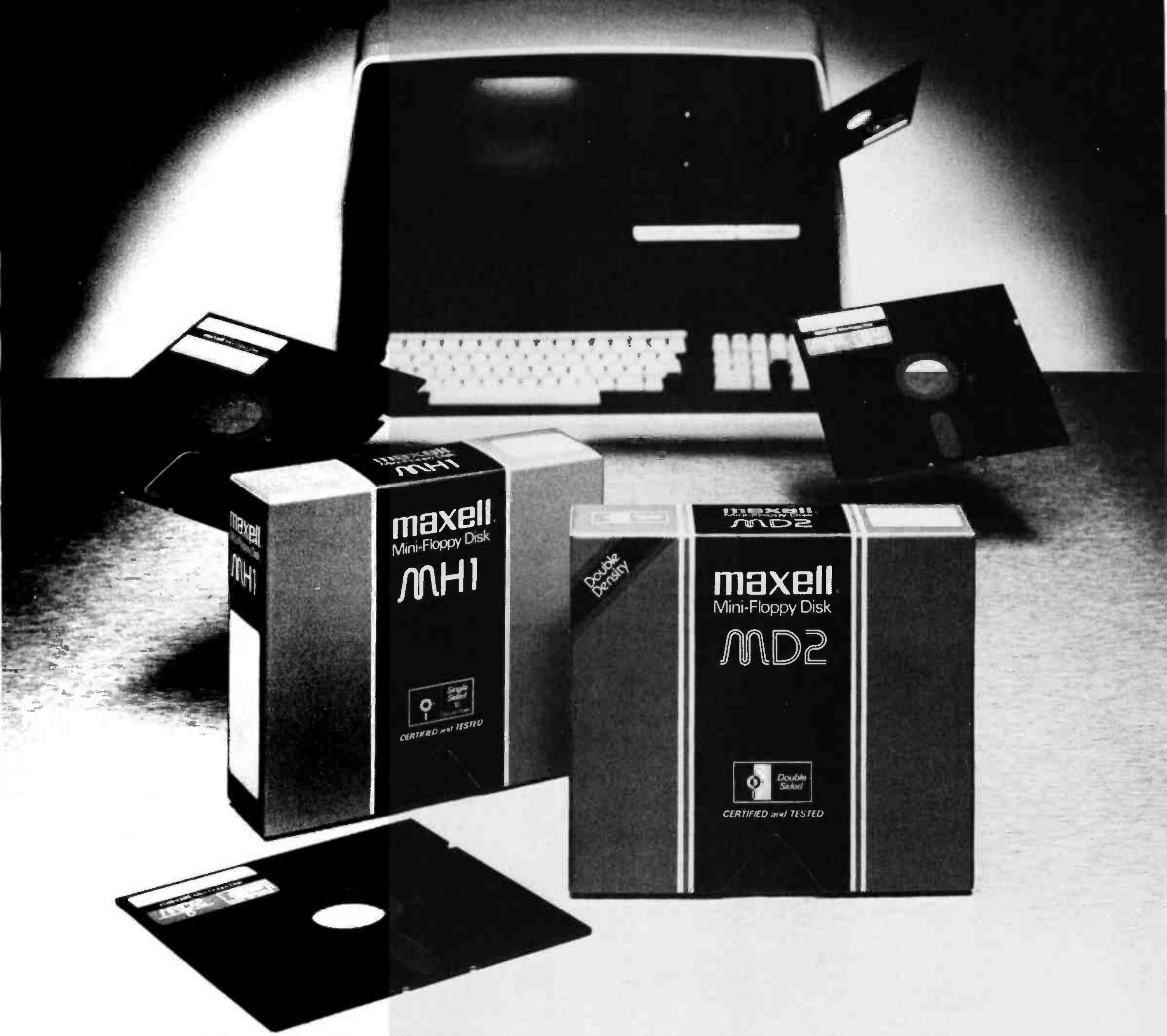


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# A Relocatable Bootstrap for the Tarbell Disk Controller

Hector M Smith
9852 Dandelion Ave
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Some Z80 microprocessors do not work properly with the Tarbell disk-controller ROM (read-only memory). For example, Ithaca Intersystems recommends that the bootstrap program be relocated to high memory and that a power-on jump to it should be executed. You can make the program independent of memory location by using the Z80 relative-jump instruction.

Listing 1 is a relocatable version of the Tarbell bootstrap loader. Relative jumps are included at hexadecimal locations 0010 and 0016. A test bit instruction is located at hexadecimal 000E.

The original 8080 code is shown in listing 2. In the code, at hexadecimal locations 000E and 000F, ORA resets the sign flag if the MSB (most significant bit) of INTRQ is 0. If this is the case, JP jumps to RDONE.

Because the Z80 does not have a relative jump instruction activated by a positive test, BIT 7,A is used to check if bit 7 (INTRQ) is 0. If it is, a jump relative to RDONE is executed. At hexadecimal location 0016, a jump relative to RLOOP and NOP was substituted for the original jump.

The modified bootstrap (listing 1) can be located anywhere in memory. A jump to it will boot the CP/M operating system. ■

**Listing 1:** *A Z80 relocatable bootstrap program for the Tarbell disk controller. The mnemonics are TDL Assembler.*

```
ADDR MACH       LABEL   ASY LANGUAGE COMMENTS
     CODE

0000 DB FC      BOOT:   IN      WAIT    ;WAIT FOR HOME.
0002 AF                 XRA     A       ;COMPLETE.
0003 6F                 MOV     L,A     ;SET L=0.
0004 67                 MOV     H,A     ;H&L=0.
0005 3C                 INR     A       ;SET A=1.
0006 D3 FA              OUT     SECT    ;SECTOR=1.
0008 3E 8C              MVI     A,8CH   ;READ SECTOR.
000A D3 F8              OUT     DCOM
000C D2 FC      RLOOP:  IN      WAIT    ;WAIT FOR DRQ OR INTRQ.
000E CB 7F              BIT     7,A     ;TEST BIT 7
0010 28 07              JRZ     RDONE   ;DONE IF INTRQ
0012 DB FB              IN      DDATA   ;READ A BYTE OF DATA.
0014 77                 MOV     M,A     ;PUT INTO MEMORY.
0015 23                 INX     H       ;INCREMENT POINTER
0016 18 F4              JMPR    RLOOP   ;DO IT AGAIN
0018 00                 NOP             ;FILLS EMPTY SPACE
0019 DB F8      RDONE:  IN      DSTAT   ;READ DISK STATUS.
001B B7                 ORA     A       ;SET FLAGS.
001C CA 7D 00           JZ      07DH    ;IF ZERO, GO TO SBOOT.
001F 76                 HLT             ;DISK ERROR, SO HALT.
                WAIT    =       OFCH
                SECT    =       OFAH
                DCOM    =       OF8H
                DDATA   =       OFHB
                DSTAT   =       OF8H
```

**Listing 2:** *Original 8080 code before modification for the Z80 microprocessor.*

```
000E        B7          ORA     A
000F        F2 19 00    JP      RDONE

0016        C3 0C 00    JMP     RLOOP
```

# A Closer Look at the TI Speak & Spell

**Peter Vernon**
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**Australia**

Congratulations to Michael Rigsby on his article "Dissecting the TI Speak & Spell" (September 1980 BYTE, page 76). He is not alone in desiring an economical voice-output device for his computer, and the Speak & Spell is an excellent choice. Economy is one reason, and the circuitry of this device has features that make it potentially one of the most flexible and comprehensive speech synthesizers available.

The problem is how to interface the Speak & Spell to a computer. Mr Rigsby's approach *is* the first step, but it allows only a spelling computer, not a talking one. In order to achieve more, it is necessary to know something about the workings of the device. This information is difficult to obtain. Texas Instruments has not been very informative, although considering the investment it has in speech technology this is perhaps understandable. Thus, the Speak & Spell is an irresistible challenge to the experimenter.

Mr. Rigsby has, however, made one fundamentally incorrect assumption: the TI Speak & Spell is most definitely *not* based on the SN76477N complex-sound generator, nor does it store words, or even phrases, as individual pulses in memory. As I will show, it uses an entirely different technique.

## The Heart of the Unit

The TMC0281NL is a proprietary Texas Instruments integrated circuit that is virtually an entire digital signal processor, with timing and decoding circuits, a 10-pole digital lattice filter, and a D/A (digital-to-analog) converter. All of this is contained on a tiny piece of silicon just 44 mils square. This is the heart of the speech synthesizer.

Also on the board is the controller, the TMC0271NL, which is a member of the TMS-1000 microprocessor family. The TMC0271 shares the same basic architecture as the TMS-1000 used in TI's calculators, but it has been modified to enhance its BCD (binary-coded decimal) arithmetic capabilities. It also has an expanded instruction set and an output multiplexer to reduce the number of pinouts required in its role as a controller for the speech synthesizer IC (integrated circuit).

**The Speak & Spell is an irresistible challenge to the experimenter.**

As Mr Rigsby guessed, the other two integrated circuits on the board are high-density ROMs (read-only memories). The TMC0350 family are 128 K-bit ROMs, organized as 16 K by 8 bits. They incorporate an internal 18-bit address counter/register and two 8-bit output buffers, with the four high-order bits of the address driving a 1-of-16 device-select decoder and the other 14 bits addressing the ROM array directly.

## Linear Predictive Coding

The circuitry is only part of the story. The real secret of the Speak & Spell and other Texas Instruments speech-synthesis devices is a technique called LPC (*linear predictive coding)*. This technique makes it possible to encode a complex speech waveform with relatively little data. A speech signal is highly redundant, made up of a few basic waveforms that are repeated to produce speech sounds. Essentially, LPC eliminates the redundancy inherent in the speech signal and retains only the data required to drive the speech synthesizer.

The TMC0281 can be thought of as an electronic model of the human vocal tract. The data input is a description of the filter parameters necessary to model the vocal tract as its characteristics change over time. Codes for twelve synthesis parameters are stored in the ROMs. These parameters are ten filter coefficients, and pitch and energy information.

The filter parameters are derived from samples of actual speech and are encoded by a complex mathematical algorithm that makes it possible to predict a speech waveform based on information derived from previous waveforms. Because of the finite-time response of the human vocal tract, only a fixed number of speech sounds can follow a particular vocalization.

To produce speech, the controller specifies the starting point of a string of data stored in the ROMs. The ROM output provides the pitch, amplitude, and filter parameters from which the synthesizer constructs the speech waveform.

The input to the filter is either a periodic or random sequence of pulses. A random sequence of pulses is used to recreate unvoiced sounds,

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such as "f" or "s," while a periodic sequence creates voiced sounds such as "a." The pitch information either varies the frequency of the periodic pulses or, if all the bits are zero, selects random noise as the input to the lattice filter. An amplification factor is also input to the synthesizer and adjusts the amplitude of the excitation source to produce sounds of varying intensity.

The lattice filter of the synthesizer has ten stages. Each stage carries out two multiplications and two additions on its two digital inputs before passing the results backward and forward to its neighbors. The operations of the ten stages are carried out sequentially, as are the operations within each stage. Through careful consideration of timing and the use of a pipeline approach, only one adder and one multiplier are needed to carry out the mathematical operations. Each separate arithmetic operation requires only 6 $\mu$s.

Figure 1 is a block diagram of the basic elements of the TMC0281. The multistage lattice filter uses the parameters $K_1$ thru $K_n$ to digitally filter the amplified excitation signal, and passes its output to a D/A converter connected to the speaker.

The coefficients of the filter are updated approximately every 20 ms. However, because of the redundancies in speech patterns, a complete set of parameters is not always required. Sections of the data stream may be replaced by a single "repeat" bit, cutting the data required to control the filter from a maximum of 49 bits to a minimum of 4, thus conserving memory space.

During speech the TMC0281 accesses the ROMs directly until it receives an end-of-phrase command and returns control to the TMC0271 controller. Five lines are used to transfer data and commands within the system. One of these lines is the processor data clock, which determines when the data on the other four lines is valid. These are the five lines mentioned by Mr Rigsby.

### Timing

Timing for the synthesizer is based on a 50 Hz frame rate—so a new speech segment is read from the ROM every 20 ms. The speech patterns coded in the ROM are sampled at a rate of 10 kHz, which corresponds to the maximum bandwidth of speech—5

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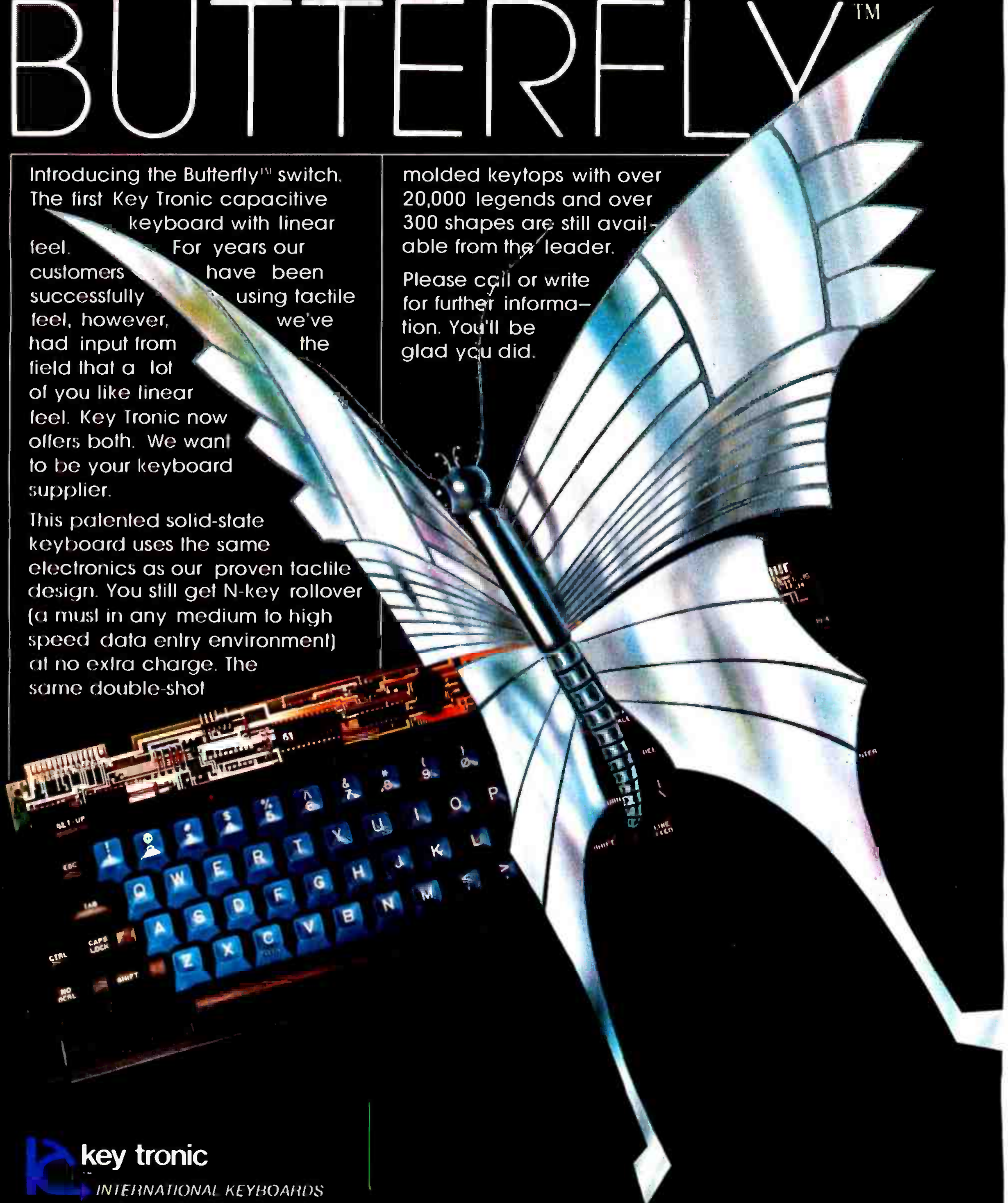

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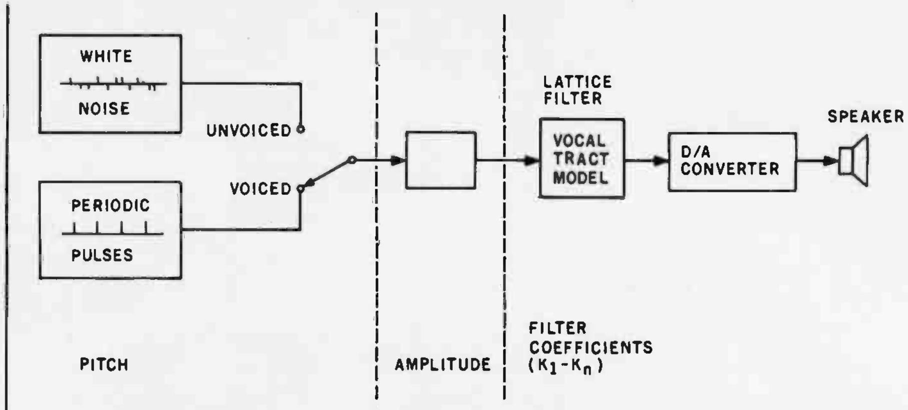


**Figure 1:** *Block diagram of the heart of the TI Speak & Spell—the Texas Instruments TMC0281NL integrated circuit. The TMC0281NL is a proprietary circuit that is virtually an entire digital signal processor and can be thought of as an electronic model of the human vocal tract. It includes timing and decoding circuits, a 10-pole digital lattice filter, and a D/A converter. Speech synthesis takes place through a process called LPC (linear predictive coding), which makes it possible to encode a complex waveform with relatively little data. Either pseudo-random noise (for unvoiced sounds) or periodic pulses (for voiced sounds) are amplified and fed to the lattice filter, which models the vocal tract in accordance with coefficients stored in two external 16 K by 8-bit ROMs (read-only memories). A maximum of 49 bits is needed to specify each sound pattern, which is updated every 20 ms. This results in an overall data rate of 2400 bps (bits per second). The TMC0281NL is controlled by a TI TMC0271 microprocessor, a specialized member of the TMS-1000 microprocessor family.*

kHz. (The maximum bandwidth for telephone-quality speech is 3.5 to 4.5 kHz.) An 800 kHz oscillator is divided by four to produce the major system clock. This four-phase clock controls the transfer of data within the system. The individual bit patterns in each 20 ms frame are clocked into the synthesizer at a rate corresponding to the sample frequency of 10 kHz. It is this clock which produces the 0.1 ms pulses measured by Mr Rigsby.

A maximum of 49 bits is needed to specify the sound pattern that will be produced every 20 ms. This is an overall data rate of about 2400 bps (bits per second). One hundred seconds of speech time thus requires the storage of 240,000 bits of information, which corresponds well with the 256,000 bits of storage provided by the two TMC0351 ROMs.

## Capabilities and Challenge

Because the Speak & Spell reconstructs speech sounds from a constant-excitation signal filtered under digital control, it is potentially capable of reproducing any sound at all. The challenge for the experimenter is to determine what information needs to be input to create a particular sound. Trial and error seems to be the only approach. With much work it would be possible to determine which combinations of data are needed to produce each phoneme of the English language. (All words are made up of combinations of particular sound units called *phonemes*. About 42 phonemes are used in the English language.) These phoneme patterns could be stored in memory and arranged to produce any word. At 49 bits per phoneme and 42 phonemes, only 2058 bits are required. The problem is, of course, to find the right bits.

Perhaps the best place to start would be the connector provided for the attachment of expansion modules. The module-select key on the keyboard of the Speak & Spell is used to signal the controller that an expansion module is in place and that it should instruct the synthesizer to access this module rather than the ROMs on the main circuit board. By using this signal it is possible to force the synthesizer to accept data that is input on the module connector. The system clock can be used to govern the rate of this data input. Experimenting with this approach produces a weird and wonderful series of sounds. At present, my computer (an Exidy Sorcerer) can only grunt and squeak, but after all, that's how we all started! ■

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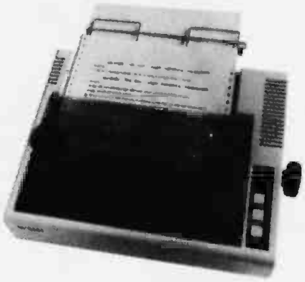

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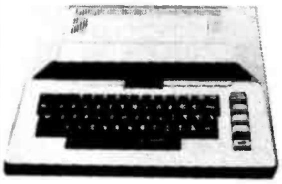

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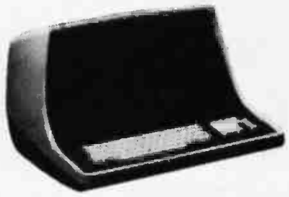

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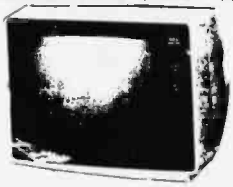

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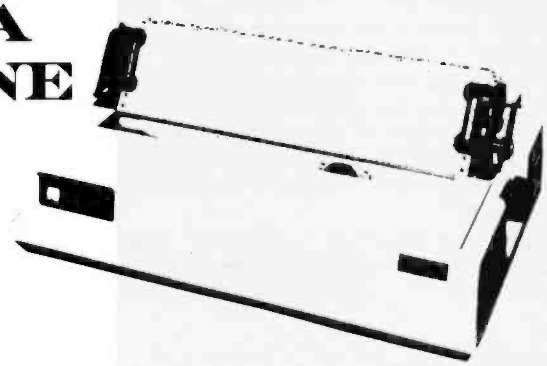

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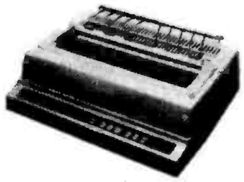

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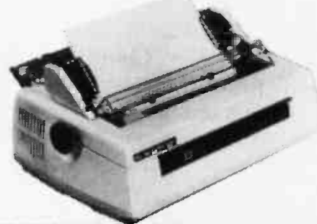

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The listing follows this form: 1. Name of organization or name of publication; 2. Mailing address; 3. Contact person and telephone number; 4. Newsletter or publication; 5. Special interests.

### Zips 00000—10000

1. *Syntax ZX80*
2. The Harvard Group, Bolton Rd, RD 2, Box 457, Harvard MA 01451
3. Ann Zevnik, Editor, (617) 456-3661
5. News about the Sinclair ZX80 microcomputer.

1. **Gosub TRS-80 Users Group**
2. POB 712 Worcester MA 01613
3. Jim Mercanti, (617) 845-1851, (617) 458-7263
4. *Gosub TRS-80 Users Group Buffer*
5. Noncommercial.

1. **TRUGEM (TRS-80 Users Group of Eastern Massachusetts)**
2. 3 Driscoll Dr, Framingham MA 01701
3. Ronald M Egalka, Secretary, (617) 877-4520
4. *The TRUGEM Newsletter*
5. TRS-80 hardware and software; peripherals from Radio Shack and independents; Programs Exchange Library (noncommercial); demonstrations and sales of commercial hardware and software encouraged.

1. **New England Computer Society**
2. POB 198 Bedford MA 01730
3. Bob Waite, President (617) 448-6351 home; (617) 897-3221, ext 2499, work
4. *NECS Newsletter*
5. User Groups: PET, Apple, 6800, Digital Group, and TRS-80. CBBS (Computerized Bulletin Board System), (617) 864-3819.

1. **The Boston Computer Society**
2. 3 Center Plz, Boston MA 02108
3. (617) 720-0597
4. *The Boston Computer Society Update* (an enormous publication with nationwide industry exclusives and news of New England)
5. User Groups: PET, Sorcerer, OSI, North Star and others. Subgroups: education, business applications, Pascal and beginner tutorials.

1. *Classroom Computer News*
2. POB 266, Cambridge MA 02138
3. Lloyd Prentice, (617) 787-0420
5. This bimonthly newsletter is interested in education, curriculum development, and related topics.

1. **Technical Education Research Centers**
2. 8 Eliot St, Cambridge MA 02138
3. Robert Tinker, Director or Susan Warner-Mills, Assistant, (617) 547-3890
4. *Hands On!*(A Forum for Science and Technology Educators)
5. Applications to education, especially science.

1. **RICH (Rhode Island Computer Hobbyists)**
2. POB 599, Bristol RI 02809
3. Emilio D Iannuccillo
4. Yes
5. We are an active group dedicated to keeping abreast of current technology, plus lending a hand to each other regarding hardware and software. We also give help and advice to newcomers into the world of microprocessors.

1. **PIE (PET Information Exchange)**
2. 27 Leicester Way, Pawtucket RI 02860

1. **SNAC (Southern New Hampshire Apple Core)**
2. Computerland of Nashua, 419 Amherst St, Nashua NH 03060
3. Don Fairchild, Treasurer, (603) 434-5626
4. *S.N.A.C.*
5. This group is involved in all aspects of home computing using Apple systems.

1. **Manchester Users Group**
2. 346 S Taylor St, Manchester NH 03103
3. Scott, (603) 624-0089
4. Yes
5. TRS-80s.

1. **Southern Maine TRS-80 Group**
2. 15 Mountain View Rd, Cape Elizabeth ME 04107
3. Douglas Stewart, (207) 767-2351
4. *Byte Babble*
5. TRS-80s.

1. **Doctor's Computer Club**
2. 42 E High St, East Hampton CT 06424
3. Dr Aziz Ghaussy, (203) 267-2400
4. *Medical Computer Journal Newsletter*
5. Application of computers in medical practices.

1. *The Pocket Computer Newsletter*
2. POB 232, Seymour CT 06483

1. *Computers in Psychiatry/Psychology*
2. 26 Trumbull St, New Haven CT 06511
3. Marc D Schwartz, MD, Editor, (203) 562-9873
5. This publication is for professionals interested in the use of computers in their work.

1. **Connecticut Computer Club**
2. 18 Ridge Ct W, West Haven CT 06516
3. Leo Taylor, Secretary
4. *CCC Newsletter*
5. We have two talks per meeting; generally one on software and one on hardware. The club does not specialize in any one machine.

1. *APL Market Newsletter*
2. POB 5314, Mt Carmel CT 06518
3. Raymond C Jordan, (203) 288-0283

## Clubs and Newsletters

1. **Amateur Computer Group of New Jersey**
2. 1776 Raritan Rd, Scotch Plains NJ 07076
3. Sol Libes, (201) 277-2063
4. *ACG-NJ News*
5. User Groups: 8080/Z80, 6800, KIM-1, TRS-80, PET, CP/M, 1802, S-100, Apple, and Pascal. We also have software libraries and tutorials.

1. **OSI Users Group**
2. 4 Swimming River Rd, Lincroft NJ 07738
3. Bob Childs, (201) 747-8888

1. **Data Processing Club**
2. c/o Dennis M Lloyd, Business Studies Division, Gloucester County College, Tanyard Rd, Sewell NJ 08080
3. (609) 468-5000, ext 242
4. Interested in microcomputer programs inside and outside of the classroom.

### Zips 10000—20000

1. **New York Amateur Computer Club**
2. POB 106, Church Street Sta, New York NY 10008
3. Garry Sawyer, (212) 864-4595.
4. *New York Amateur Computer Club Newsletter*
5. Anything to do with computers.

1. *Computer Careers News*
2. 135 W 50th St, New York NY 10020
3. Connie Winkler, Editor, (212) 582-9617
5. Careers publication for processing professionals.

1. *Feedback From Fujitsu*
2. c/o Ruder & Finn Inc, 110 E 59th St, New York NY 10022
3. Darrell J Aherin, (212) 593-6317
5. News of the Japanese computer, telecommunications, and electronics industries.

1. *Lifelines*
2. 1651 Third Ave, New York NY 10028
3. Mary Anna Feczo, (212) 722-1700
5. This publication is for CP/M users.

1. **Association for Computers and the Humanities**
2. Queens College, Flushing NY 11367
3. Joseph Raben, (212) 520-7407
4. *ACH Newsletter*
5. Humanities applications.

1. *Small Computer News*
2. Edwards Publications, 78-56 86th St, Flushing NY 11385
3. (212) 441-4082

1. **D G Independent User's Group**
2. POB 316, Woodmere NY 11598
3. Lloyd Kishinsky, (516) 374-6793
4. *Bridge*
5. Digital Group computers.

1. **Long Island Computer Association**
2. 3788 Windsor Dr, Bethpage NY 11714
3. A M Stone, Editor, (516) 731-1649
4. *The Stack*
5. User Groups: S-100, TRS-80, and 6502.

1. **Digiac Corporation**
2. 175 Engineers Rd, Smithtown NY 11787
3. James D Gobetz, President, (516) 273-8600
4. *MAPS Digest*
5. For MP/M users.

1. **CAMS (Capital Area Micro Computer Society)**
2. POB 348, Ridge Rd, RD #1, Scotia NY 12302
3. Stanley L Mathes, (518) 372-3767
4. Occasional
5. Subgroups for Apple (associated with International Apple Corps), TRS-80, S-100, and other groups.

1. **Sphere Microcomputer Group**
2. 2 Tor Rd, Wappingers Falls NY 12590
3. Jeffrey Brownstein, DDS, (914) 297-3950
4. *Sphere Newsletter*
5. 6800 microcomputers.

1. **CHIP-S Microcomputer Club**
2. POB 504, Syracuse NY 13201

1. **Mohawk Valley Microcomputer Club**
2. 706 Lee St, Rome NY 13440
3. Rich Weaver
4. *Micros Along the Mohawk*
5. Several special interest groups: 6800, 8080/Z80, and beginners.

1. **RAMS (Rochester Area Microcomputer Society)**
2. POB 90808, Rochester NY 14609
3. Erwin Rahn, (716) 473-3184
4. *Memory Pages*
5. Special interest groups: UFORTH (University of Rochester FORTH) and 6800/6809/68000. Users groups: North Star and CP/M.

1. **Monroeville Apple Users Club**
2. Dr G J Harloff
3. 579 Carnival Dr, Pittsburgh PA 15239

1. **Central Pennsylvania Computer Club**
2. 3263 Bull Rd, York PA 17404
3. Cletus Hunt III, (717) 764-4977
4. *Data Dump*
5. Special interests: SS-50 bus and TRS-80 systems.

1. **Wyoming Valley TRS-80 Club**



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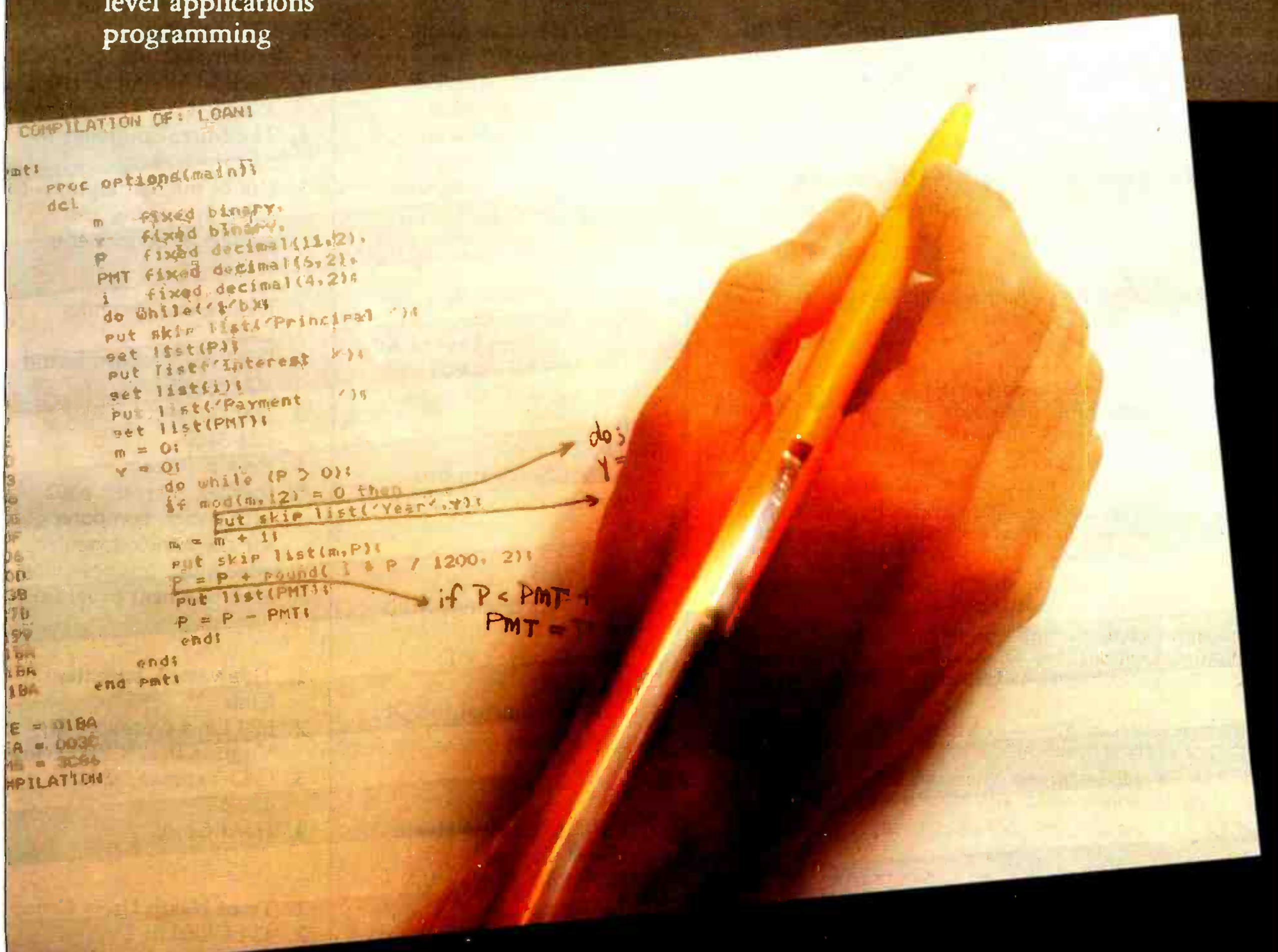


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Circle 109 on inquiry card.

2. 302 Wyoming Ave, Kingston PA 18704
3. Art Prutzman, (717) 287-1014
5. Special interests: TRS-80 uses and modems.

1. **Delaware Valley Computer Society**
2. POB 651, Levittown PA 19058
3. Howard Kalodner, (215) 742-6612
4. *DVCS Newsletter*
5. TRS-80 users group.

1. **PACS (Philadelphia Area Computer Society)**
2. POB 1954, Philadelphia PA 19105
3. Dick Moberg, Eric Hafler; Hot line (215) 925-5264
4. *The Data Bus*
5. Users groups for all major microcomputers, courses on languages, computers for children, and other groups.

## Zips 20000—30000

1. *Buss: The Independent Newsletter for Heath Company Computers*
2. 325-B Pennsylvania Ave SE, Washington DC 20003
3. Charles Floto, (202) 544-0484
5. News on items that are hardware- and software-compatible with Heath Company computers and Zenith Data Systems.

1. **Battery Lane Publications**
2. POB 30214, Bethesda MD 20014
3. Eric Balkan, (301) 770-2726
4. *Computer Consultant*
5. Information of interest to free-lance and corporate consultants.

1. **Washington DC CP/M Users Group**
2. 7315 Wisconsin Ave, Washington DC 20014
3. Winston Riley III, (301) 986-1234
5. Public-domain software exchange, review of operating systems, languages, and packages.

1. **WACS (Washington Amateur Computer Society)**
2. 4201 Massachusetts Ave, #168, Washington DC 20016
3. Robert Jones, Director
4. *JWACS*
5. Interested in I/O Selectric conversions; inexpensive terminals and personal systems; 9900, 6800, 8080/Z80 hardware and software.

1. **Washington Apple Pi**
2. POB 34511, Washington DC 20034
3. Bernie Urban, (301) 229-3458; club phone (301) 468-2305
4. *Washington Apple Pi*
5. Education, medical, Pascal, assembly language, games, helping neophytes in computer programming.

1. **TI Programmable Calculator Club**
2. 9213 Lanham Severn Rd, Lanham MD 20801
3. Maurice E T Swinnen, Editor
4. *TI PPC Notes*
5. All AOS system programmable calculators.

1. *PEEK(65)*
2. POB 347, Owings Mills MD 21117
3. Al Peabody, (301) 268-0561
5. This is a journal for OSI users.

1. **CHUG (Capital Heath Users' Group)**
2. POB 341, Fairfax VA 22030
3. Dale Grundon, Secretary
4. *>CHUG*
5. Interested in all Heath computers and related equipment.

1. **AMRAD (Amateur Radio Research and Development Corporation)**
2. 1524 Springvale Rd, McLean VA 22101
3. Paul L Rinaldo, (703) 356-8918
4. *AMRAD Newsletter*
5. Special interests: amateur radio and computers, computers and communications devices for the deaf, amateur computer networking.

1. **WAKE (Washington Area KIM Enthusiasts)**
2. 5112 Williamsburg Blvd, Arlington VA 22207
3. Ted Beach
4. Monthly
5. KIM and other 6502 single-board computers.

1. **The MicroComputer Investors Association**
2. 902 Anderson Dr, Fredericksburg VA 22401
3. Jack M Williams, (703) 371-5474
4. *The MicroComputer Investor*
5. Use of microcomputers to assist in making and managing investments.

1. **Delmarva Computer Club**
2. POB 36, Wallops Island VA 23337
3. Jean Trafford, (804) 824-3400
4. *Peek-n-Poke*
5. Special interests: 6502 processors, computer aids for the handicapped, education, business, and entertainment programs.

1. **Tidewater Computer Club**
2. 677 Lord Dunmore Dr, Virginia Beach VA 23464
3. C D Yeoman, (804) 420-6379
4. *Hard Copy*

1. **Triad Heath Users Group**
2. 424 Cliffdale Dr, Winston-Salem NC 27104
3. Hughes Hoyle, (919) 378-1050; Steve Minor, (919) 765-7717

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1. **Carolina Apple Core**
2. POB 31424, Raleigh NC 27612
3. Joseph H Budge, (919) 489-4284
4. *From The Core*
5. Apple computer users group.

1. **TRS-80 Users Group**
2. 7554 Southgate Rd, Fayetteville NC 28304
3. R Gordon Lloyd
4. *TRS-80 Users Group Newsletter*
5. We are interested in all aspects of the TRS-80.

1. **TIPS Users Group**
2. 101 Brookbend Ct, Mauldin SC 29662
3. Fred Holmes, (803) 288-5664
4. *TIPS Newsletter*
5. Special-purpose stand-alone systems and home-brew computers.

## Zips 30000—40000

1. **Digital Publications Inc**
2. 3169 Holcomb Bridge Rd, Suite 307, Norcross GA 30071
3. John Rapp, Publisher, (404) 451-1156
4. *Mini-Micro*, free software exchange
5. Software exhanges and publications for Data General, IBM, and DEC PDP-11 and PDP-8 systems.

1. **Culpepper and Associates Inc**
2. 4922 Heatherdale Ln, Atlanta GA 30360
3. Warren Culpepper, (404) 451-3797
4. *Salt 'n' Pepper*
5. Special interests: software product management.

1. **CSRA Computer Club**
2. POB 284, Augusta GA 30903
3. Jim Graves, President, (404) 738-1378
4. *CSRA Computer Club Newsletter*

5. Users groups: TRS-80, Apple, and 6800.

1. **Albany Computer Club**
2. Albany Junior College, 2400 Gillionville Rd, Albany GA 31707
3. Dr Donald Cook, (912) 439-4205
5. Our interest covers all microcomputers.

1. **Level II Club**
2. 4406 W Lawn Ave, Tampa FL 33611
3. D Griffith
5. We are interested in trading original software.

1. **ASCII, Sol User's Group**
2. POB 10325, Tampa FL 33679
3. J Brockway, (813) 837-4655
4. *ASCII*
5. Sol computers.

1. **CAMS (Central Alabama Microcomputer Society)**
2. 6375 Pinebrook Dr, Montgomery AL 36117
3. Lewis E Garrison, (205) 272-8462
4. *READY*
5. TRS-80 hardware and software.

1. **National Association of Computer Stores**
2. 3255 S US 1, Ft Pierce FL 33450
3. Steven W Koerner, Executive Director, (305) 465-9450
4. Monthly newsletter

## Zips 40000—50000

1. **ACSCO (Amateur Computer Society of Central Ohio)**
2. 215 Delhi Ave, Apt J, Columbus OH 43202
3. Paul Pittenger, President, (614) 267-3412
4. *I/O*
5. Graphics and personal networks.



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1. **Midwest Affiliation of Computer Clubs**
2. POB 20205, Columbus OH 43220
3. Douglas Troughton, (614) 574-8152
4. *MACC-Pack*, and *Computerfest*
5. Promoting personal computing by helping member clubs in any way possible.

1. **TI 99/4 Users of Cincinnati**
2. 8075 Spring Garden Ct, West Chester OH 45069
3. Larry Morrow, (513) 777-7042
5. Exchange of information and ideas concerning the TI 99/4.

1. **DMA (Dayton Microcomputer Association)**
2. c/o Dayton Museum of Natural History, 2629 Ridge Ave, Dayton OH 45414
3. Gary Turner, (513) 848-6911
4. *Data Buss*
5. Numerous special interest groups and help for beginners.

1. **Apple-Dayton Users Group**
2. 4819 Leafburrow Dr, Dayton OH 45424
3. Dick Peschke, Secretary,





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Calabasas, Ca. 213-883-8594

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Mississauga, Ontario Canada
416-274-6033

**SIRTON PRODUCTS**
Surrey, England, U.K.
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(513) 236-3619
4. *Apple-Dayton Newsletter*

1. **TRI-STATE Computer Club**
2. 2669 Highmeadow Ct, RT 1, Wheelersburg OH 45694
3. Douglas Troughton, (614) 574-8152
4. Yes
5. Special interests: TRS-80, Apple, OSI, KIM, PDP-11, and 6800 systems.

1. **AIM-65 User's Group**
2. R R#2, Spencerville OH 45887
3. Donald Clem, (419) 647-6576
4. *Target*
5. Special interests: AIM-65- and 6502-related information.

1. **Apple One Library**
2. 51625 Chestnut Rd, Granger IN 46530
3. Joe Torzewski, (219) 272-4670
5. We actively support the Apple I computer.

1. **Northern Indiana Computer Hobbyist Exchange**
2. 927 S 26th St, South Bend IN 46615
3. Eric Bean, (219) 288-2101
4. *NICHE Newsletter*

1. **Evansville Computer Club**
2. c/o National Sharedata Corporation, POB 3895, Evansville IN 47737
3. Robert Heerdink
5. Special interests: S-100, TRS-80, Bally, and Apple systems.

1. *The Midwest Buss*
2. 441 E Bernhard, Hazel Park MI 48030
3. Art Blundell, (313) 547-3011
5. Special interests: our buy-and-sell forum and swapping news from club to club.

1. **Sorcerer's Apprentice Computer User's Group**

medicine, dentistry, health sciences, and micro- and minicomputers.

1. **ICCA (International Computer Chess Association)**
2. ICCA, Vogelback Computing Center, Northwestern University, Evanston IL 60201
3. B Mittman, (312) 492-3682
4. *ICCA Newsletter*
5. Computer chess.

1. **CHICATRUG (Chicago TRS-80 Users Group)**
2. 203 N Wabash, Rm 1510, Chicago IL 60601
3. Emmanuel B Garcia Jr
4. *CHICATRUG News*
5. TRS-80s.

1. **Quad City Computer Club**
2. 4211 7 Ave, Rock Island IL 61201
3. John Greve, (309) 786-8187
5. General-interest club.

1. **SCAMPUS (SC/MP Users Society)**
2. POB 132, Knob Noster MO 65305
3. Tom Bohon, Coordinator, (816) 563-2650
4. *SCAMPUS Newsletter*
5. Anything to do with National Semiconductor's SC/MP I and II integrated circuits (systems, controllers, etc).

1. *Financial Systems Report*
2. c/o Syntax Corporation, 4500 W 72nd Ter, Prairie Village KS 66208
3. Vernon K Jacobs, (913) 362-9667
4. *Financial Systems Report*
5. This 8-page monthly newsletter provides information about computer systems for financiers.

1. **Lincoln Micro-Computer Club**
2. 1209 Garber Ave, Lincoln NE 68521
3. Hubert Paulson Jr, (402) 435-1507

2. POB 1131, Troy MI 48099
3. Don Gottwald, (313) 792-3867
4. *Sorcerer's Apprentice*
5. This club is interested in any topics concerning the Exidy Sorcerer microcomputer.

1. **OSI-MUG (OSI Michigan Users Group)**
2. 3247 Lakewood Ave, Ann Arbor MI 48103
3. (313) 761-5358

1. **SEMCO (South Eastern Michigan Computer Organization)**
2. POB 02426, Detroit MI 48202
3. Information number, (313) 775-5320
4. *Data Bus*
5. Special interests: networking, TRS-80, Atari, 6800, 650X, Heath, Digital Group, CP/M, S-100, and any aspect of computing.

1. **Detroit Interact Group**
2. 15356 Prevost, Detroit MI 48227
3. Stephen Cook, (313) 272-7594
4. *Interaction Newsletter*
5. Special interests: the Interact computer.

1. **Flint 6500 Users Group**
2. POB 4310, Flint MI 48504
3. R Riley, (313) 695-1117, 7-8 PM weekdays

1. **ERCC (Educational, Recreational Computer Club)**
2. POB 325, Owasso MI 48867
3. John Horvath, (517) 725-2835
4. *ERCC Newsletter*
5. Emphasis on educational, recreational, business, and scientific uses of computers.

1. **Battle Creek Area Microcomputer Club**
2. 8587 Q Dr N, Battle Creek MI 49017
3. Jeff Stanton, (616) 763-9685, evenings
4. Yes
5. Special interests: mostly the TRS-80.

1. **Heath User's Group**
2. Hilltop Rd, St Joseph MI 49085
3. Bob Ellerton, (616) 982-3463
4. *REMark*
5. Heath hardware and software.

1. **Microcomputer Users International**
2. c/o Jack Decker, 1804 W 18th St, Lot #155, Sault Ste Marie MI 49783
3. Jack Decker, (906) 632-3248; in Ontario, Canada, Phil Barton or Frank Gardner, (705) 942-1363
4. *Northern Bytes*
5. Serving microcomputer users in Sault Ste Marie Ontario/Michigan area. We wish to exchange newsletters with other clubs.

## Zips 50000—60000

1. **Eastern Iowa Computer Club**
2. POB 1189, Cedar Rapids IA 52406
3. Sam Dillon, (319) 377-0889
4. Bimonthly

1. *H8SCOOP*
2. 2918 S 7th St, Sheboygan WI 53081
3. Henry E Fale, (414) 452-4172
5. Special interests: Heathkit H-8 and H-89 computers.

1. **Fox Valley Crab-Apples**
2. Mathematics Department, University of Wisconsin—Oshkosh, Oshkosh WI 54901
3. John Oman, (414) 424-1362
5. Use of the Apple II in the classroom.

1. **MICRO**
2. 335 W Prospect St, Appleton WI 54911
3. John Ensley, (414) 731-7183
4. Yes
5. Special interests: computer networks, graphics, and educational uses.

1. **Mini 'App'les**
2. 13516 Grand Ave S, Burnsville MN 55337
3. D Buchler, President, (612) 890-5051
4. *Mini 'App'les Newsletter*
5. Apple II users group. Special interests: Pascal, education, personal, business, and industrial applications.

1. **XXX-11**
2. POB 2017, Fargo ND 58107
3. C R Corner, (218) 233-7894
4. *XXX-11 Newsletter*
5. Special interests: languages.

## Zips 60000—70000

1. *Dental Computer Newsletter*
2. 1000 North Ave, Waukegan IL 60085
3. E Neiburger, Editor, (312) 244-0292
4. Monthly
5. Special interests:

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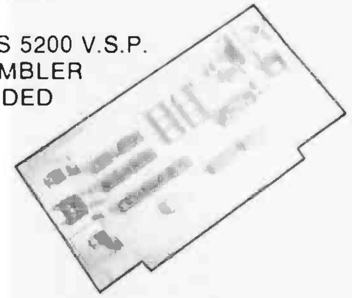

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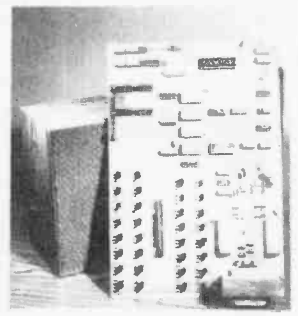

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| 78L15 | TO92 | 45 |
| 79L05 | TO92 | 65 |
| 79L12 | TO92 | 65 |
| 79L15 | TO92 | 65 |
| 7805P | TO220 | 1 20 |
| 7812P | TO220 | 1 20 |
| 7815P | TO220 | 1 20 |
| 7905P | TO220 | 1 25 |
| 7912P | TO220 | 1.25 |
| 7915P | TO220 | 1 25 |
| 7805K | TO3 | 1 50 |
| 7812K | TO3 | 1 50 |
| 7815K | TO3 | 1 50 |
| 7905K | TO3 | 1 60 |
| 7912K | TO3 | 1 60 |
| 7915K | TO3 | 1 60 |
| 309H | TO39 | 95 |
| 309K | TO3 | 1 25 |
| 317P | TO220 | 1.95 |
| 317K | TO3 | 2.95 |
| 323K | TO3 | 5 50 |
| 337P | TO220 | 2.40 |
| 337K | TO3 | 3 80 |
| 350K | TO3 | 5.75 |

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| SY2 | 5.75 |
| SY2.4576 | 5 75 |
| SY3 579 | 5.75 |
| SY4 | 4 50 |
| SY5 068 | 4 50 |
| SY6 | 4 50 |
| SY6 144 | 4.50 |
| SY8 | 4.50 |
| SY10 | 4.50 |
| SY12 | 4.50 |
| SY14.31818 | 4 50 |
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| 150pf | 07 | 06 | .04 |
| 220pf | 07 | 06 | .04 |
| 270pf | .07 | 06 | 04 |
| 330pf | 07 | .06 | .04 |
| 470pf | 07 | .06 | .04 |
| .001mf | 07 | 06 | .04 |
| .0022mf | 07 | .06 | .04 |
| .0033mf | 07 | 06 | 04 |
| .0047mf | 07 | .06 | .04 |
| .01mf | 07 | 06 | .04 |
| .022mf | .10 | 08 | 06 |
| .033mf | .10 | .08 | .06 |
| .047mf | 11 | 09 | 07 |
| .1mf | .14 | .12 | .10 |

### DIODES
Switching

| | |
|---|---|
| 1N914 | 12/$1 00 |
| 1N4148 | 12/$1 00 |

### SOCKETS

LOW-PROFILE SOLDER TIN

| Part# | 1 + | 25 + | 100 + |
|---|---|---|---|
| S8LT | 15 | 11 | 08 |
| S14LT | 18 | 16 | 14 |
| S16LT | 21 | 18 | 16 |
| S18LT | 26 | 22 | 18 |
| S20LT | 31 | 26 | 20 |
| S22LT | 33 | 28 | 22 |
| S24LT | .35 | 29 | 24 |
| S28LT | 41 | 34 | 28 |
| S40LT | 53 | 47 | 40 |

WIRE-WRAP SOLDER TIN

| Part# | 1 + | 25 + | 100 + |
|---|---|---|---|
| S8WT | 37 | 33 | 30 |
| S14WT | 48 | 43 | 39 |
| S16WT | 53 | 48 | 43 |
| S18WT | .61 | 55 | 50 |
| S20WT | 65 | .77 | 69 |
| S22WT | 89 | 80 | 72 |
| S24WT | .96 | 86 | 77 |
| S28WT | 1.22 | 1 11 | .99 |
| S40WT | 1 75 | 1 57 | 1.40 |

WIRE-WRAP GOLD

| Part# | 1 + | 25 + | 100 + |
|---|---|---|---|
| S8WG | 54 | 49 | 44 |
| S14WG | 77 | 69 | 62 |
| S16WG | 83 | .75 | 68 |
| S18WG | 1 00 | 90 | .81 |
| S20WG | 1.24 | 1 11 | .99 |
| S22WG | 1 35 | 1.22 | 1 10 |
| S24WG | 1.40 | 1.26 | 1 13 |
| S28WG | 1.78 | 1 60 | 1.44 |
| S40WG | 2.25 | 2 03 | 1.83 |

### SOLID DIPPED TANTALUM CAPACITORS 20%

| Value | Volts | 1 + | 25 + | 100 + |
|---|---|---|---|---|
| .1mf | 35v | .35 | .30 | 26 |
| .15mf | 35v | .35 | .30 | 26 |
| .22mf | 25v | 35 | 30 | 26 |
| .33mf | 35v | 35 | 30 | .26 |
| .47mf | 35v | 35 | 30 | .26 |
| .68mf | 35v | 35 | .30 | .26 |
| 1mf | 35v | .35 | 30 | 26 |
| 1 5mf | 35v | 45 | 39 | 33 |
| 2.2mf | 35v | .45 | .39 | .33 |
| 3 3mf | 35v | .50 | .42 | 36 |
| 4 7mf | 25v | .50 | 42 | .36 |
| 4.7mf | 35v | 65 | 56 | .44 |
| 6.8mf | 35v | .65 | .56 | .44 |
| 10mf | 25v | 85 | .72 | .61 |
| 10mf | 35v | 1.19 | 1.00 | .84 |
| 15mf | 25v | 1.30 | 1 09 | 92 |
| 22mf | 25v | 1.30 | 1.09 | 92 |
| 33mf | 25v | 1 35 | 1 12 | .95 |
| 47mf | 25v | 1.55 | 1 29 | 1.05 |
| 100mf | 6v | 2 95 | 2.48 | 2 08 |

### ¼ WT & ½ WT CARBON FILM 5% RESISTORS

| | | | | | |
|---|---|---|---|---|---|
| 10 | 100 | 1K | 10K | 100K | 1M |
| 11 | 110 | 1.1K | 11K | 110K | 1.1M |
| 12 | 120 | 1.2K | 12K | 120K | 1.2M |
| 13 | 130 | 1.3K | 13K | 130K | 1.3M |
| 15 | 150 | 1.5K | 15K | 150K | 1.5M |
| 16 | 160 | 1.6K | 16K | 160K | 1.6M |
| 18 | 180 | 1.8K | 18K | 180K | 1.8M |
| 20 | 200 | 2K | 20K | 200K | 2M |
| 22 | 220 | 2.2K | 22K | 220K | 2.2M |
| 24 | 240 | 2.4K | 24K | 240K | 2.4M |
| 27 | 270 | 2.7K | 27K | 270K | 2.7M |
| 30 | 300 | 3K | 30K | 300K | 3M |
| 33 | 330 | 3.3K | 33K | 330K | 3.3M |
| 36 | 360 | 3.6K | 36K | 360K | 3.6M |
| 39 | 390 | 3.9K | 39K | 390K | 3.9M |
| 43 | 430 | 4.3K | 43K | 430K | 4.3M |
| 47 | 470 | 4.7K | 47K | 470K | 4.7M |
| 51 | 510 | 5.1K | 51K | 510K | 5.1M |
| 56 | 560 | 5.6K | 56K | 560K | 5.6M |
| 62 | 620 | 6.2K | 62K | 620K | |
| 68 | 680 | 6.8K | 68K | 680K | |
| 75 | 750 | 7.5K | 75K | 750K | |
| 82 | 820 | 8.2K | 82K | 820K | |
| 91 | 910 | 9.1K | 91K | 910K | |

**MINIMUM ORDER PER TYPE:**
**5 pcs—any qty 5 pack @ $.25**

**MINIMUM ORDER PER TYPE:**
**100 pcs**
**Price Per 100 Pk:**

| QTY | ¼ WT | ½ WT |
|---|---|---|
| 100 up | $1.70 | $1.80 |
| 1,000 up | 1.50 | 1.60 |
| 5,000 up | 1.30 | 1.40 |
| 10,000 up | 1.10 | 1.20 |

### ZENER DIODES
½ WT

| Part# | Price |
|---|---|
| 1N5231B | 20 |
| 1N5239B | 20 |
| 1N5242B | .20 |
| 1N5245B | .20 |
| 1N5248B | 20 |
| 1N5250B | .20 |
| 1N5252B | 20 |
| 1N5255B | 20 |

1 WT

| Part# | Price |
|---|---|
| 1N4733A | 30 |
| 1N4739A | 30 |
| 1N4742A | .30 |
| 1N4744A | .30 |
| 1N4746A | .30 |
| 1N4747A | .30 |
| 1N4749A | 30 |

### POLYESTER CAPACITORS + & − 10% TOLERANCE 50V

| Value | 1 + | 25 + | 100 + |
|---|---|---|---|
| .001mf | .13 | 11 | 08 |
| .0012mf | .13 | .11 | .08 |
| .0015mf | .13 | .11 | .08 |
| .0018mf | .13 | .11 | .08 |
| .0022mf | .13 | .11 | 08 |
| .0027mf | .13 | .11 | 08 |
| .0033mf | .13 | .11 | 08 |
| .0039mf | .13 | .11 | .08 |
| .0047mf | .13 | .11 | 08 |
| .0056mf | .13 | .11 | .08 |
| .0068mf | .13 | .11 | .08 |
| .0082mf | .13 | .11 | .08 |
| .01mf | .13 | .11 | .08 |
| .012mf | .13 | .11 | .08 |
| .015mf | .13 | .11 | 08 |
| .018mf | .14 | .12 | .09 |
| .022mf | .14 | .12 | 09 |
| .027mf | .14 | .12 | 09 |
| .033mf | .14 | .12 | .09 |
| .039mf | .15 | .13 | .10 |
| .047mf | .15 | .13 | .10 |
| .056mf | .16 | .13 | .10 |
| .068mf | .17 | .14 | .11 |
| .082mf | .17 | .14 | .11 |
| .1mf | .18 | .15 | .12 |
| .12mf | .20 | .17 | .14 |
| .15mf | .22 | .18 | .15 |
| .18mf | .24 | .20 | .16 |
| .22mf | .26 | .22 | .17 |
| .27mf | .30 | .25 | .20 |
| .33mf | .33 | .28 | .23 |
| .39mf | .37 | .31 | 25 |
| .47mf | .40 | .34 | 30 |

### TRANSISTORS

| | |
|---|---|
| 2N2219A | $ .35 |
| 2N2222A | .25 |
| 2N2905A | .30 |
| 2N2907A | .25 |
| 2N2369A | .25 |
| 2N3904 | .20 |
| 2N3906 | .20 |
| PN2222A | .19 |
| PN2907A | .19 |

### RECTIFIERS (1A)

| | | 100 + |
|---|---|---|
| 1N4001 | 12/1.00 | .07 |
| 1N4002 | 12/1.00 | .07 |
| 1N4003 | 12/1.00 | 07 |
| 1N4004 | 12/1.00 | .07 |
| 1N4005 | 10/1.00 | .08 |
| 1N4006 | 10/1.00 | 08 |
| 1N4007 | 10/1.00 | .08 |

### 74 LS

| Part # | Price | Part # | Price |
|---|---|---|---|
| 74LS00 | .32 | 74LS152 | .79 |
| 74LS01 | .32 | 74LS153 | .79 |
| 74LS02 | .32 | 74LS154 | 2.05 |
| 74LS03 | .32 | 74LS157 | 1.15 |
| 74LS04 | .32 | 74LS158 | 1.15 |
| 74LS05 | .32 | 74LS160 | 85 |
| 74LS08 | .32 | 74LS161 | 85 |
| 74LS09 | .35 | 74LS162 | .85 |
| 74LS10 | .38 | 74LS163 | 95 |
| 74LS11 | .38 | 74LS164 | 1.10 |
| 74LS12 | 39 | 74LS165 | 1.10 |
| 74LS13 | .32 | 74LS166 | 2.55 |
| 74LS14 | 65 | 74LS170 | 1.90 |
| 74LS15 | 35 | 74LS173 | 1.35 |
| 74LS20 | .32 | 74LS174 | 1.25 |
| 74LS21 | .36 | 74LS175 | 95 |
| 74LS22 | 36 | 74LS181 | 2 35 |
| 74LS26 | .35 | 74LS190 | 1.15 |
| 74LS27 | 39 | 74LS191 | 1.15 |
| 74LS28 | .37 | 74LS192 | 1.15 |
| 74LS30 | 36 | 74LS193 | 1.15 |
| 74LS32 | .40 | 74LS194 | 1.15 |
| 74LS37 | 38 | 74LS195 | 1.15 |
| 74LS38 | .39 | 74LS196 | .99 |
| 74LS40 | 36 | 74LS197 | .99 |
| 74LS42 | 95 | 74LS221 | 95 |
| 74LS47 | 1.15 | 74LS240 | 1.05 |
| 74LS48 | 1.15 | 74LS241 | 1.05 |
| 74LS51 | .32 | 74LS242 | 1.45 |
| 74LS54 | 38 | 74LS243 | 1.45 |
| 74LS55 | .34 | 74LS244 | 1.05 |
| 74LS73 | 49 | 74LS245 | 2.15 |
| 74LS74 | .49 | 74LS251 | 1.29 |
| 74LS75 | 63 | 74LS253 | .99 |
| 74LS76 | .55 | 74LS255 | 99 |
| 74LS83 | 95 | 74LS257 | 1.15 |
| 74LS85 | 1.25 | 74LS258 | 1.15 |
| 74LS86 | .55 | 74LS260 | .95 |
| 74LS90 | .79 | 74LS261 | 2.49 |
| 74LS92 | .75 | 74LS266 | .65 |
| 74LS93 | .75 | 74LS273 | 1.65 |
| 74LS95 | .99 | 74LS283 | 1.05 |
| 74LS107 | .50 | 74LS365 | .85 |
| 74LS109 | .50 | 74LS366 | .85 |
| 74LS112 | .52 | 74LS367 | .85 |
| 74LS113 | .52 | 74LS368 | .85 |
| 74LS114 | .52 | 74LS373 | 1.65 |
| 74LS123 | 1.05 | 74LS374 | 1.45 |
| 74LS125 | .70 | 74LS375 | .99 |
| 74LS126 | .70 | 74LS377 | 1.15 |
| 74LS132 | 95 | 74LS386 | .59 |
| 74LS136 | .53 | 74LS390 | 1.75 |
| 74LS138 | .85 | 74LS393 | 1.75 |
| 74LS139 | .85 | 81LS95 | 1.35 |
| 74LS148 | 1.75 | 81LS96 | 1.35 |
| 74LS151 | .79 | 81LS97 | 1.35 |
| | | 81LS98 | 1.35 |

### 4000 CMOS
B SERIES ONLY

| Part # | Price |
|---|---|
| 4000 | 35 |
| 4001 | 35 |
| 4002 | 35 |
| 4006 | 1.05 |
| 4007 | 35 |
| 4008 | 1.15 |
| 4009 | 45 |
| 4010 | 45 |
| 4011 | 35 |
| 4012 | 35 |
| 4013 | 50 |
| 4014 | 85 |
| 4015 | 75 |
| 4016 | 55 |
| 4017 | 1.05 |
| 4018 | 95 |
| 4019 | 55 |
| 4020 | 1 10 |
| 4021 | 1 10 |
| 4022 | 75 |
| 4023 | 35 |
| 4024 | 85 |
| 4025 | 35 |
| 4026 | 1.45 |
| 4027 | 50 |
| 4028 | 75 |
| 4029 | 1 15 |
| 4030 | 50 |
| 4034 | 2 55 |
| 4035 | 99 |
| 4040 | 1 15 |
| 4041 | 1 15 |
| 4042 | 1.05 |
| 4043 | 95 |
| 4044 | 95 |
| 4046 | 1.15 |
| 4047 | 1 35 |
| 4048 | 99 |
| 4049 | .50 |
| 4050 | .50 |
| 4051 | 1 10 |
| 4052 | 1 10 |
| 4053 | .85 |
| 4060 | 1.39 |
| 4066 | 39 |
| 4068 | .35 |
| 4069 | 35 |
| 4070 | .39 |
| 4071 | 39 |
| 4072 | 39 |
| 4073 | .39 |
| 4075 | .39 |
| 4076 | 1.15 |
| 4077 | .39 |
| 4078 | 35 |
| 4081 | .35 |
| 4082 | 35 |
| 4093 | .95 |
| 4503 | .85 |
| 4508 | 2 95 |
| 4510 | .89 |
| 4511 | .89 |
| 4512 | 1.10 |
| 4514 | 2.55 |
| 4515 | 2 55 |
| 4516 | 1 25 |
| 4518 | 1.25 |
| 4519 | .55 |
| 4520 | 1 25 |
| 4526 | 1.65 |
| 4527 | 1.65 |
| 4528 | 1.45 |

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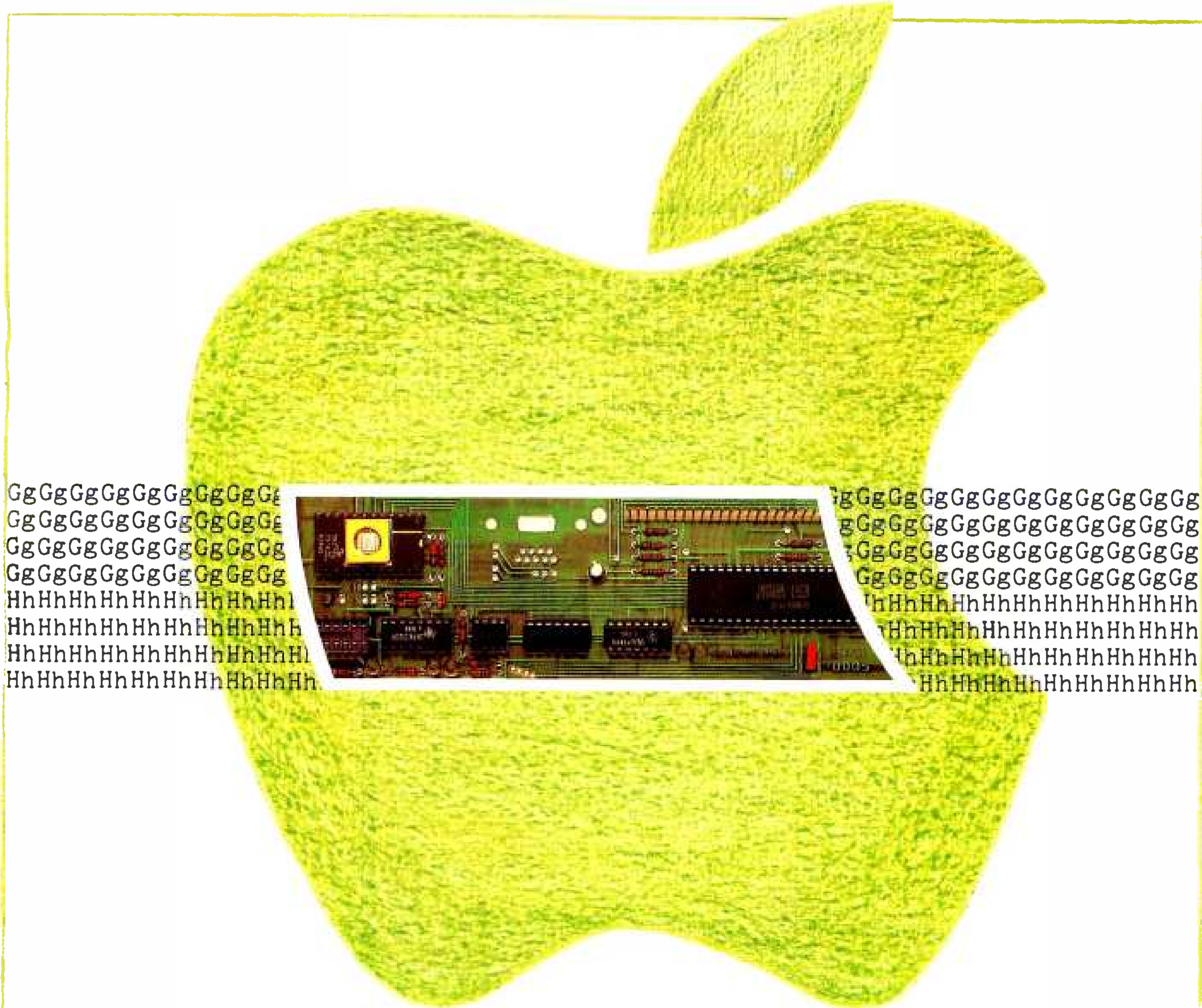
## Zips 70000—80000

1. **99/4 Home Computer Users Group**
2. POB 95148, Oklahoma City OK 73143
3. Charles LaFara, (405) 787-8521
4. Monthly newsletter
5. We have a program exchange and are looking for more information on TI BASIC.

1. **The Tulsa Computer Society**
2. POB 1133, Tulsa OK 74101
3. Mike Parr, (918) 492-8292
4. *I/O Port*
5. Everything!

1. **Theatre Computer Users Group**
2. 104 N St Mary, Dallas TX 75214
3. Mike Firth, (214) 827-7734
4. *TCUG Notes*
5. Special interests: the use of computers in live drama.

1. **FWAUG (Fort Worth Apple Users Group)**
2. 1401 Hillcrest Dr, Arlington TX 76010
3. Lee Meador, (817) 461-1981
4. *FWAUG Newsletter*
5. Apple hardware and software.



# APPLE II Computer – now with genuine upper/lower case

We used to think the sophistication of the Apple II/ PLUS could not be improved upon. With increasing availability of business software capital letters on the screen are not sufficient. Especially for wordprocessing and the PASCAL editor the lack of lower case was disturbing.

After searching for a better solution we developed a new keyboard-encoder to implement upper and lower case in the keyboard and on the screen.

- typewriter mode or ALPHA-LOCK mode operation
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Ask your Apple dealer for the new keyboard-encoder from BASIS. For $ 125,00 you save time and get a new clear screen.

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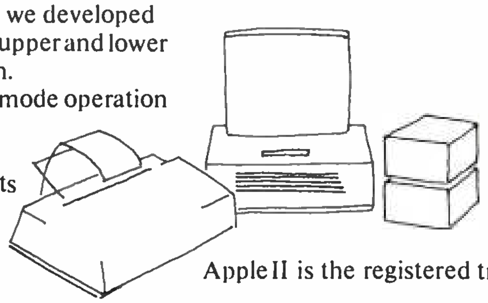

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1. Club 1802
2. POB 985, Dickinson TX 77539
3. John L Hubisz, (713) 938-4098
4. Newsletter
5. Our activities are for beginners in microcomputing. We use ELFs and other 1802-based boards that employ simple controls.

1. **High Plains TRS-80 Users Group**
2. POB 30545, Amarillo TX 79120
3. Tom Whittenburg, (806) 374-9711

1. **Permian Basin Amateur Computer Group**
2. c/o Ector School District, POB 3912, Odessa TX 79760
3. John Rabenaldt, (915) 697-4607 (after 6 PM) or (915) 332-9151 (9 AM to 5 PM)
5. Special interests: Selectric interfaces, color displays, MECA tape, and Altair 8800 systems.

1. **Apple π**
2. 415 E 43rd, Odessa TX 79762
3. Larry Brown
5. Apple II microcomputers.

1. **Permian Basin TRS-80 Users Group**
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3. Allan D Emert, (915) 381-3138
5. TRS-80 Model I.

## Zips 80000—90000

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2. Computer Shack, 1635 S Prairie, Pueblo CO 81005
3. Tom Thomas, (303) 564-3545
4. Monthly newsletter

1. **Utah Computer Association**
2. 378 E 9800 S, Sandy UT 84070
3. Lawrence N Barney, (801) 571-9661
4. *UCA Bits*
5. Special interests: advanced software, hardware, CP/M, and Pascal.

1. **SNPCS (Southern Nevada Personal-Computing Society)**
2. 1405 Lucilee St, Las Vegas NV 89101
3. Cy or Edna Wells, (702) 642-0212
4. *Hard Copy*
5. Both hardware and software; exchange of information and experience; and guidance and encouragement for new hobbyists. We participate in fairs and exhibitions.

## Zips 90000—99999

1. **Poly 88/8813 Users Group**
2. 13022 Psomas Way, Los Angeles CA 90009
3. Pat or Roger Lewis
4. *Poly 88/8813 Users Group Newsletter*
5. Software exchange.

1. **LA Apple Users Group**
2. 9513 Hindry Pl, Los Angeles CA 90045
3. Philip A Wasson, (213) 649-1428

1. **The San Fernando Valley 6502 Users Club**
2. 3816 Albright Ave, Los Angeles CA 90066
3. Larry Goga, (213) 398-6086
5. This club is open to all owners of 6502-based computers including KIM, SYM, and AIM. PET and Apple owners are also welcome.

1. *SuperLetter*
2. Abrams Creative Services, 369 S Crescent Dr, Beverly Hills CA 90212
3. (213) 277-1588
5. Newsletter for SuperBrain users.

1. **OSI Users Independent**
2. 6061 Lime Ave #2, Long Beach CA 90805
3. Charles Curley, (213) 422-3673
4. *OSI Users Independent Newsletter*
5. OSI computers and software.

1. **ELF of the Valley**
2. 2670 Calle Abedul, Thousand Oaks CA 91360
3. Richard Cox, (805) 492-4128
5. RCA 1802 microcomputers.

1. **Compucolor/Intecolor Users Group**
2. 5250 Van Nuys Blvd, Van Nuys CA 91401
3. Stan Pro, (213) 788-8850
4. Bulletin
5. We are an international group of color-computer users, with over 1000 programs in our library.

1. **The Cursor Group**
2. POB 266, North Hollywood CA 91603
4. *The Cursor*
5. User group of the Bally Arcade.

1. **ET-3400 Users Group**
2. 11231 Oak St, El Monte CA 91731
3. Charles Van Dyke, (213) 443-2237; CompuServe acct 70250,413

1. **San Diego Heath User's Group**
2. 12202 Kingsford Ct, El Cajon CA 92021
3. Jim Quinn, President, (714) 561-2540; Cliff Dudley, Secretary, (714) 697-8796
4. Coming soon
5. Special interests: the exchange of ideas, information, and assisting Heath computer users.

1. **CIE (Computer Information Exchange)**
2. POB 158, San Luis Rey CA 92068
3. Bill McLaughlin, (714) 757-4849
4. *CIE People's Software News*
5. Special interests: TRS-80.

1. **Apple for the Teacher**
2. 9525 Lucerne St, Ventura CA 93004
3. David Miller, Editor, (805) 647-1063; Ted Perry, President, (916) 961-7776
4. *Apple Educators' Newsletter*
5. Education using Apple II microcomputers.

1. **International Apple Core**
2. POB 976, Daly City CA 94017
3. Ken Silverman, (415) 878-5382
4. *The Apple Orchard*

5. Apple hardware and software.

1. **Homebrew Computer Club**
2. POB 626, Mountain View CA 94042
3. Robert Reiling, (415) 967-6754
4. *Homebrew Computer Club Newsletter*
5. Information exchange on all systems.

1. **Proteus**
2. 1690 Woodside Rd, 219, Redwood City CA 94061

1. **FORTH Interest Group**
2. POB 1105, San Carlos CA 94070
3. Roy Marteus, (415) 962-8653
4. *FORTH Dimensions*
5. The FORTH language.

1. **San Francisco Apple Core**
2. 1515 Sloat Blvd, Suite 2, San Francisco CA 94132
3. Randy Fields, (415) 775-7965
4. *Cider Press*
5. Apple computers.

1. **CUssP**
2. POB 784, Palo Alto CA 94302
3. Dave Dameron, Editor
4. *CUssP Newsletter*
5. Cromemco computers and systems.

1. **INSUA (International North Star User's Association)**
2. POB 1318, Antioch CA 94509
3. William Banaghan
4. *The Compass*
5. For North Star computer users.

1. *Arcadian*
2. 3626 Morrie Dr, San Jose CA 95127
3. R Fabris, (408) 742-6048 (8 AM to 4 PM) or (408) 258-4586 (6 to 10 PM)
5. For the Bally/AstroVision Arcade.

1. **CUE (Computer-Using Educators)**
2. Independence High School, 1776 Education Park Dr, San Jose CA 95133
3. Don McKell, (408) 926-7378
4. Bimonthly newsletter
5. Computers in education.

1. **Pascal/Z Users Group**
2. 7962 Center Pky, Sacramento CA 95823
5. The purpose of our group is to encourage the use of Pascal.

1. **68XX(X) User Group**
2. POB 18081, San Jose CA 95158
3. Ray Boaz, (408) 269-9522
5. All 68XX(X) microcomputers and related hardware and software.

1. **SYM-1 Users Group**
2. POB 315, Chico CA 95927
3. H R Luxenburg, (916) 895-8751
4. *SYM-Physis*
5. Graphics, voice, music, word processing, and intercomputer communications for the SYM-1.

1. **Group/380**
2. POB 1131, Mt Shasta CA 96067
3. Mokurai Cherlin
4. *Group/380 News*
5. IBM 370-compatible microcomputers.

1. **The Aloha Computer Club**
2. POB 4470, Kailua HI 96734
3. Roger Wickenden, President, (808) 262-4673
4. *The Debugga*
5. Anything to do with microcomputers.

1. **Z80 Microfans—A Sorcerer Users Group**
2. POB 12504, Portland OR 97212
3. C Douglas Auburg, Editor, (206) 694-7769, evenings
4. *Z80 Microfans Newsletter*
5. Special interests: sharing problems, tips, and solutions in the use of the Exidy Sorcerer.

1. **Portland Computer Society Inc**
2. POB 17371, Portland OR 97217
3. Neal J Bonome, (503) 654-5932
4. *Portland Computer Society Newsletter*
5. Information exchange for all types of microcomputers.

1. **Salem Area Computer Club**
2. POB 7715, Salem OR 97303
3. Kenneth Ernst, (503) 393-1173
4. *SACC Newsletter*
5. Users groups: Apple, TRS-80, PET, and VisiCalc.

1. *Home Computers*
2. POB 616, Silverton OR 97381
5. General information on personal computers.

1. **Atari Computer Enthusiasts**
2. 3662 Vine Maple Dr, Eugene OR 97405
3. M R Dunn, Editor,
4. *A.C.E. Newsletter*
5. This group is dedicated to the use of Atari microcomputers.

1. **Hex Users Group**
2. 36012 Military Rd S, Auburn WA 98002
3. Charles Worstell, (206) 927-6038
4. Newsletter on an irregular basis
5. Special interests: 6800 and 6809 small systems.

1. **PN HUG (Pacific Northwest Heath Users Group)**
2. c/o POB 993, Bellevue WA 98009
3. Jan N Johnsen, (206) 464-5666

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## Clubs and Newsletters

4. Newsletter published every other month
5. Special interests: Heath H-8 and H-89 microcomputers.

1. **NW PET Users Group**
2. 2565 Dexter N #203, Seattle WA 98109
3. Richard Ball, (206) 284-9417
4. Newsletter
5. PET users group.

1. **Apple Puget Sound Program Library Exchange**
2. 304 Maine Ave S, Suite 300, Renton WA 98055
3. Dick Hubert, (206) 271-4514
4. *Call—A.P.P.L.E.*
5. Everything related to the Apple II.

1. **SPOHUG (Spokane Heath Users Group)**
2. RFD #1, Box 676, Spokane WA 99204
3. Charles K Ballinger, President, (509) 448-9727
4. *SPOHUG Newsletter*
5. Special interests: Heath H-8 and H-89 computers.

## Foreign Clubs and Newsletters

1. **Computer Education Group of Victoria**
2. POB 245, Niddrie, Victoria 3042, Australia
3. Greg Johnstone, (03) 336-1855
4. *COM-3*
5. Educational uses of computers.

1. **Brazilian Microcomputer Club**
2. Rua Sambaiba, 516, Leblon, Rio de Janeiro 22450, Brazil
3. Douglas Gilson, 274-2439
5. Special interests: exchanging programs and ideas with other clubs.

1. **Apple's British Columbia Computer Society**
2. #101-2044 W 3rd Ave, Vancouver, British Columbia, V6J 1L5, Canada
3. Gary Little, (604) 731-7886
4. *Applegram*
5. Apple II microcomputers.

1. **Apple-Can**
2. POB 696, Station B, Willowdale, Ontario, M2K 2P9, Canada
3. Louis H Milrad, (416) 961-6691 or 223-0599
4. Yes
5. All areas concerning microcomputers.

1. **Association of Computer Experimenters**
2. c/o B Murphy, 102 McCraney St, Oakville, Ontario, L6H 1H6, Canada
3. B Murphy, (416) 845-1630
4. *Ipso Facto*
5. Special interests: CDP 1802 microprocessor-based hobby computers.

1. **I-SUG**
2. POB 1542, St Catharines, Ontario, L2R 7J9, Canada
5. Interested in Exidy Sorcerer microcomputers.

1. **Kitchener—Waterloo Microcomputer Club**
2. Reading Room—E2-3354, Electrical Engineering Department, University of Waterloo, Waterloo, Ontario, N2L 3G1, Canada
3. Roger Sanderson, work (519) 885-1211, ext 3815
5. Special interests: 6800 and 6809 SwTPC systems.

1. **OSMIE (Ontario Society for Microcomputers in Education)**
2. Unit for Computer Science, McMaster University, Hamilton, Ontario, L8S 4K1, Canada
3. N Solntseff, (416) 525-9140, ext 4689
5. All educational uses of microcomputers.

1. **The Ottawa Computer Group**
2. POB 5691, Station F, Ottawa, Ontario, K2C 3M1, Canada
3. John Mainwaring, President, (613) 725-9441; or Dennis Tubie, Secretary, (819) 561-1645
4. *OCG Newsletter*
5. Special interests: microprocessors and computer bulletin board.

1. **TRACE (Toronto Region Association of Computer Enthusiasts)**
2. POB 6922, Station A, Toronto, Ontario, M5W 1X6, Canada
3. Ross Cooling, (416) 488-3314
4. *TRACE*

1. **CPE (Central Program Exchange)**
2. Department of Computing & Mathematical Sciences, The Polytechnic, Wulfruna St, Wolverhampton, WVI 1LY, England
3. Judith Brown, 0902 27371, ext 93
4. *Program Exchange*
5. Microcomputer usage in schools and educational computer-aided learning.

1. **North London Hobby Computer Club**
2. c/o D.E.C.E. Polytechnic of North London, Holloway Rd, London N7 8DB, England
3. Robin Bradbeer, 01-607-2789
4. *Gigo*
5. Special interests: business, homebrew, and games workshops. PET users group.

1. **Microtel—Club**
2. 9, rue Huysmans 75006 Paris, France
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**PRACTICAL MICROCOMPUTER PROGRAMMING: THE INTEL 8080** *by Weller, Shatzel and Nice* — *$23.95*

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## Clubs and Newsletters

1. Japan Microcomputer Club
2. Rm 313, 3-5-8, Shibakoen, Minato-Ku, Tokyo 105, Japan
3. Keigo Aono, Director 03-438-1869
4. *Microcomputer Circular*
5. This is the largest, non-profit, nationwide group in Japan. An English-language version of the club's newsletter is available.

1. Microcomputer Club
2. Fte de Quijote #5, Tecamachalco, Mexico 10-D F, Mexico
3. Alfredo Buzali, (905) 589-2279
4. Bulletin
5. Primarily concerned with the Apple computer.

1. HCC (Hobby Computer Club)
2. Christinastraat 171, 5 615 RK Eindhoven, Netherlands
4. *Hobby Computer Club Nieuwsbrief*
5. The goals of the HCC are to increase contacts between computer amateurs and to exchange ideas and experiences.

1. Club de Computación Lampas de Carabobo
2. Apartado 716, Valencia, Venezuela 2001A, Venezuela
5. Use of microcomputers in civil engineering, basic sciences, and administration. ■

## Answers to MicroShakespeare Quiz

| | | | |
|---|---|---|---|
| 1 - m | 6 - o | 11 - i | 16 - e |
| 2 - j | 7 - b | 12 - c | 17 - t |
| 3 - a | 8 - q | 13 - r | 18 - k |
| 4 - f | 9 - l | 14 - g | 19 - n |
| 5 - h | 10 - s | 15 - p | 20 - d |

| Number of Correct Matches | MicroShakespeare Rating |
|---|---|
| 20 | Hit "START" with confidence. |
| 17 - 19 | One short debug session and you're home free. |
| 13 - 16 | Check your system monitor. |
| 9 - 12 | Must have mixed up the pinouts. |
| 5 - 8 | Blame it on a power surge. |
| 4 or fewer | Back to collecting stamps. ■ |



Circle 14 on inquiry card. →

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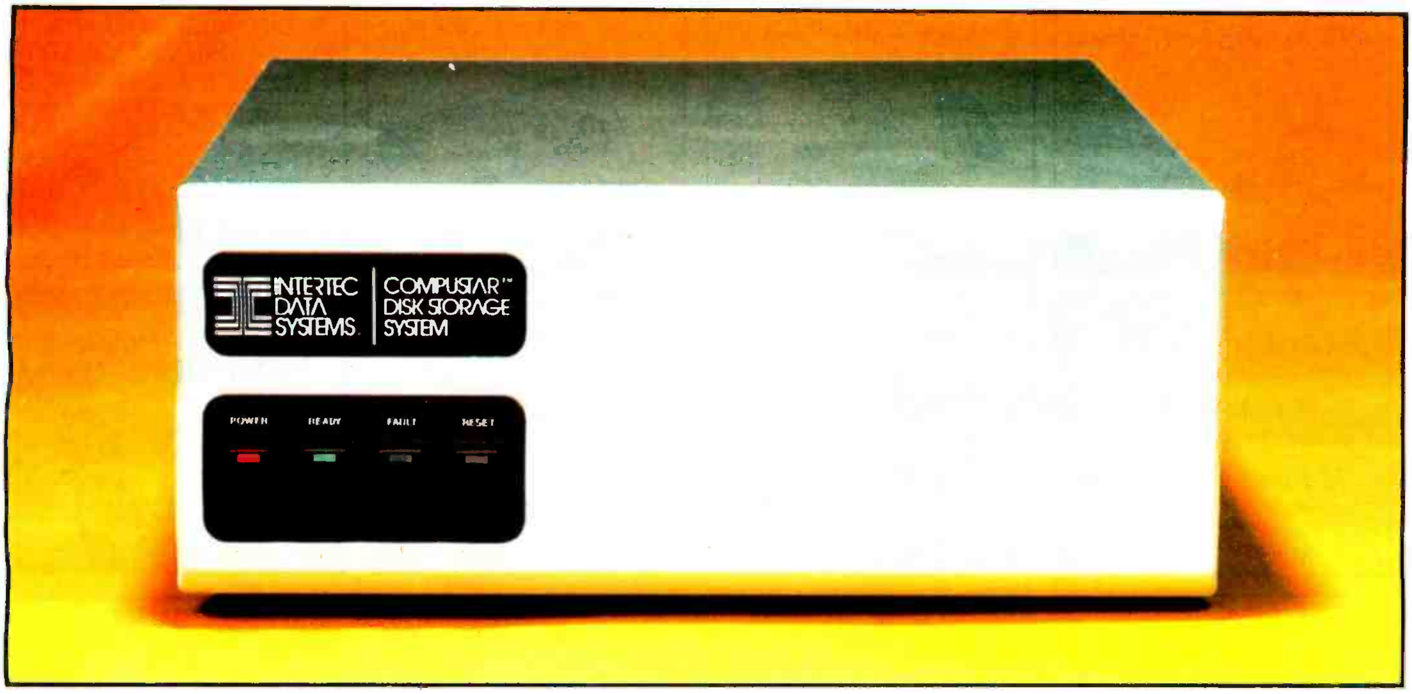


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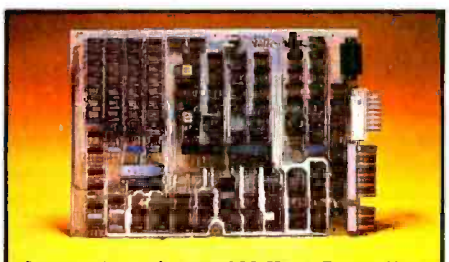

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THE HISTORY OF MICROCOMPUTERS
BY TOM SLOAN
BACK IN PRE-HISTORIC TIMES, CAVEMEN DID ALL THEIR FIGURING ON THEIR FINGERS. BUT THE ONLY TROUBLE WAS 10 WAS AS HIGH AS THEY COULD COUNT.
LETS SEE NOW... THE √144 IS...UH, HMM WELL, IT MUST BE 10.
COUNTING REMAINED THAT WAY UNTIL SOME GREAT SUMERIAN DISCOVERED THAT NUMBERS CAN EXIST HIGHER THAN 10.
5+5=11
THE EGYPTIANS LOVED LARGE NUMBERS, AND...
SO THEY INVENTED A CRUDE ADDING MACHINE.
IT EVEN HAD ITS OWN SET OF GRAPHIC CHARACTERS.
AS TIME PROGRESSED SO DID MAN'S NEED FOR EVEN MORE COMPLICATED NUMBER WORK.
THE GREEKS CAME UP WITH A WHOLE SET OF VARIABLES: THE ALPHABET
LOOK ZUES!
WOW
THE CHINESE PUT IT TO IMMEDIATE USE.
THEN PASCAL INVENTED THE BUILT IN POWER SUPPLY.
MADE IN JAPAN
GUTENBERG INVENTED THE FIRST MOVABLE PRINT HEAD.
PEOPLE COULD NOW HAVE A HARD COPY OF ANYTHING. IT WAS EVEN USED BY OUR FOUNDING FATHERS.
DECLARATION OF INDEPEND
ALONG CAME DeFORREST'S VACUUM TUBE, WHICH MEANT HEAVEN FOR MANY AN INVENTOR!
WITH THAT, THE FIRST TRUE DIGITAL COMPUTERS WERE BUILT. THEY WERE GIANT AND USED MILLIONS OF TUBES.
OH BOY, IS THIS GREAT.
ENIAC
BUT WHEN REPLACING TUBES BECAME MORE COSTLY THAN THE FIGURING WAS WORTH, SOLID STATE TECHNOLOGY TOOK OVER. SO INSTEAD OF MASSIVE COMPUTERS FILLING UP AN ENTIRE FLOOR, THEY WERE BUILT TINY. ABOUT THE SIZE OF A REFRIGERATOR.
MAKE ME A SANDWICH.
OK
INSTEAD OF PAPER, SOMEONE GOT THE IDEA TO ADD A T.V.
DESPITE THEIR SMALL SIZE, THEY STILL WERE NOT QUITE SMALL ENOUGH FOR HOME USE.
GET THAT THING OUT OF MY HOUSE!
FINALLY CAME THE INVENTION OF THE MICRO-PROCESSOR!
ABRACADABRA
WHICH MADE IT POSSIBLE FOR MICRO-SIZE COMPUTERS
BOING 8800
AND NOW OUR SMALL, PORTABLE COMPUTERS ARE THOUSANDS OF TIMES MORE POWERFUL AND COST THOUSANDS OF TIMES LESS.
SO NOW IT IS EASIER THAN EVER TO WRITE A COMPLICATED PROGRAM.
WHAT DID I DO!?
12090 STOP
12100 END
NEW
Tom Sloan
* FACT: BEN FRANKLIN COINED THE ELECTRICAL TERMS "POSITIVE AND NEGATIVE".

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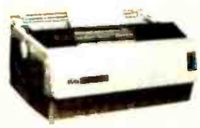

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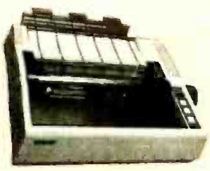

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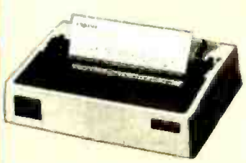

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|---|---|---|
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Software Review

# Three Versions of APL

Gregg Williams, Senior Editor
BYTE POB 372
Hancock NH 03449

When BYTE magazine published its APL language issue in August 1977, APL was far beyond the capabilities of any microcomputer. To show how rapidly things have evolved since then, the Digital Group, in that same issue, was advertising a 32 K-byte static-memory board for $995, and another advertisement began, "Introducing Apple II...." Times have changed: 32 K bytes of dynamic memory, now commonly used in several major microcomputer lines, can be bought for less than $120—and Apple is one of the oldest computer lines in the industry.

Times have changed for APL as well: several companies have announced software and hardware supporting this unique programming language. This review compares three versions of APL: Softronics APL, Ramware APL80 for the Radio Shack TRS-80, and Vanguard APL/V80. (For additional information, see the "At a Glance" boxes. Tables 1 thru 4 give timing comparisons and further information.)

## Softronics APL: I/O Options and Documentation

Softronics APL runs on any Z80-based computer that supports at least 44 K bytes of memory and the CP/M operating system. It was written by Eric Mueller of Softronics, who, in 1977, authored a subset of APL called EMPL for 8080-based microcomputers. Softronics APL (Version 2.3C), which sells for $350, has both good and bad features; a summary is given in table 2.

The most welcome feature of Softronics APL is the ability to use it with several types of keyboards and display devices. The default mode of operation is for the software to respond to a standard ASCII (American Standard Code for Information Interchange) terminal through standard CP/M input and output routines. Three other modes allow the user to use an assortment of APL-type devices.

For those of us who do not have several thousand extra dollars to spend on an APL-type I/O (input/output) device, the ASCII mode of Softronics APL is very welcome. In this mode, all APL characters that are not on a normal keyboard are replaced by either a single key (eg: an underline character to replace the APL assignment arrow) or a 3-character mnemonic (eg: $TP for the transpose operator or $RO for the Greek rho symbol). Although some users object to this arrangement, my reaction to running Xerox APL for an extended period, using such mnemonics, was one of gratitude—better this APL than no APL at all.

Listing 6 shows the output of the APL function CIRCLE. Listing 3a shows the output with slight changes in regular APL notation. I have also found that by changing the value of the system variable ⎕CS, you can cause the APL mnemonics to be displayed with angle brackets around them instead of the preceding dollar signs—on printout only (ie: not input). For example, you will still have to type in $RO for the APL reshape operator, but it will be displayed to the screen or printer as <RO>. This is a nice feature that adds to the readability of APL programs printed in ASCII mode.

Provisions are also made for using Softronics APL with the two most prevalent types of APL terminals (*bit-pairing* and *typewriter-pairing* terminals). Softronics APL begins executing in the ASCII mode but can be converted to APL terminal mode by assigning a new value to the system variable ⎕CS, or it can be modified to begin executing in terminal mode by making a 1-byte patch to the APL.COM machine-language file. Nonstandard terminals or video boards can be interfaced by adding user-supplied input and output machine-language subroutines. The manual explains what routines need to be written and where they should be placed in memory.

Finally, the manual gives documentation on still another I/O option: the use of APL input and output through a video board with a programmable character generator. The documentation includes the software driver (which works with an Objective Design Inc character generator), a Kent-Moore Alpha-VDM-II video display board, and a listing that defines all APL special characters for a character generator as a series of hexadecimal numbers. All this code is included in the APL.COM file.

The ease with which I understood these four display options is an indication of the quality of the documentation. The Softronics APL documentation is the best of the three packages reviewed here. It includes a short tutorial on APL for the complete novice, a description of all functions, sample programs (including APL defined functions that simulate certain APL operators not defined in machine language), and several useful appendices. One section of the documentation, "Bugs and Common Perplexing Error Messages," is a great time saver. It is extremely helpful in explaining some quirks of Softronics APL and how to circumvent them. This section saves the user from

spending quite a bit of time swearing that the language "just doesn't work right."

### Softronics APL: Some Problems

Despite its excellent performance in other areas, Softronics APL (Version 2.3C) has a number of deficiencies that range from minor annoyances to critical defects. The most serious defect is that Softronics APL does not notify the user of an error situation. Any computation that has a result over $9.2 \times 10^{18}$ is replaced by a seemingly random value between $10^{18}$ and $10^{19}$. The low limit on computation size is *not* what makes this error dangerous; rather, the danger lies in the language substituting an inaccurate answer and *not* stopping the computation with an error message.

A second problem with Softronics APL is that it responds with the message SYNTAX ERROR to any number over 7 digits long. I feel that the inability of this language to accept a longer number by rounding it off and, when necessary, putting it into scientific notation is a serious defect.

Many numeric operations that should come out "even" result in numbers ending in ...9999 or ...9997. For example, any variable assigned either the value 0.1 or 1/10 is printed as .099999. The dyadic power function has, for integral exponents, a cumulative round-off error that results in some incorrect answers. For example, $5^8$ is calculated to be 390,622 (it is 390,625) and $3^{12}$ is calculated to be 531,436 (it is 531,441), with higher powers also being incorrect.

When using the power function for fractional powers, such as square roots, the results seem to be one or two units off in the least significant digit. Even though 6 significant digits are given in all calculations, I would recommend using only 5 significant digits when using the dyadic power function to calculate a root.

The trigonometric functions, such as sine, cosine, tangent, and arctangent, agree with the results found in the Chemical Rubber Company's *CRC Standard Mathematical Tables*. However, the arctangent function seems to work with a scalar (ie: a single value) but not with a vector (ie: a one-dimensional array of values).

Softronics APL still lacks several useful functions that are found in the more expensive Vanguard APL: arccosine, arctangent, and all hyperbolic trigonometric functions; rotation on three-dimensional and higher matrices; the grade-up and grade-down functions; and the deal (ie: dyadic question-mark) function. Other,



### At a Glance

**Name**
Softronics APL, Version 2.3C

**Type of Software Package**
Version of APL programming language

**Manufacturer**
Softronics, 35 Homestead Ln, Roosevelt NJ 08555

**Price**
$350

**Format**
8-inch standard CP/M floppy disk

**Language Used**
8080 machine language

**Computer Needed**
An 8080-, 8085-, or Z80-based computer with at least 44 K bytes of programmable memory, running the CP/M operating system

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

**Audience**
APL users, programming language enthusiasts

### At a Glance

**Name**
APL80 (by Phelps Gates)

**Type of Software Package**
Version of APL programming language

**Manufacturer**
Ramware, 6 South St, Milford NH 03055 (603) 673-5144

**Price**
$39.95

**Format**
5-inch floppy disk

**Language Used**
Z80 machine language

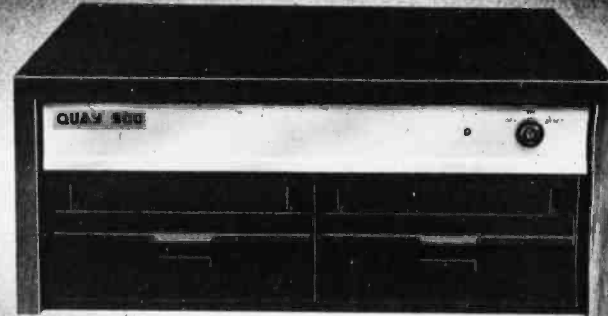
**Computer Needed**
Radio Shack TRS-80 Model I with one floppy-disk drive, Level II BASIC, and 32 K bytes of memory

**Documentation**
Twenty pages, 13 by 20 cm (5 by 7¾ inches)

**Audience**
APL users, programming language enthusiasts

**Comments**
Cassette-tape version with 25% fewer features available for 16 K TRS-80 at $14.95

# 2.5 MB.

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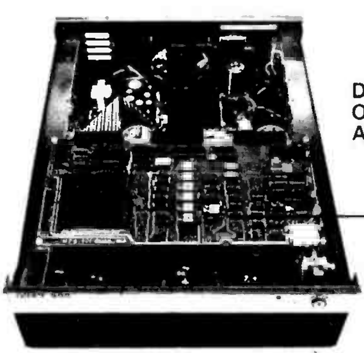

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more advanced operators that are also missing are not mentioned here. See table 2 for a more complete definition of the language.

### Ramware APL80

In its version of APL for the Radio Shack TRS-80 Model I, Ramware of Milford, New Hampshire, has made available a remarkable product. When I first saw the advertisements for the tape version of APL80, its low price ($14.95) led me to dismiss it as some kind of toy, probably written in BASIC and too slow to be useful. Even though the tape version has about 25% fewer features than the more expensive disk version ($39.95), it is still written in Z80 machine language and is a fairly usable version of the language. Author Phelps Gates has reason to be proud of this package.

Table 3 lists the operators available within APL80. The fullness of the language is due to the use of the ROM (read-only memory) modules implementing Level II BASIC. Because the author was able to use the numerical routines from Level II BASIC, much of the work of creating an entire programming language had been done for him, and he could concentrate on making it behave like APL. (APL80 has been tested and found to work on the newer TRS-80s that have Level II BASIC in two rather than three ROM devices. Until a correction can be made to the current version of APL80, however, the down-arrow symbol used for the APL drop and grade-down operations must be displayed by simultaneously

*Text continued on page 196*

#### At a Glance

**Name of System**
Vanguard APL/DTC (desk-top computer)

**Manufacturer**
Vanguard Systems Corporation, 6812 San Pedro, San Antonio TX 78216 (512) 828-0554

**Price**
$7995

**Terminal Dimensions**
32 by 45.5 by 53.5 cm (12½ by 18 by 21 inches)

**Computer Dimensions**
19 by 51 by 43 cm (7½ by 20 by 17 inches)

**Processor**
Z80, 8-bit

**System Clock Frequency**
4 MHz

**Memory**
80 K bytes of static memory (34 K bytes left for APL workspace)

**Mass Storage**
Two quad-density 5-inch floppy-disk drives

**Features**
APL/ASCII keyboard and 12-inch APL/ASCII memory-mapped video display of twenty-four 80-character lines housed in separate video terminal enclosure; display of all APL characters

**Software Included**
CP/M operating system, APL/DTC software

**Hardware Options**
Communications option (Hayes Microcomputer Products Micromodem plus special software); high-resolution (256-by-240 black-and-white or 128-by-120 sixteen-gray-level) graphics; letter-quality APL/ASCII printer, real-time clock.

**Software Options**
APL * PLUS file system simulator

**Audience**
APL users, programming-language enthusiasts

#### At a Glance

**Name**
Vanguard APL/V80

**Type of Software Package**
Version of APL programming language

**Manufacturer**
Vanguard Systems Corporation, 6812 San Pedro, San Antonio TX 78216 (512) 828-0554

**Price**
$500

**Format**
CP/M or CDOS operating system, 5-inch or 8-inch disk

**Language Used**
Z80 machine language

**Computer Needed**
Computers with at least 48 K bytes of programmable memory; a Z80 processor card; at least one floppy-disk drive

**Documentation**
Seventy-six pages, 22 by 28 cm (8½ by 11 inches)

**Audience**
APL users, programming language enthusiasts

**Features**
APL defined functions (programs) simulate some APL functions, APL * PLUS file system, and other functions

**Comments**
This version is identical to the software reported on for the APL/DTC computer, except for the reduced workspace size and the availability of the inner product function as a defined function.



 

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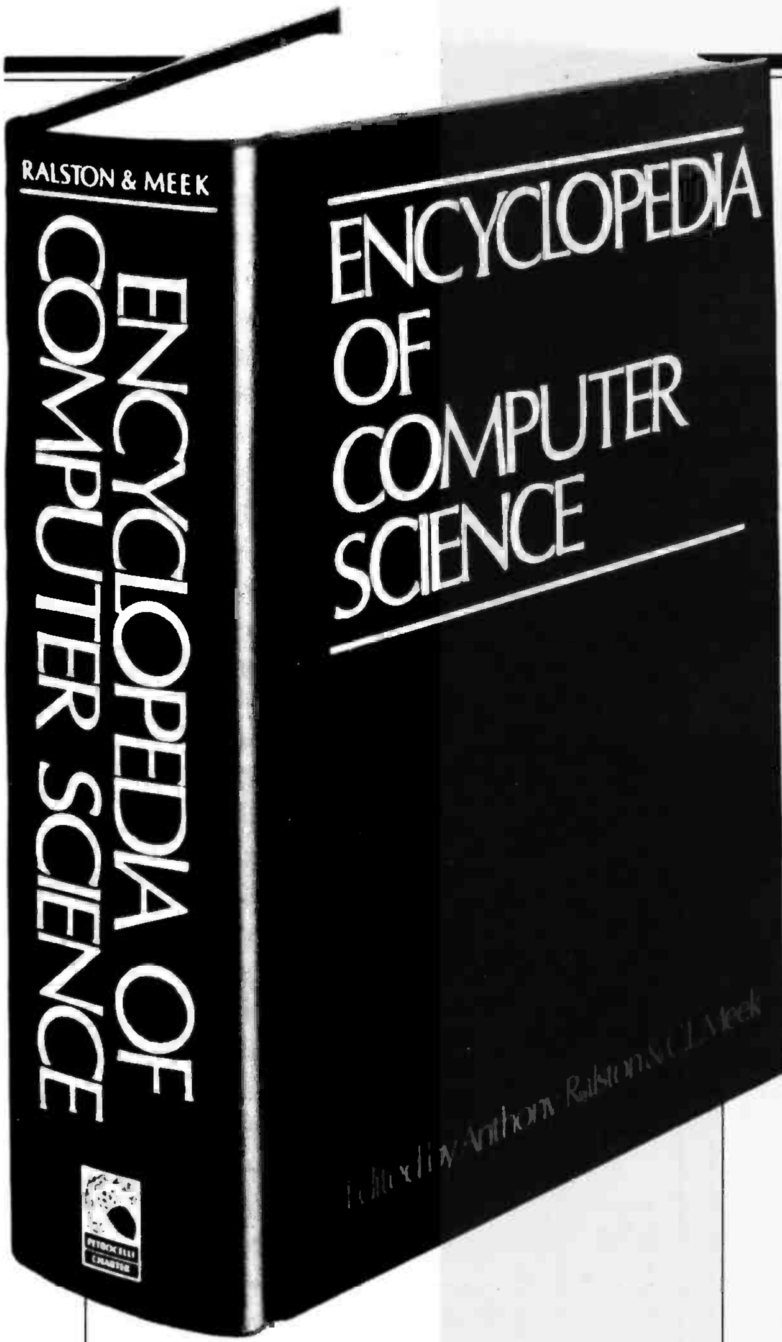


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**Listing 1:** *Listing of the APL function SETUP. This routine defines certain variables used in the execution of benchmark programs.*

```
     ∇ SETUP
[10] A←10 10ρ⍳100
[20] B←⍉A
[30] C←10×1○RA
[40] D←A×(○2)÷100
[50] E←⍳10
[60] F←1000 365 24 60 60
[70] RA←,A
[80] RB←,B
[90] M3D←2 5 10ρRA ∇
```

**Listing 2:** *Listing of the APL function TIME. When this routine is used as a benchmark program, the function to be tested replaces each occurrence of the phrase (EXP) on lines 10 thru 60. (See table 1.)*

```
     ∇ TIME N;LP
[10] LP←0
[20] BGN:(EXP)
[30] (EXP)
[40] (EXP)
[50] (EXP)
[60] (EXP)
[70] →(N>LP←LP+1)/BGN
[80] 'DONE ';N×5;' TIMES'
[90] 'UNIT TIME IS '; (÷N×5)×⎕;
     ' SECONDS PER ITERATION' ∇
```

**Listing 3:** *Listing and sample execution of the APL function CIRCLE. Listing 3a shows the function, which has the purpose of adding a set value to all matrix elements that fall within an imaginary circle with a given center and radius. Listing 3b shows a 10 by 10 array filled with zeros and, below it, the same circle after execution of the statement B←(6 5 4 8) CIRCLE A. On one of the printers used to generate these listings, the backarrow character, ←, appears as an underscore, __.*

```
     ∇B←AR  CIRCLE A;RD;ROW;COL
[10]   AR CONTAINS: ROW COORD, COL COORD, RADIUS, VALUE ADDED
[20] B←A
[30] ROW←AR[1]-AR[3]+1
[40] NEXTROW: ROW←ROW+1
[50] COL←AR[2]-AR[3]+1
[60] NEXTCOL: COL←COL+1
[70] →(AR[3]≤(((ROW-AR[1])*2)+(COL+AR[2])*2)*0.5)/ENDLP
[80] B[ROW;COL]←B[ROW,COL]+AR[4]
[90] ENDLP:→(COL<AR[2]+AR[3])/NEXTCOL
[100] →(0,NEXTROW)[1+ROW<AR[1]+AR[3]]∇
```

```
    A
0   0   0   0   0   0   0   0   0   0
0   0   0   0   0   0   0   0   0   0
0   0   0   0   0   0   0   0   0   0
0   0   0   0   0   0   0   0   0   0
0   0   0   0   0   0   0   0   0   0
0   0   0   0   0   0   0   0   0   0
0   0   0   0   0   0   0   0   0   0
0   0   0   0   0   0   0   0   0   0
0   0   0   0   0   0   0   0   0   0
0   0   0   0   0   0   0   0   0   0

    B_(6 5 4 8) CIRCLE A
    B
0   0   0   0   0   0   0   0   0   0
0   0   0   0   8   0   0   0   0   0
0   0   8   8   8   8   8   0   0   0
0   8   8   8   8   8   8   8   0   0
0   8   8   8   8   8   8   8   0   0
8   8   8   8   8   8   8   8   8   0
0   8   8   8   8   8   8   8   0   0
0   8   8   8   8   8   8   8   0   0
0   0   8   8   8   8   8   0   0   0
0   0   0   0   8   0   0   0   0   0
```

**Listing 4:** *Listing and sample execution of the APL function TRANS. Listing 4a shows the function, which translates a numeric array similar to the one in listing 3b to a character array that reflects the contents of the numeric array. Listing 4b shows the result of executing TRANS B, where B is the matrix in the lower half of listing 3b.*

```
      ∇B←TRANS A;AA;MX;MN;MAXX;CHAR
[10] CHAR←'LMNOPQRSTUVWXYZ-123456789ABCDEF+*#'
[20] MN←⌊/AA←,A
[30] MX←⌈/AA
[40] MAXX←(MX⌈-MN)÷15
[50] AA←⌊0.5+16+AA÷MAXX
[60] B←(ρA)ρCHAR[AA] ∇
```

```
       TRANS B
----------
----F-----
--FFFFF---
-FFFFFFF--
-FFFFFFF--
FFFFFFFFF-
-FFFFFFF--
-FFFFFFF--
--FFFFF---
----F-----
```

**Listing 5:** *Listing of the APL function IVER. This function, written by Kenneth Iverson (the inventor of APL), will generate a vector of all prime numbers up to and including the scalar A. (A must be greater than or equal to 7.)*

```
∇ B←IVER A
  B←(2=+/⍉0=(⍳A)∘.|⍳A)/⍳A
∇
```



**Listing 6:** *Listing of the APL function CIRCLE as generated by Softronics APL using a non-APL video terminal. APL functions can be printed on a standard printer through the use of mnemonic phrases, which begin with a $ sign. The backarrow appears here as an underscore.*

```
    $DL  B_AR CIRCLE A;RD;ROW;COL
[1]  $LP
[2]  $LP    AR CONTAINS: ROW & COL COORD, RADIUS, VALUE ADDED
[3]  $LP    (EG: (6 5 4 9) CIRCLE A   ADDS TO ARRAY A CIRCLE OF
[4]  $LP    VALUE 9 AND RADIUS 4, WITH CENTER AT (6,5))
[5]  $LP
[6]   B_A
[7]   ROW_AR[1]-AR[3]+1
[8]  NEXTROW:ROW_ROW+1
[9]   COL_AR[2]-AR[3]+1
[10] NEXTCOL:COL_COL+1
[11]  $GO ((AR[3]*2)<((ROW-AR[1])*2)+(COL-AR[2])*2)/ENDLP
[12]  B[ROW;COL]_B[ROW;COL]+AR[4]
[13] ENDLP:$GO (COL$LE AR[2]+AR[3])/NEXTCOL
[14]  $GO (0,NEXTROW)[1+ROW<AR[1]+AR[3]]
    $DL
```

*Text continued from page 192:*

pressing three keys: the *shift* key, the *down-arrow* key, and the Z key.)

Because Ramware APL80 has almost all the capabilities of Level II Disk BASIC, it has some functions and features that the other versions reviewed here do not; several examples are: single-precision or double-precision variables, inverse trigonometric functions, exponents, logarithms, and character editing within a line. Even in the benchmarks (see table 1), this version does fairly well against the other two versions when you consider the differences in price ($39.95 vs $350 and $500) and in processor speed (the TRS-80 is running at 1 MHz, while the other two are running the same type of Z80 processor, but at 4 MHz).

The method used to represent APL on an unmodified TRS-80 is odd, but it is probably the best way that could

*Text continued on page 204*

| OPERATION | UNIT TIME TO PERFORM OPERATION, SECONDS | | |
|---|---|---|---|
| | SOFTRONICS APL | RAMWARE APL80 | VANGUARD APL/DTC SOFTWARE |
| Q←A÷B | 0.79 | 4.6 | 1.2 |
| Q←A>B | 0.48 | 0.42 | 0.091 |
| Q←B | 0.059 | 0.051 | 0.012 |
| Q←2○D | 5.0 | 2.9 | 8.6 |
| Q←⍋C | 140. | 11. | 3.1 |
| Q←F⊤100000000 | NA | 0.61 | 0.13 |
| Q←¯50↑RA | 0.086 | 0.18 | 0.014 |
| Q←⌹N1 | 180. | NA | 66. |
| Q←4⌽[1]M3D | NA | 0.74 | 1.8 |
| Q←E∘.+E | 0.41 | 0.31 | 0.082 |
| Q←+/C | 0.25 | 0.25 | 0.19 |
| CIRCLE | 160. * | 230. * | 150. |
| TRANS | 9.0 * | 28. * | 11. |
| IVER | 28. | 160. * | 120. |

**Table 1:** *Timing results of APL benchmark programs. For details on this and tables 2 thru 4, see the "Notes on APL Benchmarks" text box on page 204.*

## Scalar Dyadic Operators, Softronics APL

| OPERATOR | NAME | MONADIC | DYADIC | COMMENTS |
|---|---|---|---|---|
| + | ADD | Y | Y | |
| - | SUBTRACT | Y | Y | |
| × | MULTIPLY | Y | Y | |
| ÷ | DIVIDE | Y | Y | |
| ⋆ | EXPONENT | N | Y* | Dyadic version innaccurate in last decimal place; see text. |
| ⍟ | LOGARITHM | Y | Y | |
| ⌊ | FLOOR | Y | Y | |
| ⌈ | CEILING | Y | Y | |

| OPERATOR | NAME | MONADIC | DYADIC | COMMENTS |
|---|---|---|---|---|
| \| | RESIDUE | Y | Y | |
| ! | FACTORIAL | Y* | Y | Gamma function missing. |
| ○ | CIRCLE | Y | Y* | Only sin, cos, tan, arctan implemented. |
| < ≤ > ≥ | LESS THAN, ETC. | | Y | |
| = ≠ | EQUAL TO, NOT EQUAL TO | | Y | |
| ∧∨ | AND, OR | | Y | |
| ⍲⍱ | NAND, NOR | | Y | |

## Nondyadic Scalar and Mixed Operators, Softronics APL

| OPERATOR | NAME | MONADIC | DYADIC | COMMENTS |
|---|---|---|---|---|
| ~ | NOT | Y | | |
| ? | ROLL | Y | N* | Dyadic available as defined function only. |
| ⍳ | IOTA (INDEX) | Y | Y | |
| ⍴ | RHO (RESHAPE) | Y | Y | |
| , | RAVEL | Y | Y* | Catenation for vectors only; no lamination. |
| ⊥ ⊤ | DECODE, ENCODE | | N | |
| ↑ ↓ | TAKE, DROP | | Y | |
| ∊ | MEMBERSHIP | | Y | |
| ⍋ ⍒ | GRADE-UP GRADE-DOWN | N* | | Available as defined function only. |
| ⌹ | MATRIX DIVIDE OR INVERSE | N* | N* | Both available as defined function only. |

| OPERATOR | NAME | MONADIC | DYADIC | COMMENTS |
|---|---|---|---|---|
| ⍉ | TRANSPOSE | Y | Y* | Dyadic "diagonal" transpose missing. |
| ⌽ | ROTATE OR REVERSE | Y | N* | Dyadic function available for vectors and two-dimensional matrices only available as defined function. |
| ⊖ | ROTATE | Y | N | |
| / | COMPRESS | | Y | |
| ⌿ | COMPRESS | | N* | Available as / [1] only. |
| \ | EXPAND | | N | |
| ⍀ | EXPAND | | N | |
| ⍎ | EXECUTE | Y | | |
| ⍕ | FORMAT | Y* | | Converts a vector or array to a character string (with embedded carriage return) for printing. |

## Composite Operators, Softronics APL

| OPERATOR | NAME | AVAILABLE? |
|---|---|---|
| f/ | REDUCTION | Y |
| f⌿ | REDUCTION | Y |

| OPERATOR | NAME | AVAILABLE? |
|---|---|---|
| f.g | INNER PRODUCT | Y |
| ∘.f | OUTER PRODUCT | Y |

Notes:

"Y" and "N" mean that a given operator is either present in all its forms or totally absent from this verion of APL. "Y*" means that the operator is only partially present in this version. "N*" means that the operator is not present in this version but that part or all of it is available through an APL defined function supplied with this version. Further information explaining "Y*" and "N*" is given in the "Comments" column.

A scalar is an object (number or character) with no dimension. A vector is a string of objects that have one dimension. An array is a matrix of objects that have two or more dimensions.

Other features: standard APL commands, system functions, and system variables; line editing only of defined functions; PEEK and POKE functions; 8080-type port IN and OUT functions; shared variable mechanism for interaction with disk files (sequential read and write only, in standard CP/M format); mixing of APL data structures (arrays, vectors, scalars) in records of same file; user choice of standard terminal, APL terminal, or video board with programmable character generator; and good documentation.

Other limitations: several much-needed operators are missing (see body of this table) and there is no random access to disk files' character-editing of defined functions.

**Table 2:** *Summary of Softronics APL features.*

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) **DATA MANAGER II** (The Bottom Shelf).....RANDOM ACCESS Disk based DATA MANAGEMENT SYSTEM (Similiar to INFORMATION SYSTEM above........but RANDOM ACCESS STORAGE expands the amount of storage space available).....Used to replace index cards for medium sized mail lists, inventories, personnel records, sales prospects, etc......Uses up to four disk drives on line.....Up to twenty user defined fields, programmable printouts for rolodex cards, etc.....will identify all records that contain a group of characters you've entered even if that group is in the middle of a line.....maintain up to 5 changeable presorted "key" files...... variable length random records (the smaller the record you define, the more records yu can store) **$99.95***

) **BUSINESS MAIL SYSTEM** (The Bottom Shelf).....Handles large mailing lists (up to 150,000 names).....supports 3 or 4 line addresses.....files automatically in zip code order, alphabetical within zip code.....formats for 1 to 4 across mailing labels.....supports quick disk location of single or multiple names.....meets all industry and postal standards.....numeric code fields included for printing selected records **$125.00***

) **ANALYSIS PAD** (The Bottom Shelf).....A Columnar Calculator for financial analysis, line item budgeting, cost analysis, sales analysis and almost any financial function (and many statistical functions).....create matrixes of 29 × 39.....make all entries at one time either by row or column..... add, delete, move or switch columns and rows.....edit any data from full screen display.....add, subtract, multiply and divide one column by another and put results in designated column (up to six calculations can be made and placed in designated column).....define columns as constants.....save calculations and formulas on disk.....results can be printed in a variety of report formats **$99.95***

) **CHECKBOOK II** (The Bottom Shelf).....A complete in memory checkbook balancing and reconciliation program.....five column keyboard input with 5 characters for check number, 16 for payee, 4 for code.....numerical sort routine **$49.50***

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) **HORSE SELECTOR II** (Dr. Hal Davis).....New simplified version of the original Horse Selector (for flats).....The first Horse Selection System to actually calculate the estimated offs for each horse.....easy to follow rules.....uses 4 factors (speed rating, track variant, distance of the present race, distance of the last race).....calculated estimated odds.....FREE DUTCHING TABLES allows betting on 2 or more horses with a guaranteed profit **$50.00**

) **MON-3 and MON-4** (Howe Software).....Powerful utility programs enabling you to interact directly with your TRS-80 in MACHINE LANGUAGE.....The monitor comes with complete 40-page instruction manual making it useful for both the beginner and advanced programmer.... simple commands make it easy to use.....functions include DISPLAY, DISASSEMBLE, MOVE and COMPARE, SEARCH, MODIFY, RELOCATE, PRINT, READ and WRITE, UNLOAD, SAVE and READ, INPUT and OUTPUT, SEND and RECEIVE.....MON-3 $39.95 (for cassette)..... MON-4 $49.95 (for disk).

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(22) **COPSYS** (Racet Computes).....allows the user to make copies of machines language cassettes without any knowledge of machine language **$20.00**

(23) **COMRPOC** (Racet Computes).....an auto load program for disk users.....allows the user to insert a diskette into their **MOD-III** and have the computer take over all loading.....load a machine language program, BASIC, RUN a certain program all without pressing a single button .....allows your computer to perform 10, 20, 30 or more functions without pressing a single button **$30.00***

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(29) **MAIL LIST** (Racet Computes).....all routines are in machine language allowing for quick access **$75.00**

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## Scalar Dyadic Operators, Ramware APL80

| OPERATOR | NAME | MONADIC | DYADIC |
|---|---|---|---|
| + | ADD | Y | Y |
| − | SUBTRACT | Y | Y |
| × | MULTIPLY | Y | Y |
| ÷ | DIVIDE | Y | Y |
| ⋆ | EXPONENT | N | Y• |
| ⍟ | LOGARITHM | Y | Y |
| ⌊ | FLOOR | Y | Y |
| ⌈ | CEILING | Y | Y |

| OPERATOR | NAME | MONADIC | DYADIC | COMMENTS |
|---|---|---|---|---|
| \| | RESIDUE | Y | Y | |
| ! | FACTORIAL | Y• | Y | Gamma function missing. |
| ○ | CIRCLE | Y | Y• | Hyperbolic and hyperbolic inverse not defined. |
| < ≤ > ≥ | LESS THAN, ETC. | | Y | |
| = ≠ | EQUAL TO, NOT EQUAL TO | | Y | |
| ∧∨ | AND, OR | | Y | Assumes nonzero values are equivalent to 1 or true (nonstandard). |
| ⍲⍱ | NAND, NOR | | Y | |

## Nondyadic Scalar and Mixed Operators, Ramware APL80

| OPERATOR | NAME | MONADIC | DYADIC | COMMENTS |
|---|---|---|---|---|
| ~ | NOT | Y | | |
| ? | ROLL | Y | Y | |
| ⍳ | IOTA (INDEX) | Y | Y | |
| ⍴ | RHO (RESHAPE) | Y | Y | |
| , | RAVEL | Y | Y• | Catenation for arrays, vectors, along last coordinate only; no lamination. |
| ⊥ ⊤ | DECODE, ENCODE | | Y• | Right argument of encode limited to scalars only. |
| ↑ ↓ | TAKE, DROP | | Y | |
| ∊ | MEMBERSHIP | | Y | |
| ⍋ ⍒ | GRADE-UP GRADE-DOWN | Y | | |
| ⌹ | MATRIX DIVIDE OR INVERSE | N | N | |

| OPERATOR | NAME | MONADIC | DYADIC | COMMENTS |
|---|---|---|---|---|
| ⍉ | TRANSPOSE | Y• | Y• | Monadic transpose is nonstandard for 3-dimensional or larger arrays; dyadic "diagonal" transpose missing. |
| ⌽ | ROTATE OR REVERSE | Y | Y | |
| ⊖ | ROTATE | N• | N• | Available as ⌽[1] only. |
| / | COMPRESS | | Y | |
| ⌿ | COMPRESS | | N• | Available as /[1] only. |
| \ | EXPAND | | Y | |
| ⍀ | EXPAND | | N• | Available as \ [1]. |
| ⍎ | EXECUTE | N | | |
| ⍕ | FORMAT | Y• | | Sets field width and number of decimal places for future output. |

## Composite Operators, Ramware APL80

| OPERATOR | NAME | AVAILABLE ? | COMMENTS |
|---|---|---|---|
| f/ | REDUCTION | Y | |
| f⌿ | REDUCTION | N• | Available as f/[1] |

| OPERATOR | NAME | AVAILABLE ? |
|---|---|---|
| f.g | INNER PRODUCT | Y |
| ∘.f | OUTER PRODUCT | Y |

Notes:

"Y" and "N" mean that a given operator is either present in all its forms or totally absent from this version of APL. "Y*" means that the operator is only partially present in this version. "N*" means that the operator is not present in this version but that part or all of it is available through an APL defined function supplied with this version. Further information explaining "Y*" and "N*" is given in the "Comments" column.

A scalar is an object (number or character) with no dimension. A vector is a string of objects that have one dimension. An array is an matrix of objects that have two or more dimensions.

Other features: five tutorial programs on APL included in package; standard APL commands, automatic execution of latent expression; tracing of function execution; choice of single (6-digit) or double (15-digit) precision in output; real-time clock, line and character editing of defined functions; print formatting and system control variables(APL I-bar functions); positioning of screen output (equivalent to PRINT @ in BASIC); use of periods and dashes in variable names; PEEK, POKE, and CALL functions; random or sequential access of file records; updating of file records; and mixing of APL data structures (ie: arrays, vectors, scalars) in records of same disk file.

Other limitations: only one assignment operator per line; maximum of thirty-two functions per workspace and 255 lines per defined function; arrays limited to sixty-three dimensions; uses one-letter substitutions for APL operators (but these substitutions are differentiated from normal text).

**Table 3:** *Summary of Ramware APL80 features.*

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## 1. THREADED INTERPRETIVE LANGUAGES
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Threaded languages (such as FORTH) are compact, giving the speed of assembly language with the programming ease of BASIC. They combine features found in no other programming languages. This book develops an interactive, extensible language with specific routines for the Zilog Z80 microprocessor. With the core interpreter, assembler, and data type defining words covered in the text, it is possible to design and implement programs for almost any application and equivalent routines for different processors.


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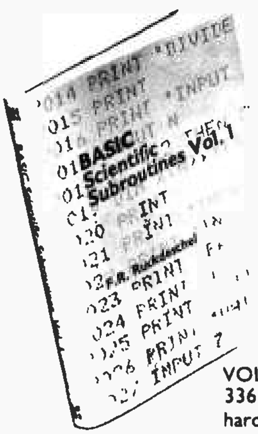


## 2. BASIC SCIENTIFIC SUBROUTINES, VOLUME I
by Fred Ruckdeschel

Designed for the engineer, scientist, experimenter, and student, this book presents a complete scientific subroutine package in BASIC. Volume I covers plotting, complex variables, vector and matrix operation, random number generation, and series approximations. This volume features routines written in both standard Microsoft and North Star BASIC, extensive appendices, and subroutine cross-references.

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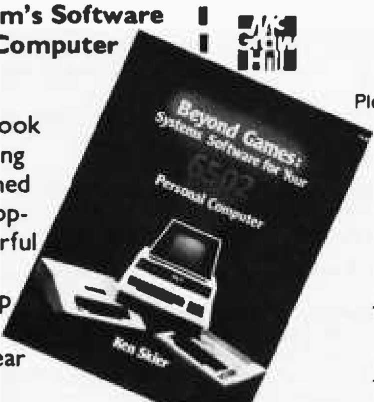


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### Scalar Dyadic Operators, Vanguard APL

| OPERATOR | NAME | MONADIC | DYADIC |
|---|---|---|---|
| + | ADD | Y | Y |
| − | SUBTRACT | Y | Y |
| × | MULTIPLY | Y | Y |
| ÷ | DIVIDE | Y | Y |
| ⋆ | EXPONENT | Y | Y |
| ⍟ | LOGARITHM | Y | Y |
| ⌊ | FLOOR | Y | Y |
| ⌈ | CEILING | Y | Y |

| OPERATOR | NAME | MONADIC | DYADIC | COMMENTS |
|---|---|---|---|---|
| \| | RESIDUE | Y | Y | |
| ! | FACTORIAL | Y* | Y | Gamma available as a defined function. |
| ○ | CIRCLE | Y | Y* | Hyperbolic, inverse $\sqrt{B^2-1}$, $\sqrt{B^2+1}$ not defined. |
| < ≤ > ≥ | LESS THAN, ETC. | | Y | |
| = ≠ | EQUAL TO, NOT EQUAL TO | | Y | |
| ∧∨ | AND, OR | | Y | |
| ⍲⍱ | NAND, NOR | | Y | |

### Nondyadic Scalar and Mixed Operators, Vanguard APL

| OPERATOR | NAME | MONADIC | DYADIC | COMMENTS |
|---|---|---|---|---|
| ~ | NOT | Y | | |
| ? | ROLL | Y | Y | |
| ⍳ | IOTA (INDEX) | Y | Y | |
| ⍴ | RHO (RESHAPE) | Y | Y | |
| , | RAVEL | Y | Y* | Catenation for arrays, vectors, along all coordinates; lamination available as defined function. |
| ⊥ ⊤ | DECODE, ENCODE | | Y | Right argument of encode limited to scalars only. |
| ↑ ↓ | TAKE, DROP | | Y | |
| ∊ | MEMBERSHIP | | Y | |
| ⍋ ⍒ | GRADE-UP GRADE-DOWN | Y | | |
| ⌹ | MATRIX DIVIDE OR INVERSE | N* | N* | Both available as defined function only. |

| OPERATOR | NAME | MONADIC | DYADIC | COMMENTS |
|---|---|---|---|---|
| ⍉ | TRANSPOSE | Y* | N | Monadic transpose for arrays available as defined function only. |
| ⌽ | ROTATE OR REVERSE | Y* | Y* | Both forms work for vectors only; for all arrays, available as defined functions only. |
| ⊖ | ROTATE | N* | N* | |
| / | COMPRESS | | Y | |
| ⌿ | COMPRESS | | N* | Available as / [1] only. |
| \ | EXPAND | | Y | |
| ⍀ | EXPAND | | N* | Available as \ [1] only. |
| ⍎ | EXECUTE | Y | | |
| ⍕ | FORMAT | | Y | Left argument is print width and number of decimal places; right argument is vector or array to be formatted. |

### Composite Operators, Vanguard APL

| OPERATOR | NAME | AVAILABLE ? | COMMENTS |
|---|---|---|---|
| f/ | REDUCTION | Y | |
| f⌿ | REDUCTION | N* | Available as f / [1] only. |

| OPERATOR | NAME | AVAILABLE ? |
|---|---|---|
| f.g | INNER PRODUCT | Y |
| ∘.f | OUTER PRODUCT | Y |

Notes:

"Y" and "N" mean that a given operator is either present in all its forms or totally absent from this version of APL. "Y*" means that the operator is only partially present in this version. "N*" means that the operator is not present in this version but that part or all of it is available through an APL defined function supplied with this version. Further information explaining "Y*" and "N*" is given in the "Comments" column.

A scalar is an object (number or character) with no dimension. A vector is a string of objects that have one dimension. An array is a matrix of objects that have two or more dimensions.

Other features: standard APL commands, system functions, and system variables; line editing only of defined functions; shared variable mechanism for interaction with disk files (sequential and random access); mixing of APL data structures (arrays, vectors, scalars) in records of same disk file; the ability to share with any Z80 I/O port.

Other limitations: only way to use this software with a non-APL terminal or video board uses one-letter substitutions of a standard ASCII character for APL operators (plus these substitutions are not differentiated from normal text); documentation is adequate but terse; no character editing of defined functions.

**Table 4:** *Summary of Vanguard APL/DTC software features.*

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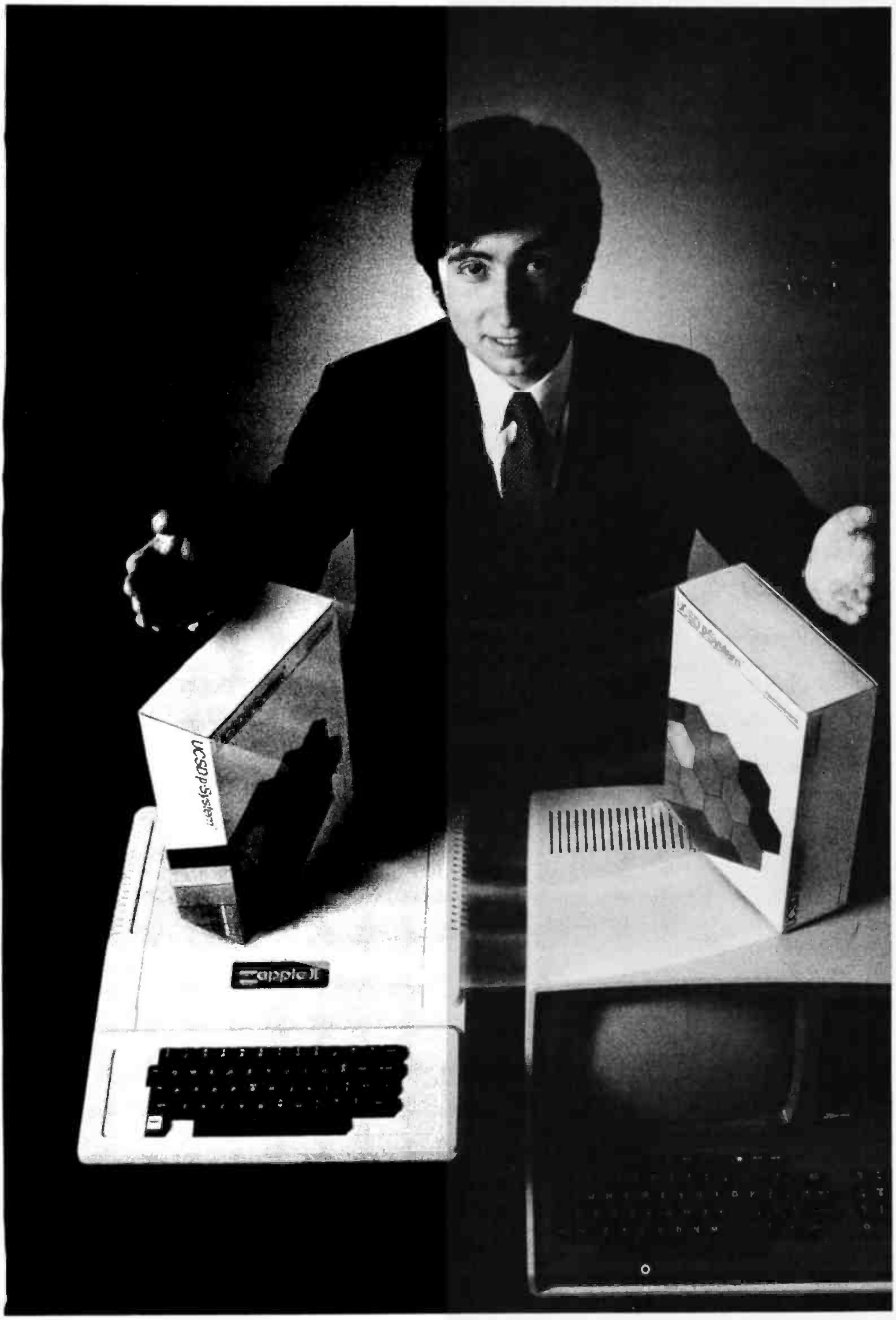

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## Notes on APL Benchmarks

*The following information specifies the tests that are run on all versions of APL that are examined at BYTE magazine. Defined function SETUP, shown in listing 1, creates the APL variables that will be used in the tests shown in table 1. A and B are 10 by 10 matrices used in tests like A÷B to perform an operation 100 times with one statement. C is a ten-element vector giving the values from π to 10π. D is a 10 by 10 matrix of trigonometric values. E is a ten-element vector of the values from 1 to 10 (used to test the outer product operator). F is a vector used to convert seconds to years, days, hours, minutes, and seconds in the test F ⊤ 100000000, using the encode (⊤) operator. RA and RB are 100-element vectors made from the elements of matrices A and B. Finally, M3D is a three-dimensional array used to test rotation around a non-default axis.*

*The function TIME in listing 2 was used in timing the performance of a function. Statements 20 thru 60 are performed N times, with the (exp) in each line replaced by the function being tested (for example, Q←A÷B). Statement 80 displays the total number of times the function has been performed, while statement 90 requests the number of seconds used in the test (timed by a stopwatch) and displays the time used to perform the function once. Each function is performed five times within TIME to maximize the time spent executing the function when compared to the time spent executing statement 10 and repeatedly executing line 70 N times. In addition, the TIME function was performed with increasing values of N until the unit time agreed to three significant places. The timing values in table 1 are rounded to two significant places.*

*Three short APL functions, CIRCLE, TRANS, and IVER, are used as benchmarks to grade the performance of an APL implementation in less abstract terms. (See listings 3, 4, and 5.) CIRCLE takes a numeric matrix and adds a set value to all matrix elements in an imaginary circle with a given center and radius. (This function was used to set up a "picture" matrix of geometric shapes in a pattern-recognition algorithm.) The TRANS function transforms a matrix of numbers into a matrix of symbols, with the individual symbols used to reflect the value of the corresponding numeric matrix entry. The IVER function was presented by Dr Kenneth Iverson in the article "Understanding APL" (August 1977 BYTE, page 36). When given a right argument of seven or larger, it returns a vector containing all the prime numbers up to and including that number. (For example, IVER 11 returns the vector 2 3 5 7 11.)*

---

*Notes:*

- *All of the above tests are performed on either 10 by 10 matrices or 100-element vectors; in addition, the tests were carried out to minimize the amount of time outside the operation being timed.*
- *In some cases, a version of APL could not operate on a given size matrix. An asterisk denotes an estimated entry made by adjusting the time an operation took for a smaller matrix.*
- *CIRCLE, TRANS, and IVER (shown in listings 3 thru 5) are APL defined functions used to compare the versions of APL in a working environment.*
- *All numbers here are given to 2 significant digits.*
- *In the cases where a version of APL gives the user an APL defined function (a short program written in APL) to use when the operation is not in the machine-code version of APL, the defined function is used in the above timing tests. For example, none of the above versions of APL incorporate matrix divide in their versions, but Softronics and Vanguard supply an APL defined function to do the same operation.*
- *NA means the function is not available in a given version of APL.*
- *The Ramware APL80 was run on an unmodified Radio Shack TRS-80 Model I with one disk drive and 48 K bytes of memory. The TRS-80 runs at 1 MHz; all timing figures should be halved for users running modified TRS-80s at 2 MHz.*
- *The Softronics APL was run on a Cromemco Z2D with 56 K bytes of memory, running at 4 MHz.*
- *The Vanguard APL/DTC software was run on an APL/DTC computer with 80 K bytes of memory, running at 4 MHz. Users buying the Vanguard APL/V80 software should expect slightly decreased performance varying with the amount of memory in the system.*

*Text continued from page 196:*
be devised. APL operators that normally do not appear on the keyboard have a 1-character substitution. For example, the character % replaces the APL division operator ÷, and parentheses () replace the square brackets [] used in APL to denote subscripts. Other characters are represented by a shifted keyboard letter; for example, shift-q is used for the APL character ⎕ (a *quad*), and shift-i is used for the APL *iota* operator ι. On the TRS-80 video screen, these characters are displayed as their uppercase alphabetic equivalents (because an unmodified TRS-80 has no lowercase letters) with a little graphic dot just below and to the left of the uppercase letter. This, plus one space on the left of the single letter substitution, makes this system more readable. (See photo 1 for the APL80 equivalent of the CIRCLE function of listing 3a).

Many other Level II-related features make Ramware APL80 a usable product and certainly the best buy dollar-for-dollar. Several other features that must be mentioned are sequential and random access of APL disk files and access to the real-time clock; other features are listed in table 3.

### Vanguard APL/DTC Computer and Software

Two of the "At a Glance" boxes describe the last ver-

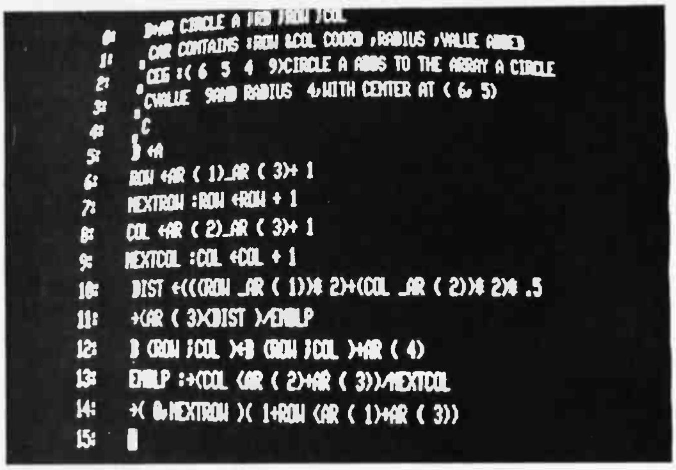


Photo 1: *The APL function CIRCLE as presented by Ramware APL80. In this version of APL for the TRS-80 Model I, nonstandard APL characters are replaced by either a 1-character substitution or by a single letter marked by a graphics dot below and to the left of the letter.*

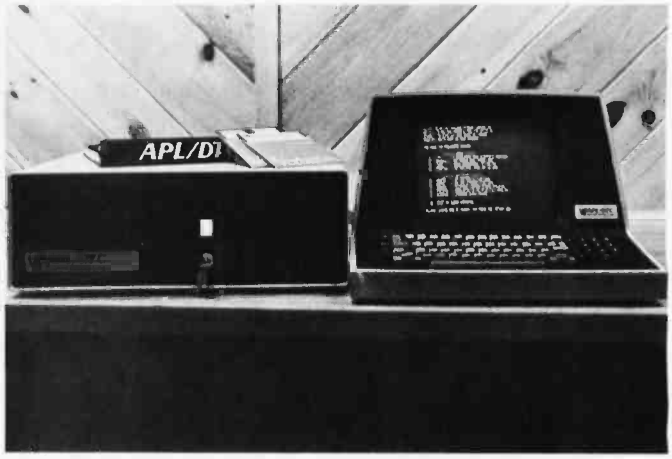


Photo 2: *The Vanguard Systems Corporation APL/DTC. The system includes: the APL/DTC (desk-top) computer, on the left; its associated APL terminal, on the right; and, on top of the computer, documentation and two floppy disks of software—customized CP/M and Vanguard APL.*

sion of APL, which was reviewed as a computer/software combination called APL/DTC. The computer and software have been optimized for each other, creating a version of APL that is slightly more powerful than its stand-alone software counterpart, APL/V80.

The APL/DTC system, which carries a label of the same name (see photo 2), is actually a Vector Graphics microcomputer with modifications made at Vanguard Systems Corp. (One modification results in the computer holding 80 K bytes of memory.) Its associated terminal, which displays all APL characters (as shown in photo 3) has an APL keyboard and is a Vector Graphics "Mindless Terminal" (a keyboard and video display that connects to a memory-mapped video board inside the computer proper). Its associated video board has a PROM (programmable read-only memory device) that generates the APL character set. The APL/DTC computer runs CP/M as customized by Lifeboat Associates and Vanguard. The

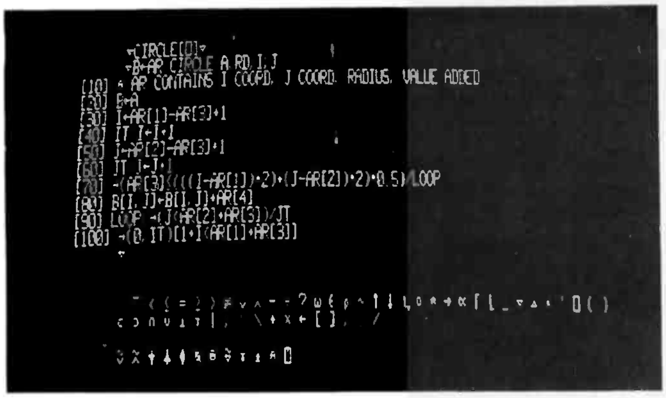

**Photo 3:** *Listing of the APL function CIRCLE on the APL/DTC terminal screen and, below, a listing of special APL characters as they appear on the APL/DTC terminal. The last row is composed of characters that are created using an overstrike.*

price tag of $7995 is rather steep for an APL machine, but a large body of CP/M software, including other computer languages, is available for the machine, somewhat mitigating the expense.

The language itself, called APL/V80 and available for $500 in a variety of formats, is the undisputed winner in every category except cost and documentation. The fact that it is more expensive is reasonable; after all, it does offer a faster APL that implements more operators. However, its weakness in the documentation, though slight, is disturbing.



Because its documentation is not of the same caliber as the rest of the package, the software must stand on its own merits. (Fortunately, it does.) The documentation is terse, sometimes cryptic. Much of the language is defined in charts that give only the name of the operation being performed. Only one or two examples are given for each operator, far too few to be able to generalize. Comparing the Vanguard documentation to the Softronics documentation (which takes up to a half page to describe an operator and includes examples), I can summarize by saying that the Softronics documentation is much more "friendly" and much more useful as both a tutorial and a reference.

On the positive side, APL/V80 includes information on customizing the software and on building and using *auxiliary processors* (software) that allow the language to interface to custom external devices through Z80 I/O ports. In addition, Vanguard provides a set of APL defined functions (in both printed and disk file form) that implements almost all of the functions not in its APL. Data files can be accessed either sequentially or randomly through a mechanism called *shared variables*; this method is used by the IBM 5100 computer and other computers to provide an APL-like mechanism for interacting with disk files.

Vanguard has solved the problem of using its APL/V80 on an unmodified ASCII computer. According to Dr John Howland of Vanguard Systems Corporation, a defined function is included in the APL/V80 package that, when executed, allows the user to edit and list APL functions using mnemonic substitutes of any length for the APL characters that are not on a regular ASCII keyboard. Although I have not seen this system at work, it sounds like a viable solution.

Several notes are in order in relation to tables 1 and 4. The information in these tables is based on the APL software supplied with the APL/DTC computer, not the APL/V80 software. Again, according to Dr Howland, the APL/V80 software should run at the same speed as the software running on the APL/DTC computer (assuming that the Z80 board of the host computer runs at 4 MHz, the system clock frequency of the APL/DTC). This means that the timing figures of table 1 are valid for the APL/V80. In addition, the software features in table 4, listed as available on the APL/DTC, are also in the APL/V80 software, with the exception of the inner product function (available as a defined function in APL/V80). The APL/DTC allows an APL workspace of 34 K bytes, while the APL/V80 software allows a workspace of about 27 K bytes when running on a 64 K-byte CP/M system. The additional memory space used by the APL/DTC software is devoted to the implementation of hardware-related features (such as access to the real-time clock and a machine-related security function).

## Conclusions

Versions of APL *are* available to fit every budget. The Ramware APL80 is a usable version of APL for the TRS-80, and it is quite a bargain at $39.95. Softronics APL, although it does have some serious limitations, is in a medium price range at $350. Vanguard APL/V80, at $500, is the fullest and fastest APL. Your needs and the amount of money you can spend will determine which version is best for you. ■

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# BYTELINES

## News and Speculation About Personal Computing

### Conducted by Sol Libes

**Sony Enters Word-Processing Arena:** The Sony Corporation is a real innovator. First, it decided to enter the word-processing market. Then it introduced a new concept in word processing that's surely a winner. Called the Typecorder, it consists of a small keyboard/ microcassette unit [*about the size of two issues of BYTE. ...***GW**] that has a microcomputer and 1-line LCD display; it costs $1400. Small enough to fit into your briefcase, it permits you to create text, edit it, and store it on tape. The tape can be run off on a companion printer, available for $800, or through a word-processor system due later this year. You can transmit the text over telephone lines via an optional acoustic-coupler modem, or you can process the text through a non-Sony system. Typecorder lets you mix audio and digital information on cassette, so you might devise some interesting computer-assisted software.

I have no doubt that Sony's concept, features, and low price will be popular and will lead to applications beyond word processing.

**A Close Look At The IBM Displaywriter:** IBM is now delivering its new low-cost Displaywriter word-processing system; it's only $1000 more than the Radio Shack TRS-80 Model II, and it's really a general-purpose microcomputer that uses the Intel 8088 microprocessor.

IBM rents word-processing software for $50 per month, which sounds rather steep; however, consider the TRS-80 owner who uses WordStar. WordStar costs $500, plus another $150 for the CP/M operating system. Further, MicroPro International issues WordStar updates about four times a year at $25 to $40 apiece. Hence, WordStar can cost a user about $850 for the first year of operation.

My point is that the price difference between a word-processing system using an IBM (or Wang, Lanier, etc) and a Radio Shack system is really not that great. Add to this IBM's terrific service and its promises of extended I/O, communications, and applications packages for the Displaywriter, and you'll see that IBM is competing aggressively in the microcomputer marketplace.

**Word-Processing Prices Dropping:** Word-processing-system prices are dropping. Following on the heels of IBM's new low-cost word-processing system, Wang Laboratories has introduced a new stand-alone system for $7500, with discounts offered on multiple units. Lanier Business Systems is expected to introduce an inexpensive system. A B Dick is planning a $7500 system that includes software (the others do not), and is drawing up plans for a local-network system that shares a printer, which will further reduce costs.

**Computer Hobbyists Gather For Huge Flea Market:** On Saturday and Sunday, April 25th and 26th, several thousand computer hobbyists will flock to Trenton State College, Trenton, New Jersey, for the Trenton Computer Festival, the world's largest personal-computer-equipment flea market. This annual outdoor event is now in its sixth year. A multitude of swap and seller tables covering more than 5 acres of real estate feature everything from complete computer systems to tiny electronic parts. There will be speakers, user-group meetings, an indoor exhibition area, and a banquet on Saturday night.

The Festival is sponsored by the Amateur Computer Group of New Jersey, the Philadelphia Area Computer Society, and the Trenton State Computer Society. The funds raised help support these nonprofit organizations and their activities. For information, call (609) 771-2487, or write to TCF-81, Trenton State College, Trenton NJ 08625.

**Credit Cards With Intelligence?** The Battelle Memorial Institute is studying the feasibility of a credit card with a built-in microprocessor. Such a card has already been developed in Europe and will soon be tested. It is expected that intelligent credit cards will provide added security without requiring large computer networks.

**Home-Information Market Takes Shape:** Several tests are underway to determine the best way to capture the lucrative home-information market. In the meantime, there's a battle brewing for control of the market, and the major contestants are the telephone companies, principally AT&T (American Telephone and Telegraph) and the cable-television companies.

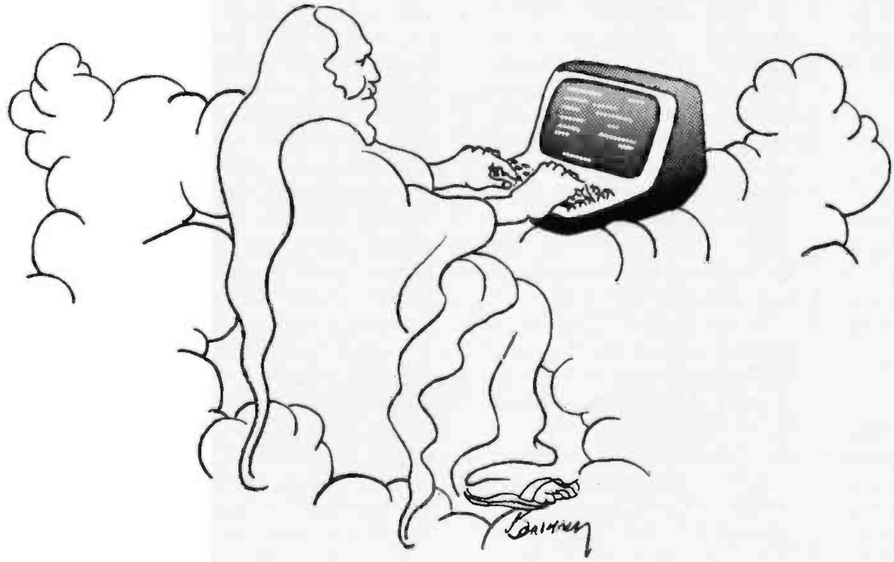
By 1983, AT&T is expected to launch its home-information systems. A user will probably have to buy a special video-display terminal, about $250, plus pay a monthly service fee in the $4 to $8 range.

The cable-television companies plan to provide the same two-way services. Companies such as Westinghouse, General Electric, and American Express are snatching up cable-television outfits. Several cable-television home-information systems are already in operation. However, the real battle is at least two years away when AT&T actually enters the market.

**The Terminal You May Have Been Waiting For:** Hewlett-Packard has introduced a super-intelligent terminal, called the Model 2626A. It displays 119 lines with 160 characters per line; moreover, the display can be divided into four windows. There are two independent I/O ports, so that you can simultaneously communicate through separate windows with two different computers. There are user-programmable keys, and the bell has fifteen pitches, sixteen intensities, and two volumes—which means that you can play decent-sounding music on it.

**Microsoft And DEC Join Forces:** Microsoft's first software product was a 4 K-byte BASIC interpreter, which used keywords similar to DEC's (Digital Equipment Corporation's) BASIC-Plus. It launched Microsoft on the road to success with expanded BASICs and other language packages. DEC has now adopted Microsoft BASIC for its GIGI (general imaging generator and interpreter) color-graphics system. Microsoft's BASIC is contained in ROM (read-only memory) in a microprocessor-based unit. GIGI is used with the PDP-11 and VAX-11 systems.

# Whether the job is building a home or a world MILESTONE[T.M.] helps...



With today's concerns about increasing costs and declining productivity it is true more than ever that any project worth doing deserves careful planning. Whether your're planning a construction project or the opening of a new retail store, you must carefully schedulue your manpower, dollars and time in order to maximize productivity.

**MILESTONE** is a critical-path-network-analysis program. It runs on a desktop microcomputer, is inexpensive and simple enough for anyone to use.

**MILESTONE's** design is a product of many years of experience in the "real world" of small-project management. In such an enivornment the primary purpose of planning is to help the project leader clarify the task at hand and to help him communicate his ideas to his subordinates and superiors. For these two reasons the designers of **MILESTONE** stressed it's ***interactivity*** and comprehensive reporting.

Most of the design effort was put into eliminating unnecessary or redundant operator input and to checking all entries for validity. By organizing the project data for you, you can interactively modify your project plan leaving **MILESTONE** to perform the tedious calculations and to display the results.

Internally, **MILESTONE** treats your project as a series of activities. Each activity has a name, duration, capitol cost, mix of manpower, and an associated list of other activities that must be completed first. The list of associated activities (or prerequisites) provides a thread that **MILESTONE** uses to link all the jobs together into an overall project schedule. Every time you add a new activity or make a change to an existing one, the entire schedule is recomputed and the results are immediately redisplayed on the screen.

For **MILESTONE** a project is simply any task made up of steps that must be performed in sequence. After dividing a project into it's composite steps, **MILESTONE** can help you plan, schedule and control the project.

Specifically here are some of the things you can do,

- Find out which activities are time critical and can't be delayed
- Discover which activities have slack time and can be delayed without delaying the entire project
- Prepare a detailed cost estimate based upon a summation of each activity's individual equipment and manpower expenses
- Change an activity and instantly see the impact on the overall project schedule
- Investigate tradeoffs between manpower, dollars, and time
- Keep track of your project's progress by periodically updating the schedule to reflect changes in the plan and completed activities

**MILESTONE** requires 54K RAM and CP/M, Apple Pascal, or UCSD Pascal. CP/M versions need no support language. All Apple II versions require 24 x 80 video card. Formats: 8" single denisty IBM soft-sectored, NorthStar DD, Micropolis Mod II, Superbrain 3.0, Apple II. Price is $295. Manual alone - $30. Add $7.00 for shipping.

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**Diagnostic Disk Troubleshoots Your Disk Drive:** Dysan Corporation *will introduce* a floppy disk that checks disk-drive operation. It contains software and geometric patterns that test radial positioning, linearity, hysteresis, eccentricity, index timing, skew, relative head positioning, azimuth, drive rpm (revolutions per minute), head load, access time, and head/media compliance. The first model to be introduced will be a $40 IBM 3740-compatible 8-inch disk.

**Word-Processor Dictionary Introduced:** IBM's new Displaywriter word-processor system features an optional dictionary-software package that checks the spelling of up to 70,000 words. Similar packages will soon be available for other systems. The first is Microspell, to be distributed by Lifeboat Associates. It checks the spelling of any ASCII-text file stored on disk under CP/M. Thus, the program can be used with files created by WordStar, WordMaster, Magic Wand, and other word-processing packages.

**IBM Status Report:** Many critics want you to believe that IBM's dominance in the data-processing market is eroding rapidly. Don't believe it, because more than a third of the $60 billion 1980 computer market was IBM's. In all industry, IBM's $23 billion in sales ranked eighth, and its $3 billion in total profits was third. By contrast, the second largest computer maker, Burroughs, had $2.83 billion sales and $305.5 million in profits.

IBM is not always the technological leader. Rather, it has used marketing clout to establish dominance in any market it enters. For example, IBM sells 70% of the large mainframe computers in the USA.

However, during the last few years, DEC (Digital Equipment Corporation), Data General, Wang Laboratories, and Amdahl have grabbed an increasing share of the computer market. Several Japanese companies, such as Fujitsu, Hitachi, and NEC (Nippon Electric Company), are also moving in on IBM's territory. On the horizon, IBM faces strong competition from AT&T, Xerox, and Exxon, as they move into local and interoffice data-communication network markets.

These factors have had a serious impact on the value of IBM's stock. In the 1960 s, it sold for as much as 66 times earnings; it now sells for 15 to 20 times earnings.

IBM's strategy for the 1980s is based on a coming generation of mainframes that will set new levels in price versus performance and emphasize telecommunication networks. In addition, IBM has opened retail stores and is entering several new markets via joint ventures, such as a videodisk project and satellite communications. However, it is likely that these projects will be a minor part in the whole IBM strategy for the 80s. Although IBM will become more involved in data networking, its focus will continue to be large central data-processing operations.

**New 8-Inch Winchester Has 136 Megabytes:** Ontrax Corporation has unveiled the largest capacity 8-inch Winchester-type disk drive to date. It stores 136 megabytes on five platters using sixteen read/write heads. With a controller, the drive sells for $5000 in quantity. That's 0.004 cents per byte, compared to about 0.2 cents per byte for a typical single-density floppy-disk drive.

**Random News Bits:** Computerland, High Technology, and The Computer Store plan to stock at least one Japanese-made personal computer. Japanese suppliers currently being considered are NEC, Casio, Canon, Sharp, and Panasonic. ...Tandy Corporation and the Professional Farmers of America (PFA) have introduced Instant Update, a data-base service that uses TRS-80 videotext terminals (actually TRS-80 Model II). Via telephone connections, the service provides information affecting commodity prices and crop yields and gives access to *Washington Watch News.* Commodity prices are updated every 10 minutes. The service costs $95 per month. ...Sony has introduced a 3½-inch microfloppy-disk drive. (**Editor's note:** *See this month's editorial.*) It is currently being marketed to OEMs and systems houses; its capacity is reputed to be over 800 K bytes (unformatted) per disk. ...Two teenagers have been charged with masterminding a scheme that shut down DePaul University's computer during enrollment week. The shutdown cost DePaul $22,252 in computer time, repairs, and manpower. The teenagers said they did it to disprove the school's claim that it couldn't be done. ...Intel Corporation announced its figures on net income and revenues for the year that ended December 31, 1980. Net income was $96.7 million, up 24% from the previous year, and revenues were $855 million, up 29% from 1979. Most of the growth occurred in the first half of the year....

**Random Rumors:** Informed sources say that Tandy will lower the price of its Videotext terminal to compete with AT&T's projected home-information terminal. ...Apple Computer is developing a new microcomputer using the 16-bit Motorola 68000 microprocessor. ...At least one software-development house has leaked that it is seriously negotiating with Apple on a disk operating system for a machine called the Apple IV. ...Look for a lower-priced version of Hewlett-Packard's HP-85 desk-top computer—maybe less than $2000—to be called the HP-83. It lacks some of the HP-85's features, but it has a plug-in disk-drive option. ...Exxon's Kylex division is developing a 40-row by 80-character LCD (liquid-crystal display) for computer-display terminals. ...Sony might be developing a personal-computer system for this year's market. Sony may include an interface for its new Typecorder word-processor terminal. ...Digital Equipment Corporation is developing a new line of personal-computer products with extensive software support, including an operating system based on RT-11 with VAX-compatible BASIC....

**COBOL For The 8086 Announced:** The software picture for 8086-based 16-bit microcomputer systems keeps improving. Seattle Computer Products has announced an 8086 version of Microsoft BASIC. Now Microsoft has COBOL-86, which runs under the CP/M-86 operating system.

The projected execution time of these packages is three times as fast as the 8080/Z80 versions. As a result of the 8086's multitasking capabilities, the packages will be better suited for multiple-user systems than the 8-bit versions.

**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.

Sol Libes
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Mountainside NJ 07092

# SuperSoft's Gallery of CP/M Masterworks

**SUPER-M-LIST:** A complete, easy to use mailing list program package. Allows for two names, two addresses, city, state, zip and a three digit code field for added flexibility. Super-M-List can sort on any field and produce mailing labels direct to printer or disk file for later printing or use by other programs. Super-M-List is the perfect companion to TFS. Handles 1981 Zip Codes!
Requires: 48K CP/M
Supplied with complete user manual: $75.00 manual alone: $10.00

**TFS-Text Formatting System:** An extremely powerful formatter. More than 50 commands. Supports all major features including:
- left & right margin justification
- user defined macros
- dynamic insertion from disk file
- underlining and backspace

TFS lets you make multiple copies of any text. For example: Personalized form letters complete with name, address & other insertions from a disk file. Text is not limited to the size of RAM making TFS perfect for reports or any big job. Text is entered using CP/M standard editor or most any CP/M compatible editor.
Requires: 24K CP/M
Supplied with extensive user manual: $85.00 manual alone: $20.00
Source to TFS in 8080 assembler (can be assembled using standard CP/M assembler) plus user manual: $250.00.

**TEXT PROCESSING**

**DIAGNOSTICS I:** Easily the most comprehensive set of CP/M compatible system check-out programs ever assembled.
Tests:
- Memory
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To our knowledge the CPU test is the first of its kind anywhere. Diagnostics I can help you find problems before they become serious. A good set of diagnostic routines are a must in any program library. Minimal requirements: 32K CP/M. Supplied with complete user manual: $75.00 Manual alone: $15.00

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- A complete Spinwriter/Diablo/Qume test has been added (Serial Interface only)
- Output may be logged to disk
- Expanded memory test
- Expanded terminal test
- Expanded disk test

Diagnostics II provides the next level in system maintenance.
Requires: 32K CP/M
Price: $100.00 Manual only: $15.00

**SYSTEM MAINTENANCE**

**UTILITIES I:** A collection of programs that you will find useful and maybe even necessary in your daily work (we did!).
Includes:
- GREP: Searches files for a specified string
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- PG: Lists files to CRT a page at a time

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Requires: 24K CP/M
Supplied with manual on discette: $60.00

**UTILITIES II:** Many new programs not available elsewhere. Includes these "file" utilities:
- DIFF: Source comparitor
- PR: Powerful multicolumn output formatter
- CAT: Concatenate files
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# An Introduction to Data Compression

Harold Corbin
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Even though the cost of data storage continues to decrease fairly rapidly, there are still a number of situations where it is desirable to squeeze more data into a physical storage device. Often the typical microcomputer has limited memory, small disks, or slow cassettes. With any of these storage limitations, data compression may offer a method of using the existing device to store larger quantities of data or to provide improved access time to the data. The use of data compression can also provide significant improvement in the transmission of data over communication networks since there are fewer bits to send in order to convey the information.

**ASCII code does not consider that the frequency of the characters in the file is not uniform.**

The basic idea in data compression is to use more efficient codes to represent the information in a file or to remove redundant and unnecessary information from the file. With data compression in effect, the system stores or sends only the minimum data necessary to convey the original information.

In a typical file, the individual characters are represented by fixed-length codes such as ASCII (American Standard Code for Information Interchange). This representation does not consider that the frequency of occurrence of the characters in the file is not uniform. In typical English text, E is the most common letter and Z is the least frequently used letter. Table 1 presents a frequency analysis for letters in English text. Using a code such as ASCII for storing or transmitting text means that the same number of bits is used for the most frequently occurring letter as well as for the least frequently occurring letter. This method of encoding data uses more bits to represent the information in the file than is necessary. In this article, I will illustrate ways to store data more efficiently.

Encoding the data in a more efficient form is called *data compression*. There are a variety of methods that have been used to compress data, but all of them attempt to reduce the redundancy of the original data. Most large data-processing systems provide some form of file compression, since storage costs money. Also, it is often less expensive to pay for the computer time to compress and expand the data than to pay for mass storage. The user of a large system usually has PACK and UNPACK commands available to allow compression and expansion of his files.

Typical data-processing systems use some form of zero or space suppression to do their data compression. This method is easy to implement and not very expensive to run, and produces fairly good compression for many types of data. The efficiency of this compression method is dependent upon how many spaces or zeros occur in the file. Typically, a source file of assembly-language statements is a good candidate for data compression. Fifteen to twenty percent compression of an assembly-language source file is not uncommon.

## Data-Compression Methods

A space-compression capability can be implemented in several ways. Two common ones are *bit mapping* and *recurrence coding*. In the bit-mapping scheme, a bit map exists that is long enough to match one bit of the bit map to each byte of data in the original file. In the map, a 0 is stored for each byte in the data that is a space, and a 1 is

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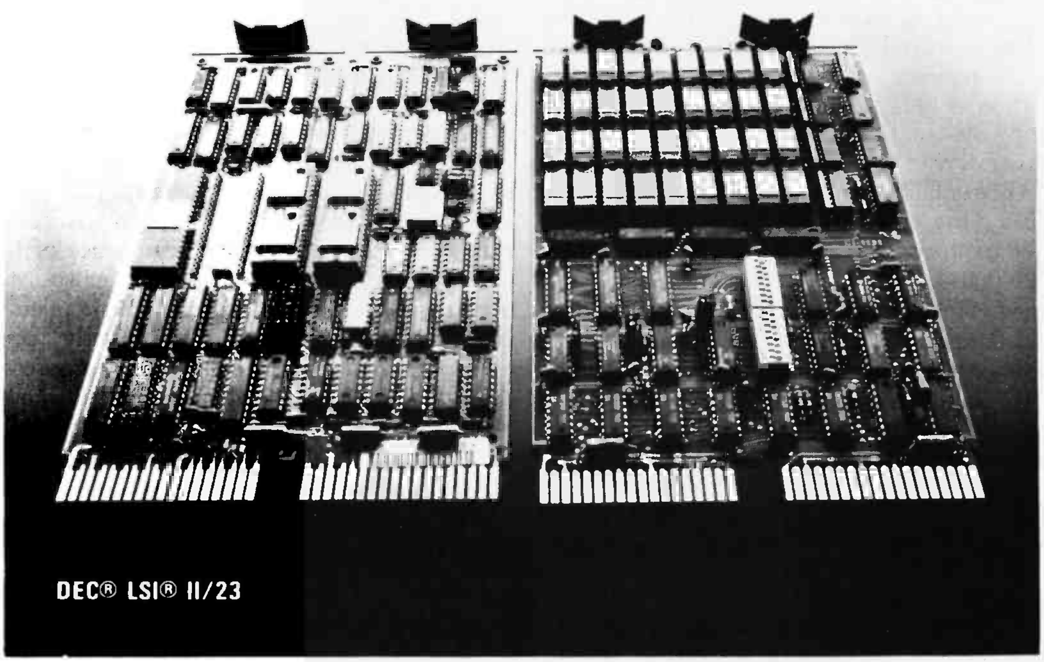


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stored in the map for each corresponding byte in the data that is not a space. This way, the data can be stored with all spaces removed and still be easily reconstructed by first examining the bit map to determine where the expanded file needs to have a space or spaces inserted as the next data byte.

Recurrence coding takes a string of more than two repetitive characters and replaces the string with a special character. It is then followed by the count of how many occurrences of the repeated character are being compressed. A variation of this method is used in the IBM VM/370 Operating System with the PACK option of the COPYFILE command.

If the string "AB*bbbb*CD" (where *b* is a space) were to be compressed using the bit-mapping technique, 5 bytes would be required to store the data and the bit map. The map would be 11000011 (1 byte) and the data would be "ABCD" (4 bytes). Since only 5 bytes are required to store the original data in compressed form instead of 8 bytes, the data is compressed to 62.5% of its original length. Storing the same string using recurrence coding would result in a compressed string of "AB*4CD", where "*4" replaces the four spaces. In this case, the data is compressed to 75% of its original length. You can see that the efficiency of a given method is dependent upon both the method itself and the characteristics of the data's redundancy.

Another method of compression is known as *pattern substitution*. In this method, each occurrence of a specific pattern is replaced by a unique code. For example, in the above text, the pattern "compression is" could be replaced by a single 8-bit byte — say, 11111001. This would compress each occurrence of the 14 ASCII bytes in the pattern to a single byte. Obviously, if there were more than 256 patterns, the code pattern would have to be bigger than 8 bits to maintain uniqueness.

Variations of this method could mix the ASCII code and the pattern code. One scheme would place a unique code — for example, the ASCII ESC (escape) character — ahead of the pattern code. When the PACK routine encounters the ESC character, the next byte is replaced with its equivalent pattern.

Another scheme that would permit ASCII and pattern codes to be mixed would tag the pattern codes by setting the high-order bit to 1. This would restrict the ASCII to 128 codes and the patterns to 128 codes.

The efficiency of the pattern-substitution compression methods can be very useful if the pattern is long and its number of recurrences is high. Some compression systems based upon this method have sophisticated programs that search the data for patterns and assign codes to the patterns in an optimal manner.

Some compression methods are data-value dependent. One of these methods is *difference compression*. For example, if succeeding records had a field with the following values:

1,732,517
1,732,217
1,732,200
1,732,190

either the difference between succeeding fields or the difference from a base value could be stored as the compressed data. In the first case, the values

1,732,517
300
17
10

would be stored. Obviously, if the field is of fixed length, nothing is gained by compression. However, if a variable field-length capability exists in the system, some space savings can be achieved with this compression method. Again, the amount of compression is highly dependent upon the data and its characteristics.

Another compression method makes use of the statistical properties of the occurrence of the data to be compressed. In this method, shorter codes are used for the more frequently occurring data elements. Longer codes are used for less frequently occurring data elements. One code used in data compression that optimizes the encoding values is the Huffman code. There

| Letter | Frequency (%) |
|---|---|
| E | 13.0 |
| T | 10.5 |
| A | 8.1 |
| O | 7.9 |
| N | 7.1 |
| R | 6.8 |
| I | 6.3 |
| S | 6.1 |
| H | 5.2 |
| D | 3.8 |
| L | 3.4 |
| F | 2.9 |
| C | 2.7 |
| M | 2.5 |
| U | 2.4 |
| G | 2.0 |
| Y | 1.9 |
| P | 1.9 |
| W | 1.5 |
| B | 1.4 |
| V | 0.9 |
| K | 0.4 |
| X | 0.15 |
| J | 0.13 |
| Q | 0.11 |
| Z | 0.07 |

**Table 1:** *Relative frequency of the alphabet in the English language. In most character codes (including the common 7-bit ASCII), every letter is represented by the same number of bits. But one method of data compression assigns shorter codes to the frequently used letters (ie: E, T, and A) and longer codes to seldom used letters (ie: Q and Z). A message stored in this kind of code should be significantly shorter in bits than the same message stored in ASCII.*

| Letter | Huffman Code |
|---|---|
| E | 100 |
| T | 001 |
| A | 1111 |
| O | 1110 |
| N | 1100 |
| R | 1011 |
| I | 1010 |
| S | 0110 |
| H | 0101 |
| D | 11011 |
| L | 01111 |
| F | 01001 |
| C | 01000 |
| M | 00011 |
| U | 00010 |
| G | 00001 |
| Y | 00000 |
| P | 110101 |
| W | 011101 |
| B | 011100 |
| V | 1101001 |
| K | 110100011 |
| X | 110100001 |
| J | 110100000 |
| Q | 1101000101 |
| Z | 1101000100 |

**Table 2:** *A Huffman code. There are many Huffman codes; this is the one that is used in figure 2 and listings 1 thru 4. Note that the shorter codes are used for frequently occurring letters, and that no code is a beginning substring of a longer code.*

*The average number of digits used to represent a letter can be reduced toward the entropy limit H if the Huffman technique is used to encode blocks of letters rather than individual ones.*

are actually many Huffman codes, but they are similar in structure.

Before explaining how to construct a Huffman code, I will describe a typical Huffman code and how it works. The code that is used in the two compression programs in this article is given in table 2.

To compress the word "compression", the appropriate binary code is assigned to each letter, which produces the binary string:

01000111000011110101101110001100110101011101100

C O M P R E S S I O N

A quick count shows that 47 bits were required to encode the word "compression" with Huffman coding as compared to the 88 bits required with ASCII code. This gives a compressed text that is 53.4% of its original length. This level of compression is not too surprising since it is well known that the English language is highly redundant.

Of course the above example is a very short one. A larger piece of data should be used to find a more exact value of the amount of compression that can be expected from using Huffman coding. The actual efficiency can also be determined mathematically, but an explanation of that method is beyond the scope of this article. Using the program code described above with English text, approximately 4.18 bits would be required for each letter. Compared to 8-bit ASCII code, the compressed text is compressed to 52.2% of its original length.

Earlier in this article I mentioned that Huffman codes are optimized based upon the probability of the occurrence (ie: frequency) of the data element being encoded. In the program-code table (table 2), the more frequently occurring letters have the shorter codes, (eg: an E is coded with 3 bits). The number of bits, $b$, needed to encode a letter can be determined by the following formula:

$$b = f(-\log_2 p)$$

where $p$ is the probability of occurrence of the letter, and $f(x)$ is the closest integer greater than or equal to $x$.

From table 1, the probability of occurrence of an E in English text is 0.13; since $-\log_2 0.13 = 2.94$, the integer length is 3. If you were to continue to compute the code lengths from the probabilities in table 1, the lengths would differ from the code lengths used in the programs. This is because the program code lengths were determined from text that differs slightly in frequency from the text used to prepare table 1.

There are several ways the actual codes can be constructed. One method is shown in figure 1. To use the algorithm in figure 1, the letters must be arranged by

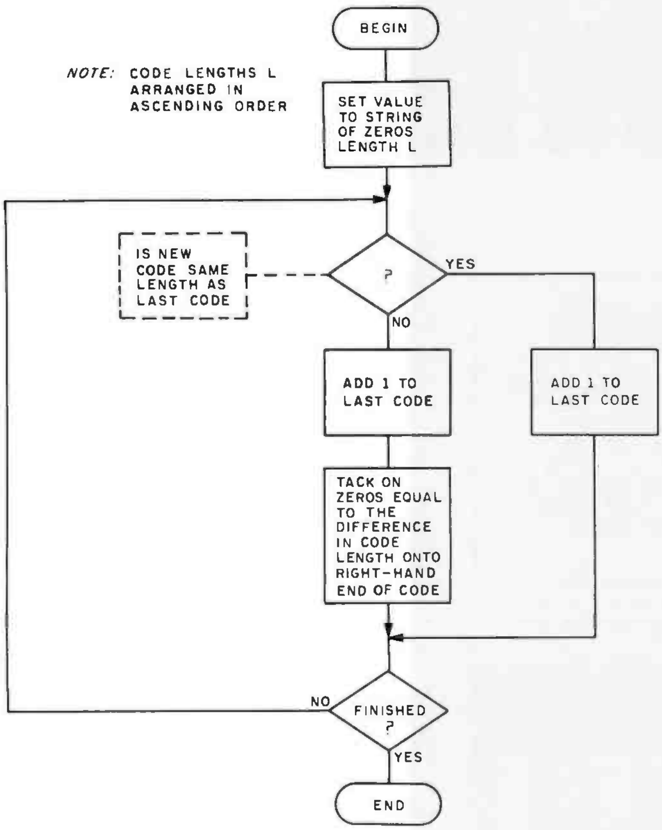


**Figure 1:** *Flowchart for assignment of Huffman codes. This algorithm will produce a series of codes (Huffman codes) with the following two characteristics: the length of the code (in bits) is inversely proportional to the relative frequency of the symbol being encoded; and no code is a beginning substring of the Huffman code of another symbol. Together, these properties define a code with a unique decoding that uses the smallest number of bits to encode an average message.*

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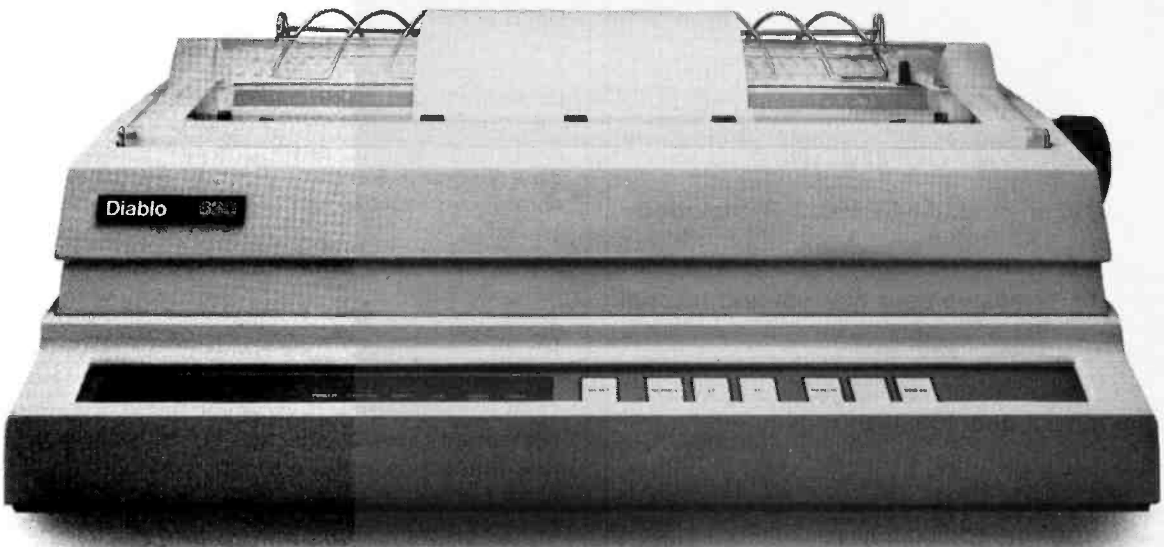


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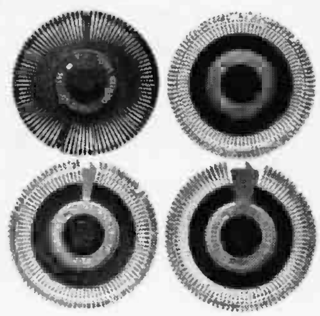

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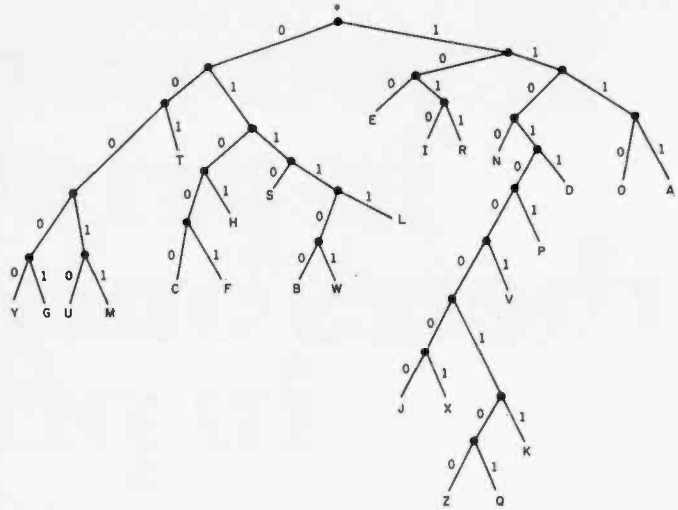

**Figure 2:** *Binary tree for a Huffman code. The Huffman code for a letter is defined as the sequence of binary digits encountered when tracing the path from the root node, *, to the letter. Thus, the code for G is 00001, and the code for E is 100. This is the code used in the programs of listings 1 thru 4. Although this code cannot be produced by the algorithm of figure 1, it is a valid Huffman code (there are many) that can be validly used to illustrate the structure and implementation of Huffman codes in general.*

ascending code length. Then the letter with the shortest length is assigned a code consisting of all 0s. Execution of the algorithm will result in the assignment of a unique code to each letter.

With any set of codes that are constructed, it is important that no code has a shorter code as part of its beginning. For example, if E is 100, then 10010 cannot be the code for another letter. This is because in scanning the bit stream from left to right, the decoding algorithm would think that 10010 is E (100) followed by 10 and not the different letter that was intended.

Regardless of the method used to construct the codes, the full set of binary Huffman codes can be represented as a binary tree. Figure 2 shows the binary tree that is equivalent to the Huffman code used in the programs of listings 1 thru 4. (These codes were not produced by the algorithm of figure 1.) This code structure allows the code to be uniquely decoded by simply starting at the top of the tree and walking down the tree, taking each branch that corresponds to the bit value, 1 or 0, as the coded data stream is scanned from left to right. This is the way the expansion program recreates the original data.

It is possible to combine various compression methods to increase the storage efficiency even more than when working with single letters. For example, Huffman codes could be assigned to patterns. Instead of working with the frequency of letters, you would use the frequency of the patterns. Thus, the pattern "code" might be represented by 010 and the pattern "data compression" might be represented by 10110. Obviously, a lot of compression could be achieved, particularly if single-letter and pattern methods are combined and certain patterns have a high frequency of occurrence.

## Sample Programs

Two versions of both the compression and the expan-

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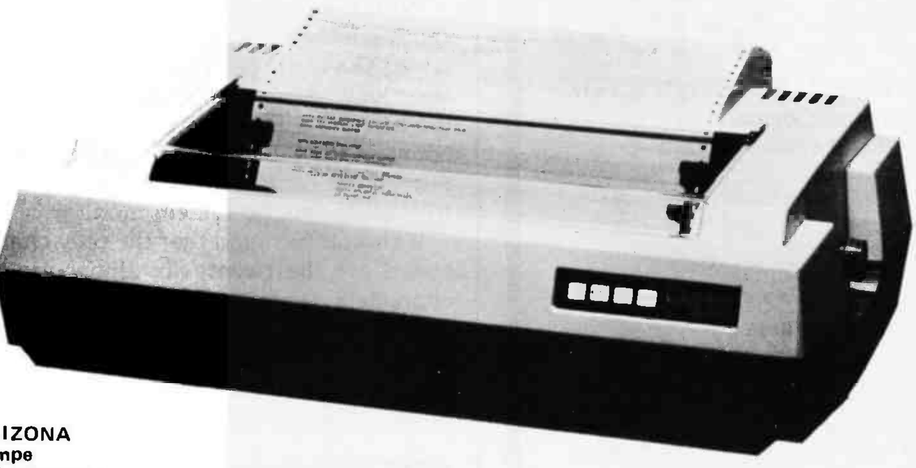

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sion programs have been prepared to demonstrate two different uses of data compression. The compression program, COMP1, demonstrates the basic concept. (See listing 1.) Characters are entered from the keyboard and the output of the program is a serial bit stream that could be sent to a cassette for storage of the compressed data. Such a scheme could result in reduced writing time and faster access to the data. The tradeoff involved is the usual one in many data-processing situations; namely, storage space saved versus computer time used to encode and decode the data.

**The amount of compression is highly dependent upon the data and its characteristics.**

Since COMP1 is for demonstration purposes only, the program is simplified somewhat by storing the serial data 1 bit per byte of memory. This is just a convenience that simplifies the expansion program, EXP1. (See listing 2.) If the data were actually being sent to a serial output port, only minor changes in the code would be required.

The second compression program, COMP2, uses the same basic compression method as COMP1. (See listing 3.) However, the resulting serial bit stream is broken into 8-bit bytes for use by a parallel storage medium such as programmable memory. This provides maximum compression in a fixed-word-length computer. The program EXP2 expands the compressed text created by COMP2. (See listing 4.) The description of the compression and expansion programs emphasizes the table structure, since both programs use tables to facilitate changing codes.



## COMP1 Description

This program takes characters entered via the keyboard, checks for a legal character, finds the Huffman code corresponding to the entered character, and stores the bit stream sequentially in memory. Each bit is stored in the lowest-order bit of a byte for demonstration convenience and for interfacing with EXP1. The first two words of the output buffer contain a count of the number of bits that are stored in the remainder of the buffer. This information is used by EXP1 to stop the decoding process on the bit stream. The input need not come from the keyboard and could be from another buffer, simply by changing a few lines of code related to the input function.

The heart of the program's operation is the table lookup and the shifting function. Based upon a letter's ASCII code, an index is computed that is then added to the base address of the encoding table. This table has the following format: two 8-bit words are required for each letter to be encoded; the low-order 4 bits of the first word in memory contain a count of the number of bits required to encode the letter. The remaining 12 bits, 8 in the second byte followed by 4 in the top half of the first byte, are used to store the compressed code. (Note that the word order in the source statement and in memory is reversed because of the assembler's treatment of the DW (Define Word) instruction. The code is stored left-justified in the 12-bit area. This format makes processing simple when the two words are loaded into the D and E register pair for shifting.

With the compressing code located, it is serialized by shifting left according to the count in the 4-bit part of the table. The DAD (add register pair to H and L) instruction effectively shifts the DE register pair's high-order bit into the carry register. As each bit is shifted out, the total bit count in the buffer is updated. The processing of the input stream continues until a period is detected, and control returns to the system monitor.

It should be noted that the only characters that are encoded are the twenty-six alphabetic letters. Any other characters (including blanks) are ignored. In a non-demonstration environment, spaces, punctuation, and other symbols would have to be included; this would require enlarging the lookup table to include the representation of the new symbols.

## EXP1 Description

The expansion program, EXP1, operates on the bit stream prepared by COMP1. (See listing 2.) It expects this data to be in the buffer defined by COMP1, with the bit count in the first two words and the data bit in the lowest bit of each byte. This program is also table-driven; but the table is more complex than the encoding table and the processing is more involved. Basically, the program searches a binary tree to decode the bit stream. The binary tree shown in figure 2 is converted to a table. The program then steps through the table, selecting the appropriate branch in the tree structure depending upon the value of each bit in the data stream. The data in the table

*Text continued on page 246*

**Listing 1:** *COMP1 text-compression routine. This routine takes only alphabetic text entered from the keyboard and converts it to the Huffman code given by the tree in figure 2. The Huffman code is stored 1 bit per byte. The routine is written in 8080 machine code.*

```
2500               *THIS ROUTINE TAKES TEXT, (LETTERS ONLY)
2500               *AND COMPRESSES THEM USING HUFFMAN CODING. FOR
2500               *TEST PURPOSES THERE IS ONE BIT PER BYTE IN THE
2500               *DATA BUFFER. THE FIRST TWO BYTES IN THE DATA BUFFER
2500               *ARE THE BIT COUNT. ENCODED DATA IS STORED IN DBUF AS 1 BIT
2500               *PER BYTE FOR TEST PURPOSES. NORMALLY DATA WOULD BE PACKED
2500               *OR OUTPUTTED SERIALLY.
2500               ECHO: EQU 0C500H ;OUTPUT DRIVER
2500               SP:   EQU 6
2500               MON:  EQU 0CH    ;MONITOR RETURN
2500 31 00 00            LXI SP,0
2503 21 00 00            LXI H,0
2506 22 00 41            SHLD DBUF  ;COMPRESSED BIT COUNT
2509 21 02 41            LXI H,DBUF+2
250C 22 8C 25            SHLD DADD  ;NEXT BIT LOCATION
250F DB 08         INCH: IN 8
2511 0F                  RRC
2512 DA 0F 25            JC INCH
2515 DB 0A               IN 10
2517 FE 2E               CPI '.'    ;END OF TEXT
2519 CA 0C 00            JZ MON     ;NO MORE
251C CD 00 C5            CALL ECHO
251F E6 7F               ANI 07FH   ;CLEAR PARITY
2521 D6 41               SUI 'A'    ;COMPUTE INDEX
2523 DA 0F 25            JC INCH
2526 FE 1A               CPI 'Z'-'A'+1
2528 D2 0F 25            JNC INCH
252B 87                  ADD A      ;MULTIPLY BY 2
252C 4F                  MOV C,A
252D 06 00               MVI B,0
252F 21 58 25            LXI H,TABL
2532 09                  DAD B      ;INDEX
2533 5E                  MOV E,M    ;GET ENCODE VALUE
2534 23                  INX H
2535 56                  MOV D,M
2536 7B                  MOV A,E    ;GET BIT COUNT
2537 E6 0F               ANI 0FH    ;MASK COUNT
2539 47                  MOV B,A    ;KEEP COUNT
253A EB                  XCHG
253B AF            NEXT: XRA A
253C 29                  DAD H      ;SHIFT OUT BIT STREAM
253D 17                  RAL        ;MSB FIRST
253E E6 01               ANI 1      ;SETUP OUTPUT BIT
2540 E5                  PUSH H
2541 2A 8C 25            LHLD DADD
2544 77                  MOV M,A    ;STORE BIT
2545 23                  INX H
2546 22 8C 25            SHLD DADD
2549 2A 00 41            LHLD DBUF
254C 23                  INX H      ;UPDATE BIT COUNT
254D 22 00 41            SHLD DBUF
2550 E1                  POP H
2551 05                  DCR B      ;REDUCE COUNT
2552 C2 3B 25            JNZ NEXT
2555 C3 0F 25            JMP INCH
2558               *ENCODE TABLE FORMAT- LOW ORDER 4 BITS ARE NUMBER OF BITS
2558               *IN ENCODED CHARACTER. REMAINING 12 BITS ARE FOR CODE.
2558               *CODE IS LEFT JUSTIFIED. E.G., AN M IS 00011
2558 04 F0         TABL: DW 0F004H  ;A
255A 06 70               DW 7006H   ;B
255C 05 40               DW 4005H   ;C
255E 05 D8               DW 0D805H  ;D
2560 03 80               DW 8003H   ;E
2562 05 48               DW 4805H   ;F
2564 05 08               DW 805H    ;G
2566 04 50               DW 5004H   ;H
2568 04 A0               DW 0A004H  ;I
256A 09 D0               DW 0D009H  ;J
256C 89 D1               DW 0D189H  ;K
256E 05 78               DW 7805H   ;L
```

*Listing 1 continued on page 230*

# COMPUTERS–TERMINALS–MODEMS!

## MODEMS AND COUPLERS

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

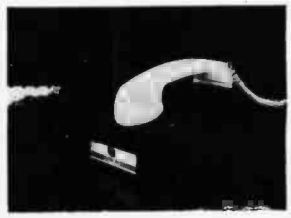
Penril

**Penril 300/1200**

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

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

USR-330D ........ $339
Bell 103/113 style. 330 baud. Manual originate, auto-answer. Half/full duplex. RS232. 1 year warranty. Direct connect to phone lines via RJ11C standard extension phone voice jack.
USR-330A ........................................ $399
Same as USR-330D but includes auto-dial capability.

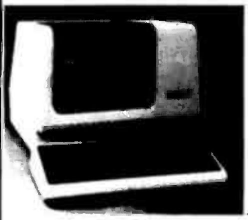


U.S. Robotics
**The Phone Link Acoustic Modem**

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

## CRT's

Digital Equipment Corporation



**DEC VT100**

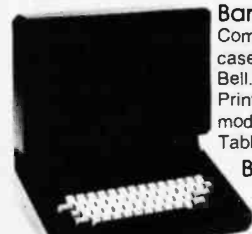
DEC VT100 ... $1668
Detachable keyboard. Separate numeric keypad with function keys. Business forms character set. Reverse video. Selectable double-size characters. Bidirectional smooth-scrolling. 80 cols or 132 cols. Split screen. Settable tabs. Line drawing graphic characters. Status line. Key-Click.

Perkin-Elmer Corporation

**Superowl 1251**

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

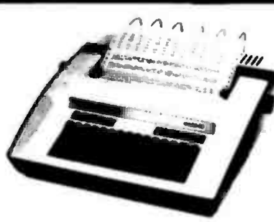
Perkin-Elmer Corporation



Bantam 550B .... $694
Compact. Silent. Upper/lower case. 80th col. wrap-around. Bell. Integrated numeric pad. Printer port. Transparent mode. Editing features. Tabbing.
Bantam 550E...$755
Same as 550B plus separate numeric keypad and cursor direction keys.
Bantam 550S ................................ $879
Same as 550E plus block mode. 8 function keys, and protected fields, reverse video fields, half intensity fields, blinking fields.

**550 Options**
20mA Current Loop Interface .......... $70
Non-Glare Screen ........................... $25
2nd page of memory (550S only).. $100

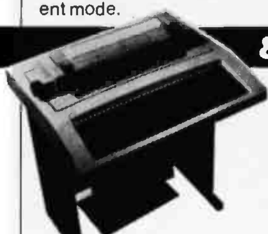
## HARDCOPY TERMINALS & PRINTERS



**Teletype Model 43**

Teletype Corporation

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

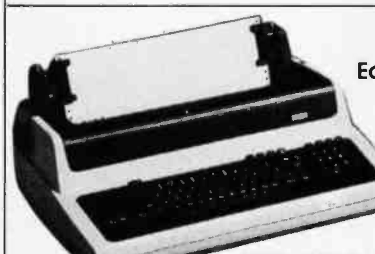


**DEC LA120**

Digital Equipment Corporation

DEC LA120 ... $2388
180 CPS. Dot matrix. Upper/lower case. 1K buffer. Designed for 1200 baud communications. 30 character answerback message. Adjustable line spacing. Adjustable character sizes including double sized characters. Settable horizontal and vertical tabs. Top-of-form capability. RS232.

Digital Equipment Corp.



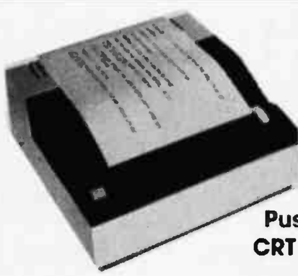
DEC LA34DA ... $939
30 CPS. Dot matrix. Upper/lower case. 4 character sizes. Up to 217 cols per line. 6 lines per inch settings. Friction feed. Settable tabs. RS232.
DEC LA34AA .............................. $1095
30 CPS. Dot matrix. Upper/lower case. 8 character sizes including double size characters. 6 lines per inch settings. Up to 217 cols per line. Friction feed. Settable horizontal and vertical tabs. Top-of-form capability.

**Options for LA34AA and LA34DA**
Tractor Feed Mechanism ............. $114
Numeric Keypad w/ Function Keys .. $69
Pedestal ......................................... $100
Paper Out Sensor ............................ $25
APL Capability with APL Keycaps .. $499
2K Buffer with Text Editor and 1200 Baud Communications Capability ...... $499

NEC Corporation
**NEC Spinwriter 5510 & 5520**

5520 KSR Spinwriter ..................... $3088
55 CPS. Impact printer. Selectric print quality. Changeable print fonts. 110, 300 and 1200 baud data rate. Numeric keypad. Friction and tractor feed.
5510 Spinwriter ............................ $2754
55 CPS. Impact printer. Selectric print quality. Changeable print fonts. 110, 300 and 1200 baud data rate. Friction and tractor feed.

Perkin-Elmer Corporation



**Pussycat 650/655 CRT Screen Printer**

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

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*Listing 1 continued:*

```
2570 05 18              DW 1805H     ;M
2572 04 C0              DW 0C004H    ;N
2574 04 E0              DW 0E004H    ;O
2576 06 D4              DW 0D406H    ;P
2578 4A D1              DW 0D14AH    ;Q
257A 04 B0              DW 0B004H    ;R
257C 04 60              DW 6004H     ;S
257E 03 20              DW 2003H     ;T
2580 05 10              DW 1005H     ;U
2582 07 D2              DW 0D207H    ;V
2584 06 74              DW 7406H     ;W
2586 89 D0              DW 0D089H    ;X
2588 05 00              DW 5H        ;Y
258A 0A D1              DW 0D10AH    ;Z
258C 00 00      DADD:   DW 0         ;NEXT BIT LOCATION
258E                    ORG 4100H
4100            DBUF:   DS 1000
```

**Listing 2:** *EXP1 text-expansion routine. This routine takes the output of COMP1, information expressed in a Huffman code, and decodes it using the binary tree of figure 2. The decoded character is displayed via a user-supplied subroutine named DISP. The routine is written in 8080 machine code.*

```
3000            *THIS PROGRAM ACCEPTS DATA PREPARED BY THE DATA COMPRESSION
3000            *(HUFFMAN CODE) PROGRAM.THE DATA BUFFER HAS THE BIT COUNT
3000            *IN THE FIRST TWO BYTES.THE PROGRAM RUNS UNTIL ALL BITS
3000            *HAVE BEEN PROCESSED.THE PROCESSING CONSISTS OF ADDING A
3000            *DATA BIT TO THE TABLE ENTRY POINT, GETTING AN INCREMENT
3000            *WHICH POINTS TO THE NEXT 0-1 PAIR AND CONTINUING UNTIL
3000            *A TAG IS FOUND IN BIT 7.THIS SIGNIFIES THAT THE NEXT
3000            *TABLE ENTRY IS THE DESIRED CHARACTER.IN A NON-TEST MODE
3000            *DATA WOULD BE EITHER PACKED IN 8 BIT BYTES OR ARRIVING
3000            *VIA A SERIAL PORT.
3000 01 00 00           LXI SP,0
3003 21 02 41           LXI H,DBUF+2    ;FIRST BIT
3006 22 97 30           SHLD DADD       ;NEXT DATA ADDRESS
3009 21 00 41           LXI H,DBUF      ;BIT COUNT
300C 4E                 MOV C,M
300D 23                 INX H
300E 46                 MOV B,M
300F C5         EXP:    PUSH B
3010 21 4B 30           LXI H,XTAB      ;DECODE TABLE
3013 E5         NEXT:   PUSH H
3014 2A 97 30           LHLD DADD
3017 4E                 MOV C,M         ;DATA VALUE
3018 23                 INX H
3019 06 00              MVI B,0
301B 22 97 30           SHLD DADD
301E E1                 POP H
301F 09                 DAD B           ;TABLE + DATA BIT
3020 7E                 MOV A,M         ;GET POINTER
3021 17                 RAL
3022 DA 32 30           JC OUTCH
3025 1F                 RAR
3026 5F                 MOV E,A
3027 16 00              MVI D,0
3029 19                 DAD D           ;TABLE+DATA BIT + POINTER
302A C1                 POP B
302B CD 44 30           CALL DECB       ;REDUCE BIT COUNT
302E C5                 PUSH B
302F C3 13 30           JMP NEXT
3032 1F         OUTCH:  RAR
3033 E6 7F              ANI 7FH         ;REMOVE TAG
3035 5F                 MOV E,A
3036 16 00              MVI D,0
3038 19                 DAD D
3039 7E                 MOV A,M         ;GET DECODED CHARACTER
303A CD 00 C5           CALL DISP
303D C1                 POP B
303E CD 44 30           CALL DECB
3041 C3 0F 30           JMP EXP
```

*Listing 2 continued on page 232*

# The Text Solution for APPLE II®

## Now APPLE II® Owners Can Solve Text Problems With VIDEOTERM 80 Column by 24 Line Video Display Utilizing 7 X 9 Dot Character Matrix

Perhaps the most annoying shortcoming of the Apple II® is its limitation of displaying only 40 columns by 24 lines of text, all in uppercase. At last, Apple II® owners have a reliable, trouble-free answer to their text display problem. VIDEOTERM generates a full 80 columns by 24 lines of text, in upper and lower case. Twice the number of characters as the standard Apple II® display. And by utilizing a 7 by 9 character matrix, lower case letters have true descenders. But this is only the start.

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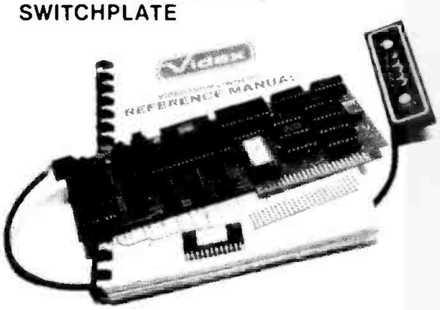
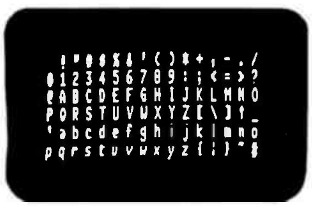


7X12 MATRIX
18X80 OPTIONAL



7X9 MATRIX
24X80 STANDARD

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**BASICs** VIDEOTERM lists BASIC programs, both Integer and Applesoft, using the entire 80 columns. Without splitting keywords. Full editing capabilities are offered using the ESCape key sequences for cursor movement. With provision for stop/start text scrolling utilizing the standard Control-S entry. And simultaneous on-screen display of text being printed.

**Pascal** Installation of VIDEOTERM in slot 3 provides Pascal immediate control of the display since Pascal recognizes the board as a standard video display terminal and treats it as such. No changes are needed to Pascal's MISC.INFO or GOTOXY files, although customization directions are provided. All cursor control characters are identical to standard Pascal defaults.

**Other Boards** The new Microsoft Softcard' is supported. So is the popular D. C. Hayes Micromodem II', utilizing customized PROM firmware available from VIDEX. The powerful EasyWriter' Professional Word Processing System and other word processors are now compatible with VIDEOTERM. Or use the Mountain Hardware ROMWriter' (or other PROM programmer) to generate your own custom character sets. Naturally, VIDEOTERM conforms to all Apple OEM guidelines, assurance that you will have no conflicts with current or future Apple II' expansion boards.

**Advanced Hardware Design** VIDEOTERM's on-board asynchronous crystal clock ensures flicker-free character display. Only the size of the Pascal Language card, VIDEOTERM utilizes CMOS and low power consumption ICs, ensuring cool, reliable operation. All ICs are fully socketed for easy maintenance. Add to that 2K of on-board RAM, 50 or 60 Hz operation, and provision of power and input connectors for a light pen. Problems are designed out, not in.

**Available Options** The entire display may be altered to inverse video, displaying black characters on a white field. PROMs containing alternate character sets and graphic symbols are available from Videx. A switchplate option allows you to use the same video monitor for either the VIDEOTERM or the standard Apple II' display, instantly changing displays by flipping a single toggle switch. The switchplate assembly inserts into one of the rear cut-outs in the Apple II' case so that the toggle switch is readily accessible. And the Videx KEYBOARD ENHANCER can be installed, allowing upper and lower case character entry directly from your Apple II' keyboard.

**Firmware** 1K of on-board ROM firmware controls all operation of the VIDEOTERM. No machine language patches are needed for normal VIDEOTERM use.

Firmware Version 2.0

| | | | |
|---|---|---|---|
| Characters | 7 x 9 matrix | Display | 24 x 80 (full descenders) |
| Options | 7 x 12 matrix option; Alternate user definable character set option; Inverse video option. | | 18 x 80 (7 x 12 matrix with full descenders) |

Want to know more? Contact your local Apple dealer today for a demonstration. VIDEOTERM is available through your local dealer or direct from Videx in Corvallis, Oregon. Or send for the VIDEOTERM Owners Reference Manual and deduct the amount if you decide to purchase. Upgrade your Apple II' to full terminal capabilities for half the cost of a terminal. VIDEOTERM. At last.

PRICE:
- VIDEOTERM includes manual . . . . . $345
- SWITCHPLATE . . . . . $ 19
- MANUAL refund with purchase . . . . $ 19
- 7 x 12 CHARACTER SET . . . . . . . . $ 39
- MICROMODEM FIRMWARE . . . . . . $ 25

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Softcard' is a trademark of Microsoft
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# APPLE II® OWNERS!

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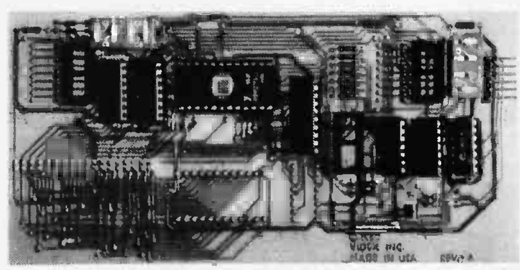
- *PUT THE SHIFT AND SHIFT LOCK BACK WHERE IT BELONGS*
- *SEE REAL UPPER AND lower CASE ON THE SCREEN*
- *ACCESS ALL YOUR KEYBOARD ASCII CHARACTERS*

Videx has the perfect companion for your word processor software: the **KEYBOARD AND DISPLAY ENHANCER**. Install the enhancer in your APPLE II and be typing in lower case just like a typewriter. If you want an upper case character, use the SHIFT key or the CTRL key for shift lock. Not only that, but you see upper and lower case on the screen as you type. Perfectly compatible with Apple Writer and other word processors like, for example, Super-Text.

If you want to program in BASIC, just put it back into the alpha lock mode: and you have the original keyboard back with a few improvements. Now you can enter those elusive 9 characters directly from the keyboard, or require the Control key to be pressed with the RESET to prevent accidental resets.

**KEYBOARD AND DISPLAY ENHANCER** is recommended for use with all revisions of the APPLE II. It includes 6 ICs, and EPROM and dip-switches mounted on a PC board, and a jumper cable. Easy installation, meaning no soldering or cutting traces. Alternate default modes are dip-switch selectable. You can even remap the keyboard, selecting an alternate character set, for custom applications.



PRICE • KDE-700 (REV. 7 or greater) . . . . . . . . . $129.
• KDE-000 (REV. 6 or less) . . . . . . . . . . . $129.

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Videx INC

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Corvallis, Oregon 97330
Phone (503) 758-0521

*Listing 2 continued:*

```
3044 0B          0340 DECB:   DCX B          ;REDUCE BIT COUNT
3045 79          0350         MOV A,C
3046 B0          0360         ORA B
3047 CA 0C 00    0365         JZ MON
304A C9          0370         RET
304B             4000 *THE DECODE TABLE HAS THE FOLLOWING FORMAT:
304B             4010 *THE TABLE VALUE IS THE INCREMENT NECESSARY TO GET TO THE
304B             4020 *NEXT 0-1 PAIR AS THE PROGRAM STEPS THROUGH THE DATA.
304B             4030 *THE TABLE VALUE JUST PRECEEDING A CHARACTER HAS A TAG
304B             4040 *SET IN BIT 7, IN ADDITION TO THE INCREMENT, TO INDICATE
304B             4050 *THAT THE NEXT VALUE IA A CHARACTER.
304B 2A          5000 XTAB:   DB 42          ;0  0
304C 01          5010         DB 1           ;1  1
304D 02          5020         DB 2           ;2  0
304E 08          5030         DB 8           ;3  1
304F 82          5040         DB 130         ;4  0
3050 02          5050         DB 2           ;5  1
3051 45          5060         DB 'E'         ;6
3052 82          5070         DB 130         ;7  0
3053 82          5080         DB 130         ;8  1
3054 49          5090         DB 'I'         ;9
3055 52          5100         DB 'R'         ;10
3056 06          5102         DB 6           ;11 0
3057 01          5104         DB 1           ;12 1
3058 82          5106         DB 130         ;13 0
3059 82          5108         DB 130         ;14 1
305A 4F          5110         DB 'O'         ;15
305B 41          5120         DB 'A'         ;16
305C 82          5130         DB 130         ;17 0
305D 02          5140         DB 2           ;18 1
305E 4E          5150         DB 'N'         ;19
305F 03          5160         DB 3           ;20 0
3060 81          5170         DB 129         ;21 1
3061 44          5180         DB 'D'         ;22
3062 03          5190         DB 3           ;23 0
3063 81          5200         DB 129         ;24 1
3064 50          5210         DB 'P'         ;25
3065 03          5220         DB 3           ;26 0
3066 81          5230         DB 129         ;27 1
3067 56          5240         DB 'V'         ;28
3068 02          5250         DB 2           ;29 0
3069 05          5260         DB 5           ;30 1
306A 82          5270         DB 130         ;31 0
306B 82          5280         DB 130         ;32 1
306C 4A          5290         DB 'J'         ;33
306D 58          5300         DB 'X'         ;34
306E 03          5310         DB 3           ;35 0
306F 81          5320         DB 129         ;36 1
3070 4B          5330         DB 'K'         ;37
3071 82          5340         DB 130         ;38 0
3072 82          5350         DB 130         ;39 1
3073 5A          5360         DB 'Z'         ;40
3074 51          5370         DB 'Q'         ;41
3075 02          5380         DB 2           ;42 0
3076 0E          5390         DB 14          ;43 1
3077 03          5400         DB 3           ;44 0
3078 81          5410         DB 129         ;45 1
3079 54          5420         DB 'T'         ;46
307A 02          5430         DB 2           ;47 0
307B 05          5440         DB 5           ;48 1
307C 82          5450         DB 130         ;49 0
307D 82          5460         DB 130         ;50 1
307E 59          5470         DB 'Y'         ;51
307F 47          5480         DB 'G'         ;52
3080 82          5490         DB 130         ;53 0
3081 82          5500         DB 130         ;54 1
3082 55          5510         DB 'U'         ;55
3083 4D          5520         DB 'M'         ;56
3084 02          5530         DB 2           ;57 0
3085 08          5540         DB 8           ;58 1
3086 03          5550         DB 3           ;59 0
3087 81          5560         DB 129         ;60 1
```

*Listing 2 continued on page 234*

# DIGITAL HARMONY

## A new synthesis of sight and sound


**Digital Harmony**
**by John Whitney**

*Digital Harmony* lays the foundation for the whole new field of audio-visual art made possible by microcomputers. John Whitney, a pioneer of the special effects technology used in STAR WARS and 2001: A SPACE ODYSSEY, explains the special union of computer graphics and music. His computer-generated visual art graphically depicts the laws of harmonic motion common to all music.

*Digital Harmony* includes a complete description of Whitney's computer, peripherals, and film techniques. Colorful illustrations are included, as well as the program listings that generated them. The descriptions are sufficient for anyone to begin to explore this new territory as a composer and computer experimenter — transforming the small computer into an ideal instrument for creating compositions in aural and visual art.

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

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*Listing 2 continued:*

```
3088 48             DB 'H'          ;61
3089 82             DB 130          ;62 0
308A 82             DB 130          ;63 1
308B 43             DB 'C'          ;64
308C 46             DB 'F'          ;65
308D 82             DB 130          ;66 0
308E 02             DB 2            ;67 1
308F 53             DB 'S'          ;68
3090 03             DB 3            ;69 0
3091 81             DB 129          ;70 1
3092 4C             DB 'L'          ;71
3093 82             DB 130          ;72 0
3094 82             DB 130          ;73 1
3095 42             DB 'B'          ;74
3096 57             DB 'W'          ;75
3097 02 41    DADD: DW DBUF+2       ;NEXT DATA ADDRESS
3099                ORG 4100H
4100          DBUF: DS 1000
44E8          DISP: EQU 0C500H      ;DISPLAY A CHARACTER
44E8          MON   EQU 000CH       ;MONITOR RETURN
44E8          SP:   EQU 0
```

**Listing 3:** *COMP2 text-compression routine. This routine is identical to COMP1 (listing 1) except that the Huffman code information is packed and stored 8 bits to the byte. The routine is written in 8080 machine code.*

```
2600           *THIS ROUTINE TAKES TEXT (LETTERS ONLY)
2600           *AND COMPRESSES THEM USING HUFFMAN CODING.
2600           *THE FIRST TWO BYTES IN THE DATA BUFFER
2600           *ARE THE BIT COUNT. ENCODED DATA IS STORED IN DBUF
2600           *IN A PACKED FORM, 8 BITS TO THE BYTE.
2600           ECHO: EQU 0C500H ;OUTPUT DRIVER
2600           SP:   EQU 6
2600           MON: EQU 0CH     ;MONITOR RETURN
2600 31 00 00        LXI SP,0
2603 21 00 00        LXI H,0
2606 22 00 41        SHLD DBUF  ;COMPRESSED BIT COUNT
2609 21 02 41        LXI H,DBUF+2
260C 22 BA 26        SHLD DADD  ;NEXT BIT LOCATION
260F AF              XRA A
2610 32 BC 26        STA POS
2613 DB 08     INCH: IN 8       ;INPUT CODE
2615 0F              RRC
2616 DA 13 26        JC INCH
2619 DB 0A           IN 10
261B FE 2E           CPI '.'    ;END OF TEXT
261D C2 37 26        JNZ PROS
2620 2A BA 26        LHLD DADD  ;CLEAN UP PARTIAL BYTE
2623 3A BC 26        LDA POS
2626 47              MOV B,A    ;COMPUTE SHIFT COUNT
2627 3E 08           MVI A,8
2629 90              SUB B
262A E6 07           ANI 7
262C 47              MOV B,A    ;KEEP SHIFT COUNT
262D 7E              MOV A,M    ;GET PACKED BYTE
262E CA 0C 00  SHFT: JZ MON     ;FINISHED
2631 17              RAL
2632 05              DCR B
2633 77              MOV M,A    ;REPLACE PACKED BYTE
2634 C3 2E 26        JMP SHFT
2637 CD 00 C5  PROS: CALL ECHO
263A E6 7F           ANI 07FH   ;CLEAR PARITY
263C D6 41           SUI 'A'    ;COMPUTE INDEX
263E DA 13 26        JC INCH
2641 FE 1A           CPI 'Z'-'A'+1
2643 D2 13 26        JNC INCH
2646 87              ADD A      ;MULTIPLY BY 2
2647 4F              MOV C,A
2648 06 00           MVI B,0
264A 21 86 26        LXI H,TABL
264D 09              DAD B      ; INDEX
```

*Listing 3 continued on page 236*

*Listing 3 continued:*

```
264E 5E                    MOV E,M     ;GET ENCODE VALUE
264F 23                    INX H
2650 56                    MOV D,M
2651 7B                    MOV A,E     ;GET BIT COUNT
2652 E6 0F                 ANI 0FH     ;MASK COUNT
2654 47                    MOV B,A     ;KEEP COUNT
2655 EB                    XCHG
2656 AF             NEXT:  XRA A
2657 29                    DAD H       ;SHIFT OUT BIT STREAM
2658 17                    RAL         ;MSB FIRST
2659 E6 01                 ANI 1       ;SETUP OUTPUT BIT
265B E5                    PUSH H
265C 2A BA 26              LHLD DADD
265F 57                    MOV D,A
2660 3A BC 26              LDA POS
2663 5F                    MOV E,A     ;KEEP CURRENT POSITION
2664 7E                    MOV A,M     ;GET OLD PACKED DATA
2665 17                    RAL         ;MAKE ROOM
2666 B2                    ORA D       ;PACK
2667 77                    MOV M,A     ;PUT IT AWAY
2668 1C                    INR E       ;UPDATE POSITION
2669 7B                    MOV A,E
266A FE 08                 CPI 8       ;FULL BYTE?
266C C2 74 26              JNZ STOR
266F AF                    XRA A       ;INITIALIZE POSITION
2670 23                    INX H       ;UPDATE DADD
2671 22 BA 26              SHLD DADD
2674 32 BC 26       STOR:  STA POS
2677 2A 00 41              LHLD DBUF
267A 23                    INX H       ;UPDATE BIT COUNT
267B 22 00 41              SHLD DBUF
267E E1                    POP H
267F 05                    DCR B       ;REDUCE COUNT
2680 C2 56 26              JNZ NEXT
2683 C3 13 26              JMP INCH
2686                *ENCODE TABLE FORMAT- LOW ORDER 4 BITS ARE NUMBER OF BITS
2686                *IN ENCODED CHARACTER.REMAINING 12 BITS ARE FOR CODE.
2686                *CODE IS LEFT JUSTIFIED. E.G., AN M IS 00011.
2686 04 F0          TABL:  DW 0F004H   ;A
2688 06 70                 DW 7006H    ;B
268A 05 40                 DW 4005H    ;C
268C 05 D8                 DW 0D805H   ;D
268E 03 80                 DW 8003H    ;E
2690 05 48                 DW 4805H    ;F
2692 05 08                 DW 805H     ;G
2694 04 50                 DW 5004H    ;H
2696 04 A0                 DW 0A004H   ;I
2698 09 D0                 DW 0D009H   ;J
269A 89 D1                 DW 0D189H   ;K
269C 05 78                 DW 7805H    ;L
269E 05 18                 DW 1805H    ;M
26A0 04 C0                 DW 0C004H   ;N
26A2 04 E0                 DW 0E004H   ;O
26A4 06 D4                 DW 0D406H   ;P
26A6 4A D1                 DW 0D14AH   ;Q
26A8 04 B0                 DW 0B004H   ;R
26AA 04 60                 DW 6004H    ;S
26AC 03 20                 DW 2003H    ;T
26AE 05 10                 DW 1005H    ;U
26B0 07 D2                 DW 0D207H   ;V
26B2 06 74                 DW 7406H    ;W
26B4 89 D0                 DW 0D089H   ;X
26B6 05 00                 DW 5H       ;Y
26B8 0A D1                 DW 0D10AH   ;Z
26BA 00 00          DADD:  DW 0        ;NEXT BIT LOCATION
26BC                POS:   DS 1        ;BIT POSITION
26BD                       ORG 4100H
4100                DBUF:  DS 1000
```

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**With the Starwriter™ Daisy Wheel 25 cps printer from C. Itoh.**

A business letter, written on a 45 cps word-processing printer, might take about two minutes to print.

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**Listing 4:** *EXP2 text-expansion routine. This routine takes the output of COMP2, information expressed in a packed Huffman code, and decodes it using the binary tree of figure 2. The decoded character is displayed via a user-supplied subroutine named DISP. The routine is written in 8080 machine code.*

```
3000                 0000 *THIS PROGRAM ACCEPTS DATA PREPARED BY THE DATA COMPRESSION
3000                 0001 *(HUFFMAN CODE) PROGRAM THE DATA BUFFER HAS THE BIT COUNT
3000                 0002 *IN THE FIRST TWO BYTES. THE PROGRAM RUNS UNTIL ALL
3000                 0003 *BITS HAVE BEEN PROCESSED THE PROCESSING CONSISTS OF
3000                 0004 *ADDING A DATA BIT TO THE TABLE ENTRY POINT, GETTING AN
3000                 0005 *INCREMENT WHICH POINTS TO THE NEXT 0-1 PAIR AND CONTINUING
3000                 0006 *UNTIL A TAG IS FOUND IN BIT 7 THIS SIGNIFIES THAT THE
3000                 0007 *NEXT TABLE ENTRY IS THE DESIRED CHARACTER.
3000                 0008 *THIS IS THE PACKED VERSION WHICH PROCESSES DATA FROM
3000                 0009 *8 BIT BYTES, MSB FIRST.
3000                 0010 DISP:   EQU 0C500H     ;DISPLAY CHARACTER
3000                 0011 MON:    EQU 000CH      ;MONITOR RETURN
3000                 0012 SP:     EQU 6
3000 31 00 00        0015         LXI SP,0
3003 21 02 41        0020         LXI H,DBUF+2   ;FIRST BIT
3006 22 C0 30        0030         SHLD DADD      ;NEXT DATA ADDRESS
3009 21 00 41        0040         LXI H,DBUF     ;BIT COUNT
300C 4E              0050         MOV C,M
300D 23              0060         INX H
300E 46              0070         MOV B,M
300F 3E 01           0074         MVI A,1        ;INITIALIZE POSITION
3011 32 C2 30        0076         STA POS
3014 C5              0080 EXP:    PUSH B
3015 21 74 30        0090         LXI H,XTAB     ;DECODE TABLE
3018 E5              0100 NEXT:   PUSH H
3019 2A C0 30        0110         LHLD DADD
301C 3A C2 30        0120         LDA POS        ;GET BIT POSITION
301F 47              0122         MOV B,A
3020 7E              0124         MOV A,M        ;GET DATA
3021 17              0126 BIT:    RAL            ;GET DESIRED BIT INTO CARRY
3022 05              0128         DCR B
3023 C2 21 30        0130         JNZ BIT
3026 3E 00           0132         MVI A,0
3028 17              0134         RAL            ;RESTORE SINGLE BIT
3029 4F              0136         MOV C,A        ;DATA VALUE
302A 06 00           0140         MVI B,0
302C 22 C0 30        0150         SHLD DADD
302F E1              0160         POP H
3030 09              0170         DAD B          ;TABLE + DATA BIT
3031 7E              0180         MOV A,M        ;GET POINTER
3032 17              0190         RAL
3033 DA 43 30        0200         JC OUTCH
3036 1F              0205         RAR
3037 5F              0210         MOV E,A
3038 16 00           0220         MVI D,0
303A 19              0230         DAD D          ;TABLE+DATA BIT + POINTER
303B C1              0240         POP B
303C CD 55 30        0250         CALL DECB      ;REDUCE BIT COUNT
303F C5              0270         PUSH B
3040 C3 18 30        0280         JMP NEXT
3043 1F              0290 OUTCH:  RAR
3044 E6 7F           0294         ANI 7FH        ;REMOVE TAG
3046 5F              0296         MOV E,A
3047 16 00           0297         MVI D,0
3049 19              0298         DAD D
304A 7E              0299         MOV A,M        ;GET DECODED CHARACTER
304B CD 00 C5        0305         CALL DISP
304E C1              0310         POP B
304F CD 55 30        0320         CALL DECB
3052 C3 14 30        0330         JMP EXP
3055 0B              0340 DECB:   DCX B          ;REDUCE BIT COUNT
3056 79              0350         MOV A,C
3057 B0              0360         ORA B
3058 CA 0C 00        0365         JZ MON
305B 3A C2 30        0370         LDA POS
305E 3C              0380         INR A          ;UPDATE BIT POSITION
305F 32 C2 30        0385         STA POS
3062 FE 09           0390         CPI 9          ;8 BITS PROCESSED?
```

*Listing 4 continued on page 240*

# DYNACOMP

*Quality software for⁺:*

| | |
|---|---|
| ATARI | TRS-80 (Level II)* |
| PET | NORTH STAR |
| APPLE II Plus | CP/M 8" Disk |

## GAMES, SIMULATIONS, EDUCATION and MISCELLANEOUS

**BRIDGE 2.0 (Available for all computers)** — **Price: $17.95 Cassette/$21.95 Diskette**
An all-inclusive version of this most popular of card games. This program both BIDS and PLAYS either contract or duplicate bridge. Depending on the contract, your computer opponents will either play the offense OR defense. If you bid too high, the computer will double your contract! BRIDGE 2.0 provides challenging entertainment for advanced players and is an excellent learning tool for the bridge novice.

**HEARTS 1.5 (Available for all computers)** — **Price: $14.95 Cassette/$18.95 Diskette**
An exciting and entertaining computer version of this popular card game. Hearts is a trick-oriented game in which the purpose is not to take any hearts or the queen of spades. Play against two computer opponents who are armed with hard-to-beat playing strategies.

**STUD POKER (ATARI only)** — **Price: $11.95 Cassette/$15.95 Diskette**
This is the classic gambler's card game. The computer deals the cards one at a time and you (and the computer) bet on what you see. The computer does not cheat and *usually* bets the odds. However, it sometimes bluffs! Also included is a five card draw poker betting practice program. This package will run on a 16K ATARI. Color, graphics, sound.

**POKER PARTY (Available for all computers)** — **Price: $17.95 Cassette/$21.95 Diskette**
POKER PARTY is a draw poker simulation based on the book, POKER, by Oswald Jacoby. This is the most comprehensive version available for microcomputers. The party consists of yourself and six other (computer) players. Each of these players (you will get to know them) has a different personality in the form of a varying propensity to bluff or fold under pressure. Practice with POKER PARTY before going to that expensive game tonight! Apple Cassette and diskette versions require a 32 K (or larger) Apple II.

**VALDEZ (Available for all computers)** — **Price: $14.95 Cassette/$18.95 Diskette**
A simulation of supertanker navigation in the Prince William Sound and Valdez Narrows. The program uses an extensive 256X256 element radar map and employs physical models of ship response and tidal patterns. Chart your own course through ship and iceberg traffic. Any standard terminal may be used for display.

**FLIGHT SIMULATOR (Available for all computers)** — **Price: $17.95 Cassette/$21.95 Diskette**
A realistic and extensive mathematical simulation of take-off, flight and landing. The program utilizes aerodynamic equations and the characteristics of a real airfoil. You can practice instrument approaches and navigation using radials and compass headings. The more advanced flyer can also perform loops, half-rolls and similar aerobatic maneuvers.

**CRIBBAGE 2.0 (TRS-80 only)** — **Price: $14.95 Cassette/$18.95 Diskette**
This is a well-designed and nicely executed two-handed version of the classic card game, cribbage. It is an excellent program for the cribbage player in search of a worthy opponent as well as the beginner wishing to learn the game, in particular the scoring and jargon. The standard cribbage score board is continually shown at the top of the display (utilizing the TRS-80's graphics capabilities), with the cards shown underneath. The computer automatically scores and also announces the points using the traditional phrases.

**CHESS MASTER (North Star and TRS-80 only)** — **Price: $19.95 Cassette/$23.95 Diskette**
This complete and very powerful program provides five levels of play. It includes castling, en passant captures and the promotion of pawns. Additionally, the board may be preset before the start of play, permitting the examination of "book" plays. To maximize execution speed, the program is written in assembly language (by SOFTWARE SPECIALISTS of California). Full graphics are employed in the TRS-80 version, and two widths of alphanumeric display are provided to accommodate North Star users.

**STARTREK 3.2 (Available for all computers)** — **Price: $ 9.95 Cassette/$13.95 Diskette**
This is the classic Startrek simulation, but with several new features. For example, the Klingons now shoot at the Enterprise without warning while also attacking starbases in other quadrants. The Klingons also attack with both light and heavy cruisers and move when shot at! The situation is hectic when the Enterprise is besieged by three heavy cruisers and a starbase S.O.S. is received! The Klingons get even!

**SPACE TILT (Apple only)** — **Price: $10.95 Cassette/$14.95 Diskette**
Use the game paddles to tilt the plane of the TV screen to "roll" a ball into a hole in the screen. Sound simple? Not when the hole gets smaller and smaller! A built-in timer allows you to measure your skill against others in this habit-forming action game.

**GAMES PACK I (Available for all computers)** — **Price: $9.95 Cassette/$13.95 Diskette**
GAMES PACK I contains the classic computer games of BLACKJACK, LUNAR LANDER, CRAPS, HORSERACE, SWITCH and more. These games have been combined into one large program for ease in loading. They are individually accessed by a convenient menu.

**GAMES PACK II (Available for all computers)** — **Price: $9.95 Cassette/$13.95 Diskette**
GAMES PACK II includes the games CRAZY EIGHTS, JOTTO, ACEY-DUCEY, LIFE, WUMPUS and others. As with GAMES PACK I, all the games are loaded as one program and are called from a menu.

Why pay $7.95 or more per program when you can buy a DYNACOMP collection for just $9.95?

**NOMINOES JIGSAW (ATARI and TRS-80 only)** — **Price: $16.95 Cassette/$20.95 Diskette**
NOMINOES JIGSAW is an intriguing and sophisticated graphical puzzle. The jigsaw consists of a 9 by 9 board partially filled with randomly chosen shapes (nominoes), of which there are 60 types. By knowing that the shapes must be legally connected, and by guessing the shape at each location, all the nominoes may be eventually deduced. Scoring is based on the number of guesses required and the difficulty of the board set-up.

**MOVING MAZE (Apple only)** — **Price: $10.95 Cassette/$14.95 Diskette**
MOVING MAZE employs the games paddles to direct a puck from one side of a maze to the other. However, the maze is dynamically (and randomly) built and is continually being modified. The objective is to cross the maze without touching (or being hit by) a wall. Scoring is by an elapsed time indicator, and three levels of play are provided.

**BLACK HOLE (Apple only)** — **Price: $14.95 Cassette/$18.95 Diskette**
This is an exciting graphical simulation of the problems involved in closely observing a black hole with a space probe. The object is to enter and maintain, for a prescribed time, an orbit close to a small black hole. This is to be achieved without coming so near the anomaly that the tidal stress destroys the probe. Control of the craft is realistically simulated using side jets for rotation and main thrusters for acceleration. This program employs Hi-Res graphics and is educational as well as challenging.

**TEACHER'S PET I (Available for all computers)** — **Price: $ 9.95 Cassette/$13.95 Diskette**
This is the first of DYNACOMP's educational packages. Primarily intended for pre-school to grade 3, TEACHER'S PET provides the young student with counting practice, letter-word recognition and three levels of math skill exercises.

**CRYSTALS (ATARI only)** — **Price: $ 9.95 Cassette/$13.95 Diskette**
A unique algorithm randomly produces fascinating graphics displays accompanied with tones which vary as the patterns are built. No two patterns are the same, and the combined effect of the sound and graphics are mesmerizing. CRYSTALS has been used in local stores to demonstrate the sound and color features of the Atari.

**CRANSTON MANOR ADVENTURE (North Star only)** — **Price: $19.95**
At last! A comprehensive Adventure game for the North Star. CRANSTON MANOR ADVENTURE takes you into mysterious CRANSTON MANOR where you attempt to gather fabulous treasures. Lurking in the manor are wild animals and robots who will not give up the treasures without a fight. The number of rooms is greater and the associated descriptions are much more elaborate than the current popular series of Adventure programs, making this game the top in its class. Play can be stopped at any time and the status stored on diskette. Requires 32K.

**NORTH STAR SOFTWARE EXCHANGE (NSSE) LIBRARY** — **Price $9.95 Diskette**
DYNACOMP now distributes the 20 + volume NSSE library. Most of these diskettes offer an outstanding value for the purchase price. Write for details regarding the contents of this library and quanity (four or more) purchases.

Circle 154 on inquiry card.

## Availability

DYNACOMP software is supplied with complete documentation containing clear explanations and examples. Unless otherwise specified, all programs will run within 16K program memory space (ATARI requires 24K). Except where noted, programs are available on ATARI, PET, TRS-80 (Level II) and Apple (Applesoft) cassette and diskette as well as North Star single density (double density compatible) diskette. Additionally, most programs can be obtained on standard (IBM format) 8" CP/M floppy disks for systems running under MBASIC.

⁺ *ATARI, PET, APPLE II, TRS-80, NORTH STAR, CP/M and IBM are registered trade names and/or trademarks.*

## BUSINESS and UTILITIES

**MAIL LIST II (Apple and North Star diskettes only)** — **Price: $24.95**
This many-featured program now includes full alphabetic and zip code sorting as well as file merging. Entries can be retrieved by user-defined code, client name or Zip Code. The printout format allows the use of standard size address labels. Each diskette can store more than 1100 entries (single density North Star or Apple DOS 3.2; over 2200 with double density North Star or Apple DOS 3.3)!

**FORM LETTER SYSTEM (FLS) (Apple and North Star diskette only)** — **Price: $17.95**
FLS may be employed to generate individually addressed form letters. The user creates the address file and separately composes the letter. FLS will then print form letters using each address. FLS is completely compatible with MAIL LIST II, which may be used to manage your address files.

FLS and MAIL LIST II are available as a combined package for $37.95.

**TEXT EDITOR I (Letter Writer)** — **Price: $14.95 Cassette/$18.95 Diskette**
An easy to use, line-oriented text editor which provides variable line widths and simple paragraph indexing. This text editor is ideally suited for composing letters and is quite capable of handling much larger jobs. Available for all computers.

**PERSONAL FINANCE SYSTEM (ATARI only)** — **Price: $34.95 Diskette**
PFS is a single disk menu oriented system composed of 10 programs designed to organize and simplify your personal finances. Features include a 300 transaction capacity; fast access; 26 optional user codes; data retrieval by month, code or payee, optional printing of reports; checkbook balancing; bar graph plotting and more. Also provides on the diskette is ATARI DOS 2.

**FINDIT (North Star only)** — **Price: $19.95**
This is a three-in-one program which maintains information accessible by keywords of three types: Personal (eg: last name), Commercial (eg: plumbers) and Reference (eg: magazine articles, record albums, etc). In addition to keyword searches, there are birthday, anniversary and appointment searches for the personal records and appointment searches for the commercial records. Reference records are accessed by a single keyword or by cross-referencing two or three keywords.

**DFILE (North Star only)** — **Price: $19.95**
This handy program allows North Star users to maintain a specialized data base of all files and programs in the stack of disks which invariably accumulates. DFILE is easy to set up and use. It will organize your disks to provide efficient locating of the desired file or program.

**COMPARE (North Star only)** — **Price: $12.95**
COMPARE is a single disk utility software package which compares two BASIC programs and displays the file sizes of the programs in bytes, the lengths in terms of the number of statement lines, and the line numbers at which various listed differences occur. COMPARE permits the user to examine versions of his software to verify which are the more current, and to clearly identify the changes made during development.

**COMPRESS (North Star only)** — **Price: $12.95**
COMPRESS is a single-disk utility program which removes all unnecessary spaces and (optionally) REMark statements from North Star BASIC programs. The source file is processed one line at a time, thus permitting very large programs to be compressed using only a small amount of computer memory. File compressions of 20-50% are commonly achieved.

**GRAFIX (TRS-80 only)** — **Price: $12.95 Cassette/$16.95 Diskette**
This unique program allows you to easily create graphics directly from the keyboard. You "draw" your figure using the program's extensive cursor controls. Once the figure is made, it is automatically appended to your BASIC program as a string variable. Draw a "happy face", call it H$ and then print it from your program using PRINT H$! This is a very easy way to create and save graphics.

**TIDY (TRS-80 only)** — **Price: $10.95 Cassette/$14.95 Diskette**
TIDY is an assembly language program which allows you to renumber the lines in your BASIC programs. TIDY also removes unnecessary spaces and REMark statements. The result is a compacted BASIC program which uses much less memory space and executes significantly faster. Once loaded, TIDY remains in memory; you may load any number of BASIC programs wishout having to reload TIDY!

## STATISTICS and ENGINEERING

**DATA SMOOTHER (Not available for ATARI)** — **Price: $14.95 Cassette/$18.95 Diskette**
This special data smoothing program may be used to rapidly derive useful information from noisy business and engineering data which are equally spaced. The software features choice in degree and range of fit, as well as smoothed first and second derivative calculation. Also included is automatic plotting of the input data and smoothed results.

**FOURIER ANALYZER (Available for all computers)** — **Price: $14.95 Cassette/$18.95 Diskette**
Use this program to examine the frequency spectra of limited duration signals. The program features automatic scaling and plotting of the input data and results. Practical applications include the analysis of complicated patterns in such fields as electronics, communications and business.

**TFA (Transfer Function Analyzer)** — **Price: $19.95 Cassette/$23.95 Diskette**
This is a special software package which may be used to evaluate the transfer functions of systems such as hi-fi amplifiers and filters by examining their response to pulsed inputs. TFA is a major modification of FOURIER ANALYZER and contains an engineering-oriented decibel versus log-frequency plot as well as data editing features. Whereas FOURIER ANALYZER is designed for educational and scientific use, TFA is an engineering tool. Available for all computers.

**HARMONIC ANALYZER (Available for all computers)** — **Price: $24.95 Cassette/$28.95 Diskette**
HARMONIC ANALYZER was designed for the spectrum analysis of repetitive waveforms. Features include data file generation, editing and storage/retrieval as well as data and spectrum plotting. One particularly unique facility is that the input data need not be equally spaced or in order. The original data is sorted and a cubic spline interpolation is used to create the data file required by the FFT algorithm.

FOURIER ANALYZER, TFA and HARMONIC ANALYZER may be purchased together for a combined price of $44.95 (three cassettes) and $56.95 (three diskettes).

**REGRESSION I (Available for all computers)** — **Price: $19.95 Cassette/$23.95 Diskette**
REGRESSION I is a unique and exceptionally versatile one-dimensional least squares "polynomial" curve fitting program. Features include very high accuracy; an automatic degree determination option; an extensive internal library of fitting functions; data editing; automatic data and curve plotting; a statistical analysis (eg: standard deviation, correlation coefficient, etc.) and much more. In addition, new fits may be tried without reentering the data. REGRESSION I is certainly the cornerstone program in any data analysis software library.

**REGRESSION II (PARAFIT) (Available for all computers)** — **Price: $19.95 Cassette/$23.95 Diskette**
PARAFIT is designed to handle those cases in which the parameters are imbedded (possibly nonlinearly) in the fitting function. The user simply inserts the functional form, including the parameters (A(1), A(2), etc.) as one or more BASIC statement lines. Data and results may be manipulated and plotted as with REGRESSION I. Use REGRESSION I for polynomial fitting, and PARAFIT for those complicated functions.

**MULTILINEAR REGRESSION (MLR) (Available for all computers)** — **Price: $19.95 Cassette / $23.95 Diskette**
MLR is a professional software package for analyzing data sets containing two or more linearly independent variables. Besides performing the basic regression calculation, this program also provides easy to use data entry, storage, retrieval and editing functions. In addition, the user may interrogate the solution by supplying values for the independent variables. The number of variables and data size is limited only by the available memory.

REGRESSION I, II and MULTILINEAR REGRESSION may be purchased together for $49.95 (three cassettes) or $61.95 (three diskettes).

**BASIC SCIENTIFIC SUBROUTINES, Volume I (Not available for ATARI)**
DYNACOMP is the exclusive distributor for the software keyed to the text *BASIC Scientific Subroutines, Volume I* by F. Ruckdeschel (see the BYTE/McGraw-Hill advertisement in BYTE magazine, January 1981). These subroutines have been assembled according to chapter. Included with each collection is a menu program which selects and demonstrates each subroutine.

- Collection #1: Chapters 2 and 3: Data and function plotting, complex variables
- Collection #2: Chapter 4: Matrix and vector operations
- Collection #3: Chapters 5 and 6: Random number generators, series approximations

Price per collection: $14.95 Cassette/$18.95 Diskette

All three collections are available for $39.95 (three cassettes) and $49.95 (three diskettes).

Because the text is a vital part of the documentation, *BASIC Scientific Subroutines, Volume I* is available from DYNACOMP for $19.95 plus 75¢ postage and handling.

**ROOTS (Available for all computers)** — **Price $9.95 Cassette/$13.95 Diskette**
In a nutshell, ROOTS simultaneously determines all the zeroes of a polynomial having real coefficients. There is no limit on the degree of the polynomial, and because the procedure is iterative, the accuracy is generally very good. No initial guesses are required as input, and the calculated roots are substituted back into the polynomial and the residuals displayed.

## Ordering Information

All orders are processed and shipped postpaid within 48 hours. Please enclose payment with order along with computer information. If paying by VISA or Master Card, include all numbers on card. For orders outside North America add 10% for shipping and handling.

Add $2.50 to diskette price for 8" floppy disk (IBM format soft sectored, CP/M, Microsoft BASIC)

*TRS-80 diskettes are not supplied with DOS or BASIC.

**Deduct 10% when ordering 3 or more programs.**

Ask for DYNACOMP programs at your local software dealer. Write for detailed descriptions of these and other programs from DYNACOMP.

**DYNACOMP, Inc.**
1427 Monroe Avenue
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Office phone (9AM-5PM EST): (716)442-8960

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New York State residents please add 7% NYS sales tax.

*Listing 4 continued:*

```
3064 C0                   RNZ
3065 3E 01                MVI A,1         ;RESET POSITION
3067 32 C2 30             STA POS
306A E5                   PUSH H
306B 2A C0 30             LHLD DADD
306E 23                   INX H           ;UPDATE BYTE ADDRESS
306F 22 C0 30             SHLD DADD
3072 E1                   POP H
3073 C9                   RET
3074            *THE DECODE TABLE HAS THE FOLLOWING FORMAT:
3074            *THE TABLE VALUE IS THE INCREMENT NECESSARY TO GET THE
3074            *NEXT 0-1 PAIR AS THE PROGRAM STEPS THROUGH THE DATA
3074            *THE TABLE VALU JUST PRECEEDING A CHARACTER HAS A TAG
3074            *SET IN BIT 7, IN ADDITION TO THE INCREMENT, TO  INDICATE
3074            *THAT THE NEXT VALUE IS A CHARACTER.
3074 2A         XTAB:     DB 42           ;0  0
3075 01                   DB 1            ;1  1
3076 02                   DB 2            ;2  0
3077 08                   DB 8            ;3  1
3078 82                   DB 130          ;4  0
3079 02                   DB 2            ;5  1
307A 45                   DB 'E'          ;6
307B 82                   DB 130          ;7  0
307C 82                   DB 130          ;8  1
307D 49                   DB 'I'          ;9
307E 52                   DB 'R'          ;10
307F 06                   DB 6            ;11 0
3080 01                   DB 1            ;12 1
3081 82                   DB 130          ;13 0
3082 82                   DB 130          ;14 1
3083 4F                   DB 'O'          ;15
3084 41                   DB 'A'          ;16
3085 82                   DB 130          ;17 0
3086 02                   DB 2            ;18 1
3087 4E                   DB 'N'          ;19
3088 03                   DB 3            ;20 0
3089 81                   DB 129          ;21 1
308A 44                   DB 'D'          ;22
308B 03                   DB 3            ;23 0
308C 81                   DB 129          ;24 1
308D 50                   DB 'P'          ;25
308E 03                   DB 3            ;26 0
308F 81                   DB 129          ;27 1
3090 56                   DB 'V'          ;28
3091 02                   DB 2            ;29 0
3092 05                   DB 5            ;30 1
3093 82                   DB 130          ;31 0
3094 82                   DB 130          ;32 1
3095 4A                   DB 'J'          ;33
3096 58                   DB 'X'          ;34
3097 03                   DB 3            ;35 0
3098 81                   DB 129          ;36 1
3099 4B                   DB 'K'          ;37
309A 82                   DB 130          ;38 0
309B 82                   DB 130          ;39 1
309C 5A                   DB 'Z'          ;40
309D 51                   DB 'Q'          ;41
309E 02                   DB 2            ;42 0
309F 0E                   DB 14           ;43 1
30A0 03                   DB 3            ;44 0
30A1 81                   DB 129          ;45 1
30A2 54                   DB 'T'          ;46
30A3 02                   DB 2            ;47 0
30A4 05                   DB 5            ;48 1
30A5 82                   DB 130          ;49 0
30A6 82                   DB 130          ;50 1
30A7 59                   DB 'Y'          ;51
30A8 47                   DB 'G'          ;52
30A9 82                   DB 130          ;53 0
30AA 82                   DB 130          ;54 1
30AB 55                   DB 'U'          ;55
30AC 4D                   DB 'M'          ;56
```

*Listing 4 continued on page 244*

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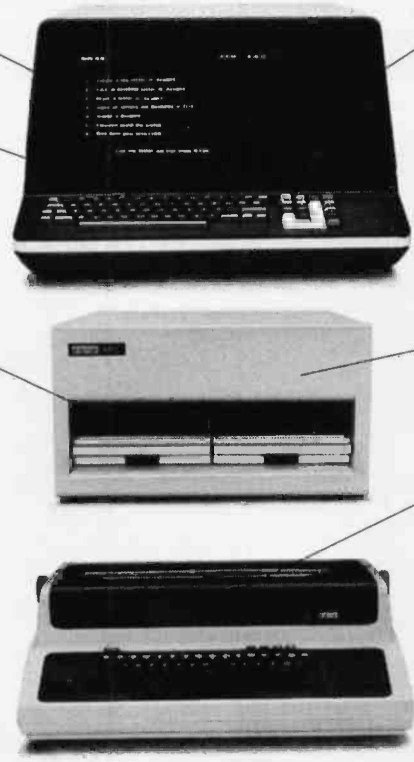

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*Listing 4 continued:*

```
30AD 02         5530        DB 2         ;57 0
30AE 08         5540        DB 8         ;58 1
30AF 03         5550        DB 3         ;59 0
30B0 81         5560        DB 129       ;60 1
30B1 48         5570        DB 'H'       ;61
30B2 82         5580        DB 130       ;62 0
30B3 82         5590        DB 130       ;63 1
30B4 43         5600        DB 'C'       ;64
30B5 46         5610        DB 'F'       ;65
30B6 82         5620        DB 130       ;66 0
30B7 02         5630        DB 2         ;67 1
30B8 53         5640        DB 'S'       ;68
30B9 03         5650        DB 3         ;69 0
30BA 81         5660        DB 129       ;70 1
30BB 4C         5670        DB 'L'       ;71
30BC 82         5680        DB 130       ;72 0
30BD 82         5690        DB 130       ;73 1
30BE 42         5700        DB 'B'       ;74
30BF 57         5710        DB 'W'       ;75
30C0 02 41      5720 DADD:  DW DBUF+2    ;NEXT DATA ADDRESS
30C2            5990 POS:   DS 1         ;BIT POSITION
30C3            5999        ORG 4100H
4100            6000 DBUF:  DS 1000
```

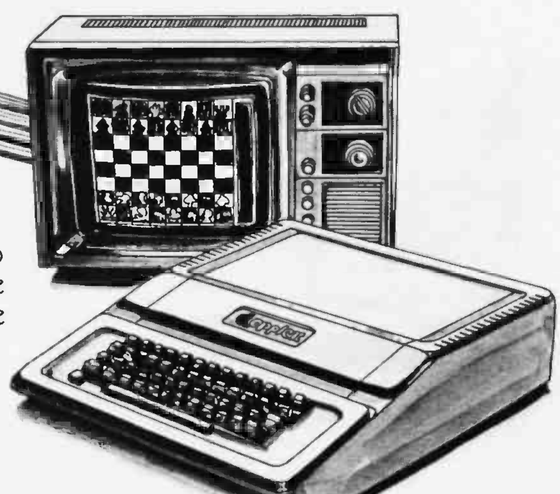
**Listing 5:** *BASIC frequency-analysis program FREQ. Written in Microsoft BASIC, this program receives text entered by the user and prints the frequency distribution of all letters and symbols. One symbol that does not appear by itself in a line of text is defined as marking the end of text; the symbol, defined in line 100, is presently "%".*

```
LIST  FREQ (FREQUENCY ANALYSIS PROGRAM)


10 CLEAR 3000
12 D=45
15 S=0
 20 DIM B$(2550)
30 DIM C(D)
40 DIM L$(D)
50 FOR N=0 0 TO D
60 L$(N)="%"
70 NEXT N
75 PRINT "ENTER ANALYSIS TEXT, TERMINATE WITH %"
80 FOR N=0 TO 10
90 INPUT B$(N)
100 IF B$(N)="%" GOTO 120
110 NEXT N
120 F=N-1
125 FORN=0 TO F
130 L=LEN(B$(N))
140 FOR K= 1 TO L
150 A$=MID$(B$(N),K,1)
160 FOR J=0 TO D
170 IF L$(J)=A$ GOTO 220
180 NEXT J
190 L$(S) = A$
200 C(S)=C(S)+1
205 T=T+1
210 S=S+1
215 GOTO 230
220 C(J)=C(J)+1
225 T=T+1
230 NEXT K
240 NEXT N
245 M=1
250 FOR K=1 TO S-2
255 FOR N=1 TO S-M
260 IF C(N-1)>=C(N) GOTO 274
262 T$=L$(N-1)
264 U=C(N-1)
266 L$(N-1)=L$(N)
268 C(N-1)=C(N)
```

*Listing 5 continued on page 246*





*Listing 5 continued:*

```
270 L$(N)=T$
272 C(N)=U
274 NEXT N
276 M=M+1
278 NEXT K
291 PRINT "LETTER FREQUENCY ANALYSIS"
292 PRINT
293 PRINT "LETTER","COUNT","PROBABILITY"
294 PRINT "-------------------------------------------"
295 PRINT
300 FOR N= 0 TO D
310 PRINT L$(N),C(N),C(N)/T
320 NEXT N
OK
```

*Text continued from page 226:*
is uniquely dependent upon the code being used. However, the basic structure and program can be used with any Huffman code.

There are three parts to the table structure: the index values that allow the program to step through the appropriate number of table entries (ie: tree branches) as the data-stream bit values are serially examined; the decoded character that results from the search; and a flag to indicate to the program that the next table entry found is a character and not an index value. The index values are always in pairs, with separate index values for a 1 or a 0 bit-stream value. Therefore, as the program scans through the table at each pair of index values, one or the other is selected, depending upon whether the bit in the data stream is a 1 or a 0.

The table-scanning process consists of adding the data bit to the current table address. This gives a new address whose contents, an index value, is added to the *address* of the index value itself. This new table address is the address of the next node in the tree of figure 2.

This process continues until a flag is detected, indicating that the next entry is the desired letter. This test is performed each time an index-value address has been computed. The flag is the most significant bit in the table entry. The remaining 7 bits are interpreted as an ASCII character if the flag is on (logical 1) or as an index value if the flag is off (logical 0). This limits the index value to 127, the maximum distance in the table that can be skipped when processing 1 data bit. To help explain this process, a portion of the table is shown in figure 3.

In the Huffman code used in this program, the letter "I" is 1010. The decoding program identifies the corresponding letter by using the data bit stream and the decoding table previously described. The first data bit is added to the table address, TAB, giving a new address, TAB+1.



| TABLE ADDRESS | | TABLE ENTRY | FLAG | DATA BIT | |
|---|---|---|---|---|---|
| TAB +0 | | 42 | OFF | 0 | CHOOSE FIRST BIT |
| +1 | ADD 1 | 1 | OFF | $\boxed{1}$ | |
| +2 | ADD 2 | 2 | OFF | $\boxed{0}$ | CHOOSE SECOND BIT |
| +3 | | 8 | OFF | 1 | |
| +4 | | 130 | ON | 0 | CHOOSE THIRD BIT |
| +5 | ADD 2 | 2 | OFF | $\boxed{1}$ | |
| +6 | | E | OFF | | |
| +7 | 130 = 128+2 | 130 | ON | $\boxed{0}$ | CHOOSE FOURTH BIT |
| +8 | | 130 | ON | 1 | |
| +9 | ADD 2 | I | - | 1010 | DECODED |
| +10 | | R | | | |
| +11 | | 6 | | 0 | |
| +12 | | 1 | | 1 | |
| (ETC.) | | | | | |

**Figure 3:** *Use of the binary tree tables in programs EXP1 and EXP2. This annotated table interprets the first 13 bytes of the lookup table in both the code-expansion routines. It corresponds to the part of the binary tree in figure 2 that leads to the letters E, I, and R. This figure shows the process by which 1010 is decoded as the letter I.*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The index value here, a 1, is added to the previous result, giving TAB+2. The first bit has now been processed.

Beginning on the second bit, 0 is added to the previous result and the new index value pointed to is 2. This is added to the previous result, giving a new address of TAB+4.

The second bit has now been processed. The next data bit, a 1, is added to the previous result, giving the address TAB+5. Adding the index value at this location, a 2, gives the new address, TAB+7. The third bit has now been processed.

Adding the last data bit, a 0, gives the entry 130. The fact that this value is greater than 128 proves that it is really an index value of 2 with the flag bit set; 130 = 128 +2. This tells the user that the next entry, two locations further, is the desired character. Adding the index value of 2 points you to the letter "I". Since a letter was found, the process is repeated from the beginning, continuing with the next bit in the data stream (providing that the supply of data has not been exhausted).

**Shorter codes are used for the more frequently occurring data elements, and longer codes are used for less frequently occurring data elements.**

## COMP2 Description

The COMP2 program, given in listing 3, is similar to COMP1 except for one significant difference—the serial bit stream that results from the encoding process is packed and stored 8 bits to the byte. This provides true compression and is useful when the compressed file is stored in main memory or when the mass-storage device requires an 8-bit word. An interesting occurrence in using a compression scheme like this is that a low degree of data encryption occurs automatically when the bit stream is broken into 8-bit bytes. Referring back to the example where the word "compression" was represented by 47 bits, you can see that the 8-bit bytes look like the following:

| (Binary) | (Hexadecimal) | (ASCII Meaning) |
|---|---|---|
| 01000111 | 47 | G |
| 00001111 | 0F | SI (Control character) |
| 01011011 | 5B | Left bracket |
| 10001100 | 8C | Not defined in 7-bit ASCII |
| 11010101 | D5 | Not defined in 7-bit ASCII |
| 1101100 | D(?) | Insufficient data |

If someone looked at this data, it would not be immediately obvious that this is the word "compression". Some knowledge about the processing method or some effort in decoding it would be necessary to retrieve the original word.

## EXP2 Description

The EXP2 program, given in listing 4, is similar to EXP1 except that it expects to find the data to be decoded in a packed form of 8-bit bytes. It works in conjunction with COMP2. As in EXP1, the decoded data is sent to some sort of terminal device. Any other destination could be used with a slight code change.

Listing 6: *Listing of the execution of program FREQ (listing 5). This listing is the result of running the FREQ program, using eight lines of BASIC code as the text to be analyzed.*

```
OK
 RUN  OF  FREQUENCY ANALYSIS PROGRAM

 ENTER ANALYSIS TEXT, TERMINATE WITH %
? "120 f=n-1"

? "125 forn=0 to f"

? "130 l=len(b$(n))"

? "140 for k= 1 to l"

? "150 a$=mid$(b$(n),k,1)"

? "160 for j=0 to d"

? "170 if l$(j)=a$ goto 220"

? "180 next j"

? %

 LETTER FREQUENCY ANALYSIS

LETTER          COUNT            PROBABILITY
--------------------------------------------

-                 1                7.75194E-03
3                 1                7.75194E-03
4                 1                7.75194E-03
M                 1                7.75194E-03
6                 1                7.75194E-03
7                 1                7.75194E-03
G                 1                7.75194E-03
8                 1                7.75194E-03
X                 1                7.75194E-03
5                 2                1.55039E-02
E                 2                1.55039E-02
B                 2                1.55039E-02
K                 2                1.55039E-02
A                 2                1.55039E-02
I                 2                1.55039E-02
D                 2                1.55039E-02
,                 2                1.55039E-02
R                 3                2.32558E-02
J                 3                2.32558E-02
2                 4                3.10078E-02
L                 4                3.10078E-02
T                 5                3.87597E-02
(                 5                3.87597E-02
)                 5                3.87597E-02
F                 6                4.65116E-02
N                 6                4.65116E-02
$                 6                4.65116E-02
=                 7                5.42636E-02
O                 8                6.20155E-02
0                 10               7.75194E-02
1                 11               8.52713E-02
                  21               .162791
%                 0                0
```

## FREQ Description

To aid in doing frequency analysis, a small program, FREQ, was written in Microsoft BASIC. (See listing 5.) This program counts the occurrence of symbols (letters, spaces, punctuation marks, etc) that have been entered and prints the frequency analysis. In order to include spaces in the count, the input array should be initialized to be filled with a symbol not occurring by itself in the text stream. The same symbol can be used to terminate the text-entry operation: I used a percent sign (%).

The size of the text block to be analyzed is limited only by available memory. To get a reasonably accurate analysis, the text block should be more than several hundred characters and be representative of the entire text. It is not necessary to do a frequency analysis every time a code is constructed. However, the closer the code lengths correspond to the frequency of occurrence, the more efficient the resulting compression will be.

A sample run of FREQ is shown in listing 6 with the text input being part of the program itself. By comparing this output with the figures of table 1, you can see how the letter frequency for a BASIC source program compares to that of plain English text.

Finally, since there are no remarks in the FREQ program, the information in table 3 will help you understand the program. ■

| Line | Operation Performed |
|---|---|
| 10 | Assign string space. |
| 12 | Maximum number of unique symbols expected. |
| 15 | Number of unique symbols entered. |
| 20 | Text working buffer. |
| 30 | Symbol count array. |
| 40 | Symbol array. |
| 50 thru 110 | Entry of text to be analyzed. |
| 80 | Loop control for number of lines (may be increased). |
| 120 | F is number of text lines entered. |
| 125 thru 180 | Input line is transferred to text buffer. |
| 190 thru 240 | Count number of each type of symbol; T is total count; C is count of corresponding symbol in symbol array. |
| 245 thru 278 | Sort symbols by count in ascending order. |
| 291 thru 320 | Computer probability and output results. |

**Table 3:** *Operations performed by lines of code in the BASIC program FREQ of listing 5.*


References

1. Hoffman, L J, *Modern Methods for Computer Security and Privacy*, Prentice-Hall, 1977.
2. Huffman, D A, *A Method for Construction of Minimum-Redundancy Codes*, Proceedings of the Institute of Radio Engineers, September 1952.
3. Tao, W Y, *A Firmware Data Compression Unit*, University of Illinois, January 1974.
4. Williams, Gregg and Rick Meyer, "The Panasonic and Quasar Hand-Held Computers: Beginning a New Generation of Consumer Computers," BYTE, January 1981, pages 34 thru 45.

# Build an Intercomputer Data Link

Mike Wingfield
93 Pine Hill Rd
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Have you ever wanted to share a program or data with someone, but had no way to get it from your machine to his without typing it by hand? While this facility is lacking on most microcomputers, it is so necessary to scientific and business computers that it has long been taken for granted. The power of a computer is greatly enchanced when it can communicate with geographically distant computers. Computers can attain increased efficiency by sharing both resources and data, or by distributing the work load among connected computers. These capabilities also increase the versatility of the computer as a tool, and make possible such services as electronic mail and quick access to data. These and similar advantages will become available to the hobbyist and the small businessman through the use of intercomputer data links.

This article describes a specific implementation of a connection be-

**The power of a computer is greatly enhanced when it can communicate with geographically distant computers**

tween two computers that provides a symmetrical facility for terminal linking and memory-to-memory file transfers. *Terminal linking* implies that the output from each terminal is echoed on the remote terminal. *File transfer* implies the error-free transmission of a block of data from one computer to the other. The purpose of this article is to provide insight into the requirements of large-scale network design through an examination of one specific implementation.

## System Overview

As presented in figure 1, each end

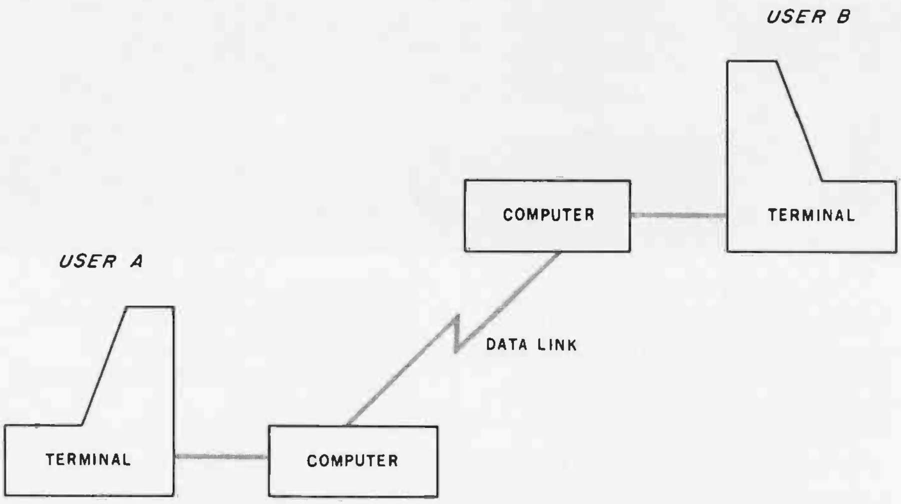
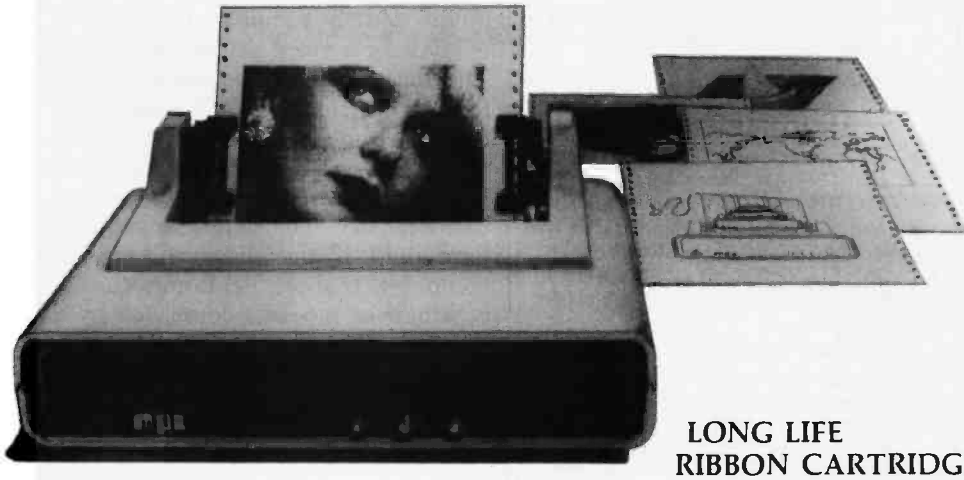



**Figure 1:** *Typical data-link system configuration. Although the connection between the terminal and the computer is hardwired (ie: a direct electrical connection), the data link between computers (bridging a large distance) is usually accomplished via radio or telephone link.*

**About the Author**

*Mike Wingfield graduated from the University of California at Los Angeles in 1972 with a PhD in computer science. Presently, he is working for the computer consulting firm of Bolt, Beranek, and Newman in Cambridge, Massachusetts, where his specialty is the design and implementation of intercomputer communication software. His hobbies include gardening and experimentation with 6800- and 6809-based microcomputers.*

# Why is the 88G Printer the new industry leader?



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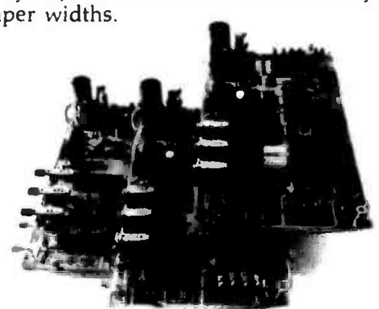

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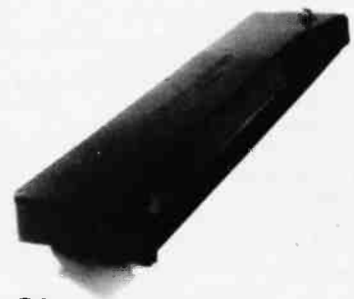

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of the connection consists of a computer and a terminal (such as a teletype or a video display terminal). The local computer is connected to the remote computer via a data link that is implemented by an asynchronous serial hardware interface and the software necessary to support data transfer. The data link may be hardwired if the distance between computers is short; or, it may consist of a pair of modems connected by a telephone line if a hardwired line is inconvenient. Figure 2 illustrates the hardware configuration of each computer—in this case, a 6800-based system. Two ACIAs (asynchronous communications interface adapters) provide the necessary interfaces to the terminal and to the line. The software involved occupies approximately 700 bytes of memory.

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- Initiation of a file transfer from one

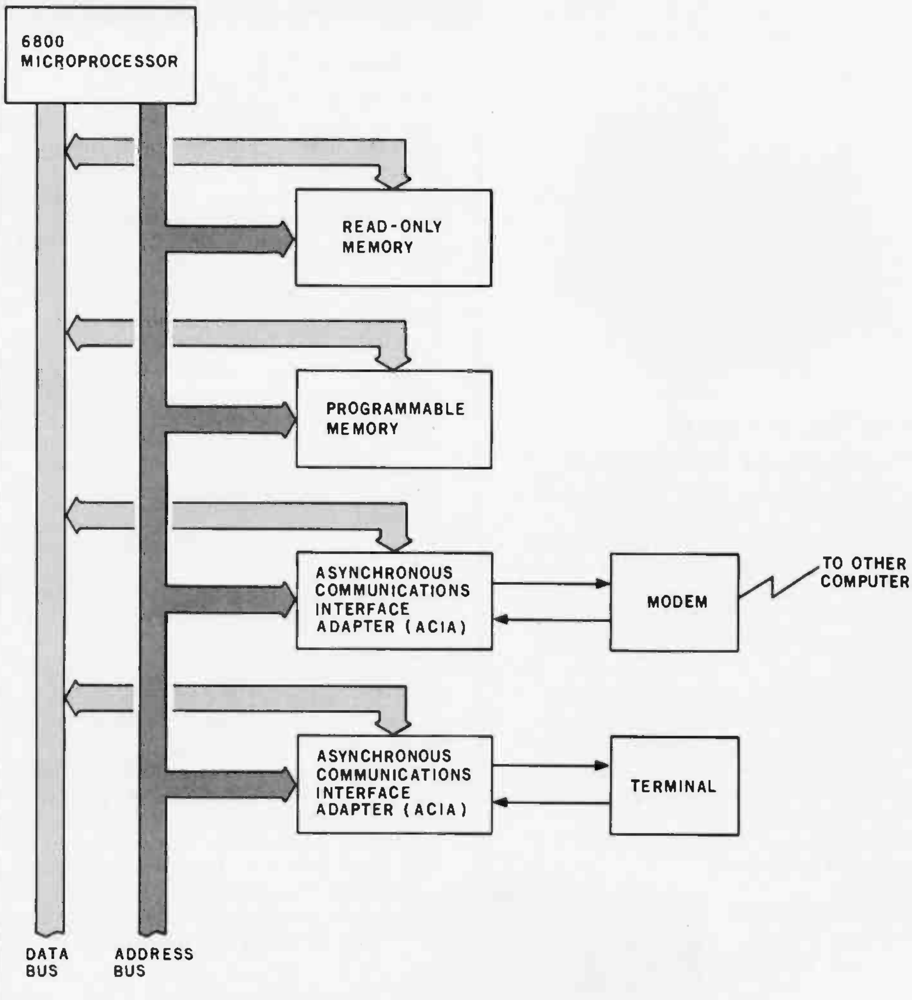


**Figure 2:** *Hardware configuration of a 6800-based computer. The computer communicates across the data link by means of the ACIA, which converts the 8-bit bytes of information to a continuous (serial) stream of bits. This serial bit stream is transmitted by use of the modem, which translates between the binary signal and a signal that can be carried across telephone lines.*

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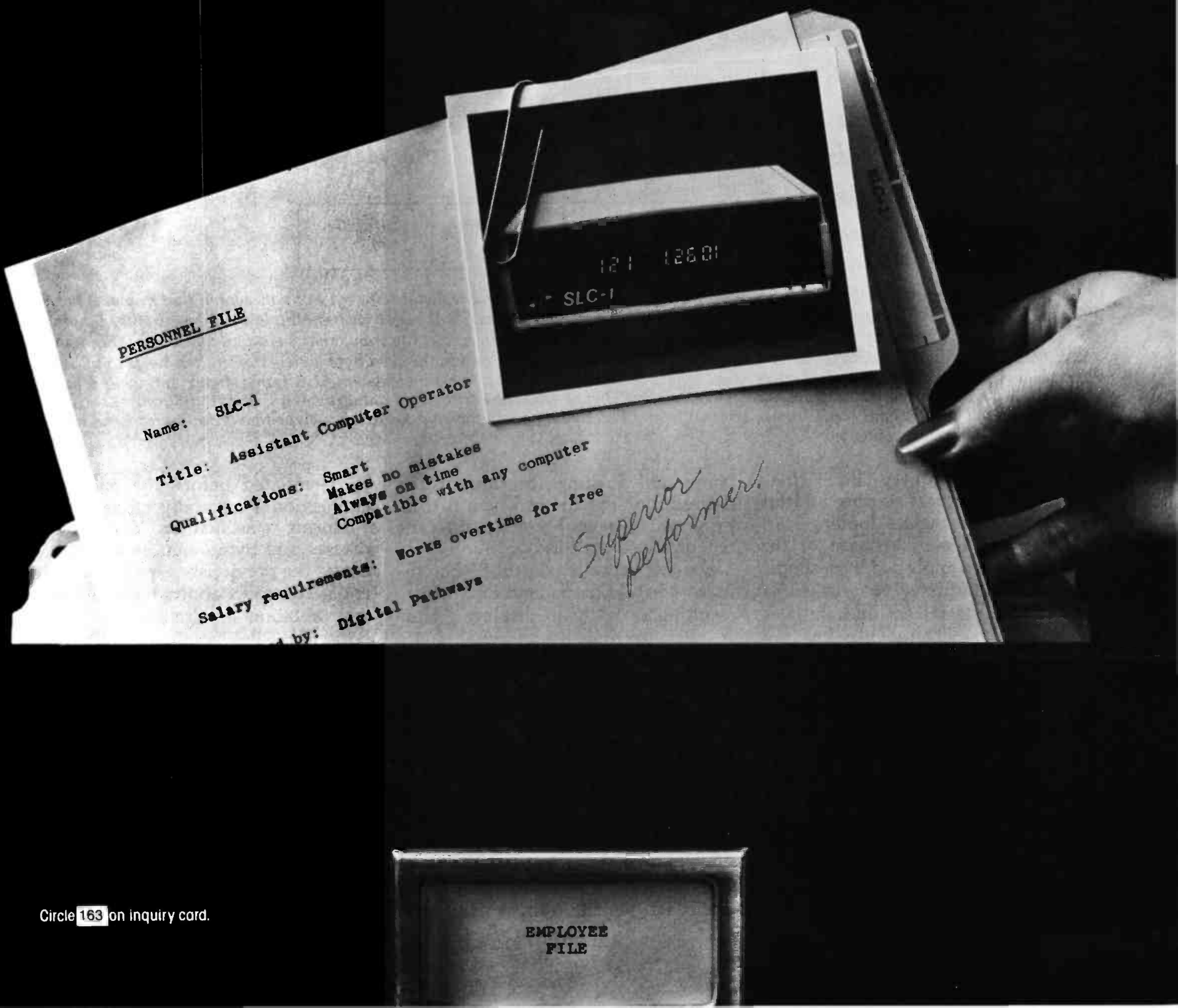


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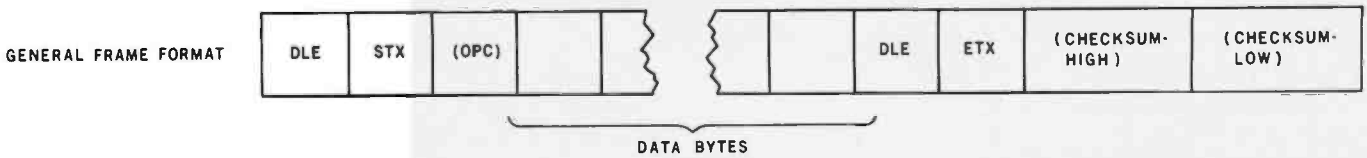


**Figure 3:** *Frame format for data transmission. A frame is information that will be transmitted across the data link as a unit and checked for accuracy upon receipt. For the purposes of transmission accuracy, the data is preceded by a header and followed by a trailer. DLE and STX are both 1-byte ASCII characters. (OPC) stands for opcode, which is a 1-byte quantity that tells the receiver what kind of data follows. A running 2-byte total of the data bytes is kept. This is deposited as a checksum, high byte first, and is used by the receiving computer as a check against transmission errors.*

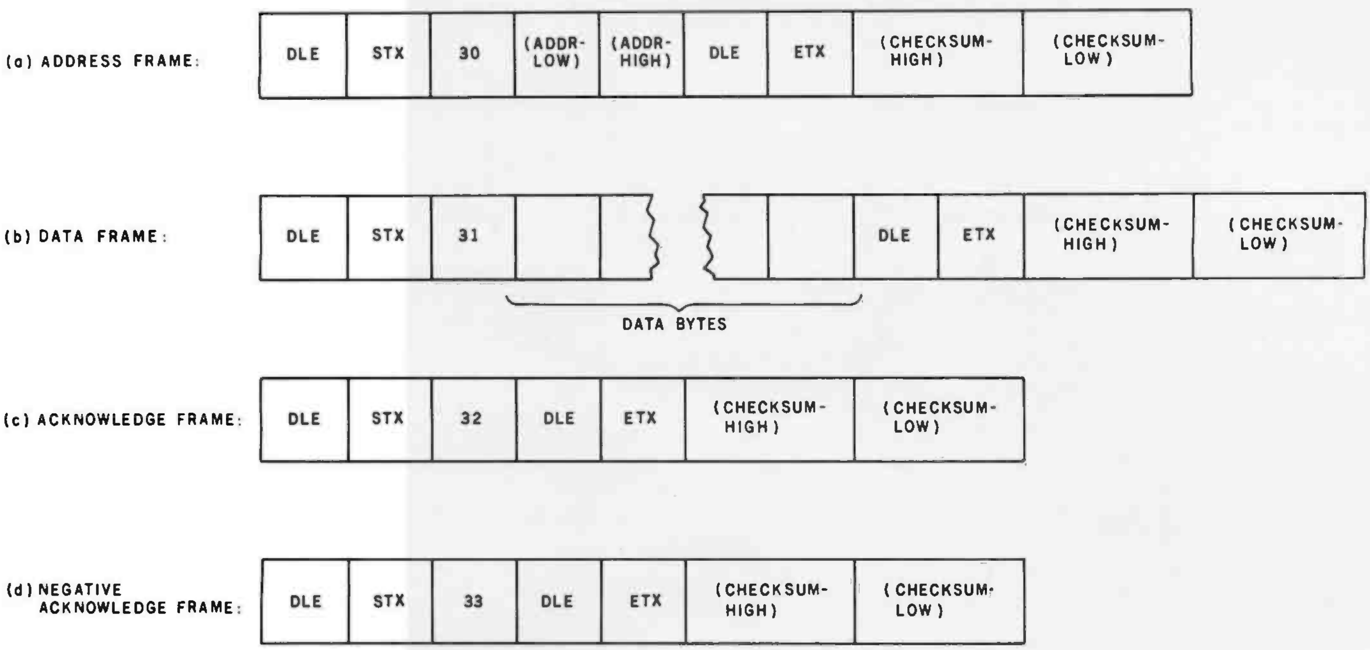


**Figure 4:** *Frame formats for different types of data. The third byte in each frame dictates the type of data sent in that frame. A hexadecimal 30 means that the current frame contains a 2-byte hexadecimal address, sent high byte first: this is an address frame, with format as illustrated in figure 4a. A hexadecimal 31 denotes a data frame, which is the only frame that has a variable length. (See figure 4b.) Because the end of the data is marked by a DLE ETX sequence, a DLE within the data byte area is transmitted twice to indicate that it is data, rather than the end of valid data. A hexadecimal 32 denotes an acknowledge or ACK frame (figure 4c), while a hexadecimal 33 denotes a negative acknowledge or NAK frame (figure 4d). The address and data frames are sent to the computer that is receiving data. The ACK and NAK frames are sent from the receiving computer to acknowledge error-free or faulty transmission of the previous frame, respectively.*

computer to the other. This is done by specifying a local starting address of the file, the remote loading-start address, and the byte count of the file. This is accomplished by a simple command interpreter that asks for these three parameters and initiates the transfer. Data blocks are transmitted by one computer, and their reception acknowledged by the other. This is the *file-transfer mode* of the software.

The following information outlines the sequence of events leading to the transfer of a file between computers. User A dials up user B over the telephone and both computers are connected via modems. (See figure 1.) User B tells user A, via the link, the name and loading location of the desired file. The file can be a BASIC program, an assembly program, a letter, or any other kind of file.

User A types a control-F that initiates the local command interpreter, resulting in "S:" being displayed. User A keys in four hexadecimal digits (representing the source address) and a carriage return. The command interpreter types "D:" and waits for four more hexadecimal characters and a carriage return (representing the destination address).

Finally, a "#:" directs user A to type in the byte count and a carriage return; this begins the file transfer. When the transfer is complete, user A's computer returns to the linking mode. Further file transfers can then be negotiated before the telephone connection is manually broken.

During specification of the addresses and byte count, a backspace erases the previously typed character and a control-X aborts the command interpretation and returns the computer to the linking mode. Any illegal hexadecimal characters typed are ignored and the terminal bell is sounded for each occurrence.

## Communication Protocol

To insure correct interpretation of a sequential stream of bytes, a communication protocol that imposes meaning on the data stream must be specified. Computer protocols, like human protocols, are those modes of behavior agreed upon between

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parties. Bridge-bidding sequences are an example of a human protocol, although the complete protocol agreement between partners must be negotiated. Computers require precisely specified protocols.

To encode meaning into a data stream, the concept of a *frame* must be introduced. A frame is a stream of bytes with a beginning-of-frame mark, a coded portion (which determines the use of the data), the data, and an end-of-frame mark. To enable more reliable communications along a noisy channel, a *checksum* is appended to the end of the frame; this is used by the receiver to verify that no bits have been dropped. Figure 3 presents the structure of the frames selected for this file-transfer application.

**Computer protocols, like human protocols, are those modes of behavior agreed upon between parties.**

Since each byte in a stream can assume any one of 256 values, a special technique is used to denote the beginning and ending of a frame. One particular byte is selected to be the data-link escape (DLE), to signify that the next byte is to be interpreted as either start of frame (STX) or end of frame (ETX). The receiver, when seeing a DLE and a STX in series, knows that a frame has begun. When the DLE ETX pair is received, it knows that the end of frame has been reached and that the next 2 bytes contain the checksum. To preclude the appearance of a DLE STX or DLE ETX pair within the data portion of the frame, all DLEs in a data frame are doubled—that is, transmitted as DLE DLE. The receiver, seeing two sequential DLE bytes, simply discards one of them to restore the frame to its original length.

The byte following the DLE STX is assigned the function of an operation code (*opc*) that is used to give meaning to the data portion of the frame. Four types of frames are defined: an address frame (hexadecimal 30), a data frame (hexadecimal 31), an acknowledge frame (hexadecimal 32), and a negative acknowledge frame (hexadecimal 33). These four frames represent the minimum set required to successfully get a file transferred from one computer to another in a simple, yet reliable fashion.

One design possibility not used here would put the address field in the data frame so that the start-load address for each frame would be available just before its associated data. This would have eliminated the necessity for the address frame; however, it would require a buffer in the receiver equal to the length of the frame. The buffer would be used to hold the data until the checksum verified that the received data is perfect. If the data were not buffered, but was simply stored at the address specified, then an error in the address bytes would cause the data to be stored in the wrong portion of memory. With a separate address frame, the address will be verified as correct before the data arrives so that no receive buffering is required.

Following receipt of the address or data frame, the receiver returns either an acknowledge (ACK) or a negative acknowledge (NAK) frame, thus indicating whether the frame received is perfect. The sender uses this information to decide whether or not to retransmit the frame. Thus, both computers must communicate to get the whole file transferred without error.

Figure 4 illustrates the structure of each of the four types of frames. Data bytes corresponding to the code for DLE are doubled only in the data frame, which has variable length. This is unnecessary in the other three frames because they have a predefined length.

The checksum is simply a 16-bit sum of all the bytes in the frame (except the first DLE and the trailing ETX). This provides an *undetected bit-error* rate which is adequate for this application.

The frame structure is used only in file-transfer mode; in linking mode, each character is sent immediately; no error checking is considered to be necessary.

The lowest level of protocol involves the hardware interface between the two computers. In this application, the two computers are connected over an asynchronous bit-serial channel. This technique was selected for several reasons. A serial

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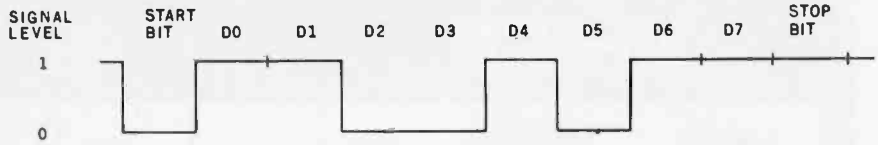


**Figure 5:** *Serial transmission of data. When transmitting data between two computers on an asynchronous serial line, the data is transmitted 1 bit at a time with each byte of data (8 bits) framed by a start bit and a stop bit; a parity bit usually comes between the last data bit ($D_7$) and the stop bit but is omitted in this application due to the error checking already provided. Here, the byte being transmitted is binary 11010011 (read from right to left).*

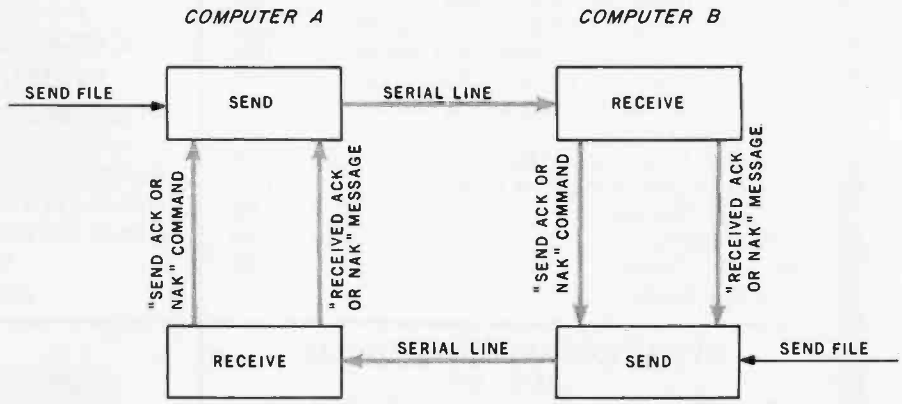


**Figure 6:** *The interconnection of send and receive software modules. When computer A sends a data frame to computer B, the receive module of computer B tells its send module to transmit an ACK frame (if the data agrees with the checksum) or a NAK frame (if it does not). This acknowledge frame is received by computer A, which then informs its send module to transmit new data, or retransmit the previous frame, as necessary.*

channel uses few wires when a direct connection is possible. For longer distances, the link can be made by a telephone line and standard modems. Also, there are integrated circuits interfacing directly to the microprocessor that can handle this format very well. Figure 5 demonstrates how 8-bit bytes are transmitted along with their start and stop bits. To improve efficiency, no parity bit is used since the checksum provides error control.

## Software Description

The software is organized into three cooperating modules: the *send routine*, the *receive routine*, and the *command interpreter*. The send and receive modules are used mainly for file transfer. The conceptual connection of these two software modules in both computers is detailed in figure 6. The send routine of computer A sends to the receive routine in computer B, and vice versa.

When the send module in A sends a frame, the receive module in B verifies the checksum and tells the send module in B to send either an ACK or a NAK back to A. The send module in B sends the ACK or NAK to A's receive module, which then informs A's send module that an ACK or a NAK was received. Thus, two flags are necessary for communicating between the send and receive modules: one commanding "send ACK or NAK," and the other stating "received ACK or NAK." A "send file" flag to the send module of A initiates the file transfer.

Note the symmetry. Because the send and receive sections in each computer are independent, and because they communicate by flags, the send output can be fed directly into the receive input in the same computer for test purposes during debugging. Files can be moved from one place in memory to another within the same machine, simulating the actions of two coupled machines.

The third module of code is the command interpreter, which is used to specify the source starting address,

*Text continued on page 266*

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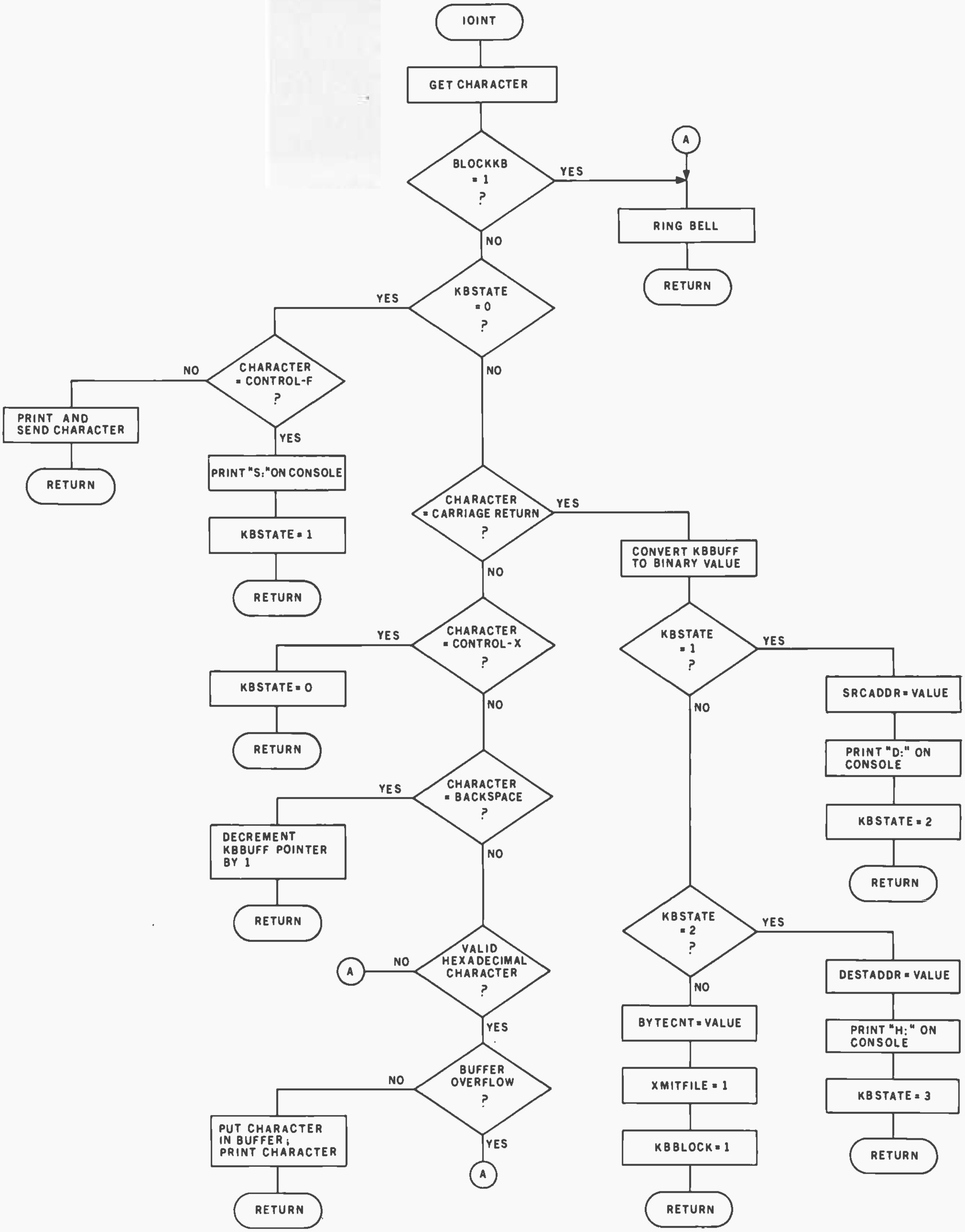


**Figure 7:** *Flowchart for the command interpreter, IOInt. This routine gathers the information necessary to initiate the transfer of a given block of information between computers. An interrupt from the keyboard causes this routine to be executed (from the beginning) every time a key is pressed. The value of KBSTATE (keyboard state) causes the routine to ask for the starting address of the block to be sent (with the prompt "S:"). This is followed by a request for the destination address for the first byte (prompted with "D:"), and the number of bytes to be transferred (prompted with "#:"). Once this information has been given, the routine disables the keyboard from further input (KBBLOCK=1) and sets a flag that tells the software send module to begin sending the block of data (XMITFILE=1).*

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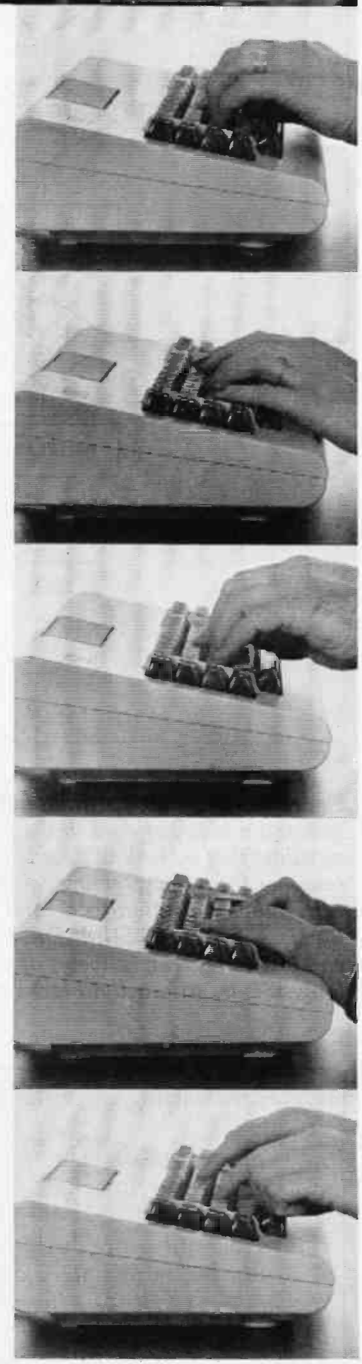

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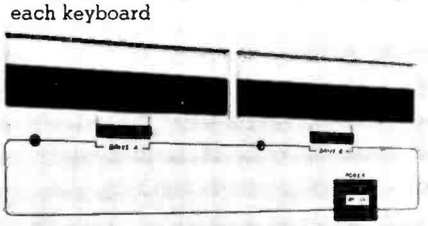

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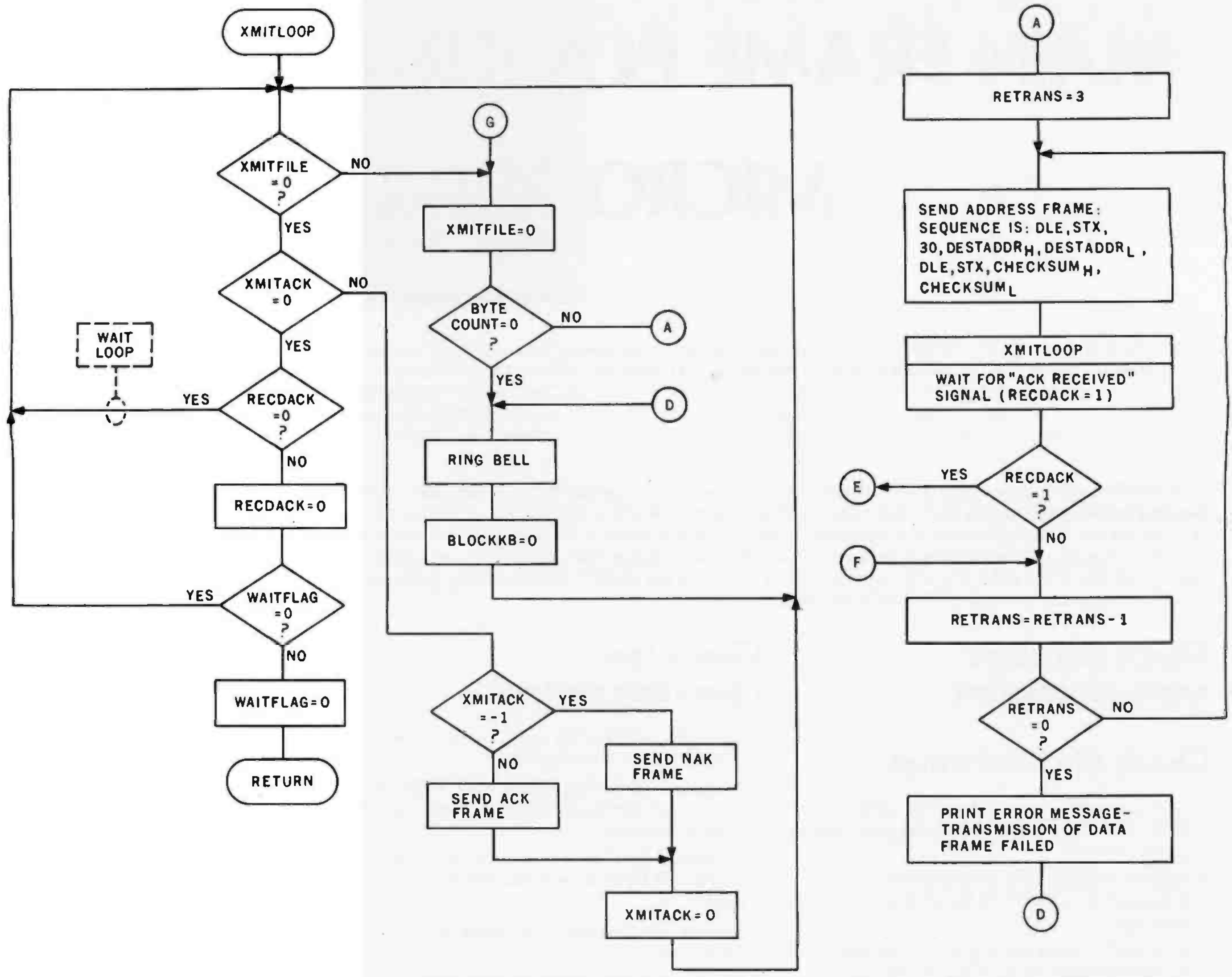


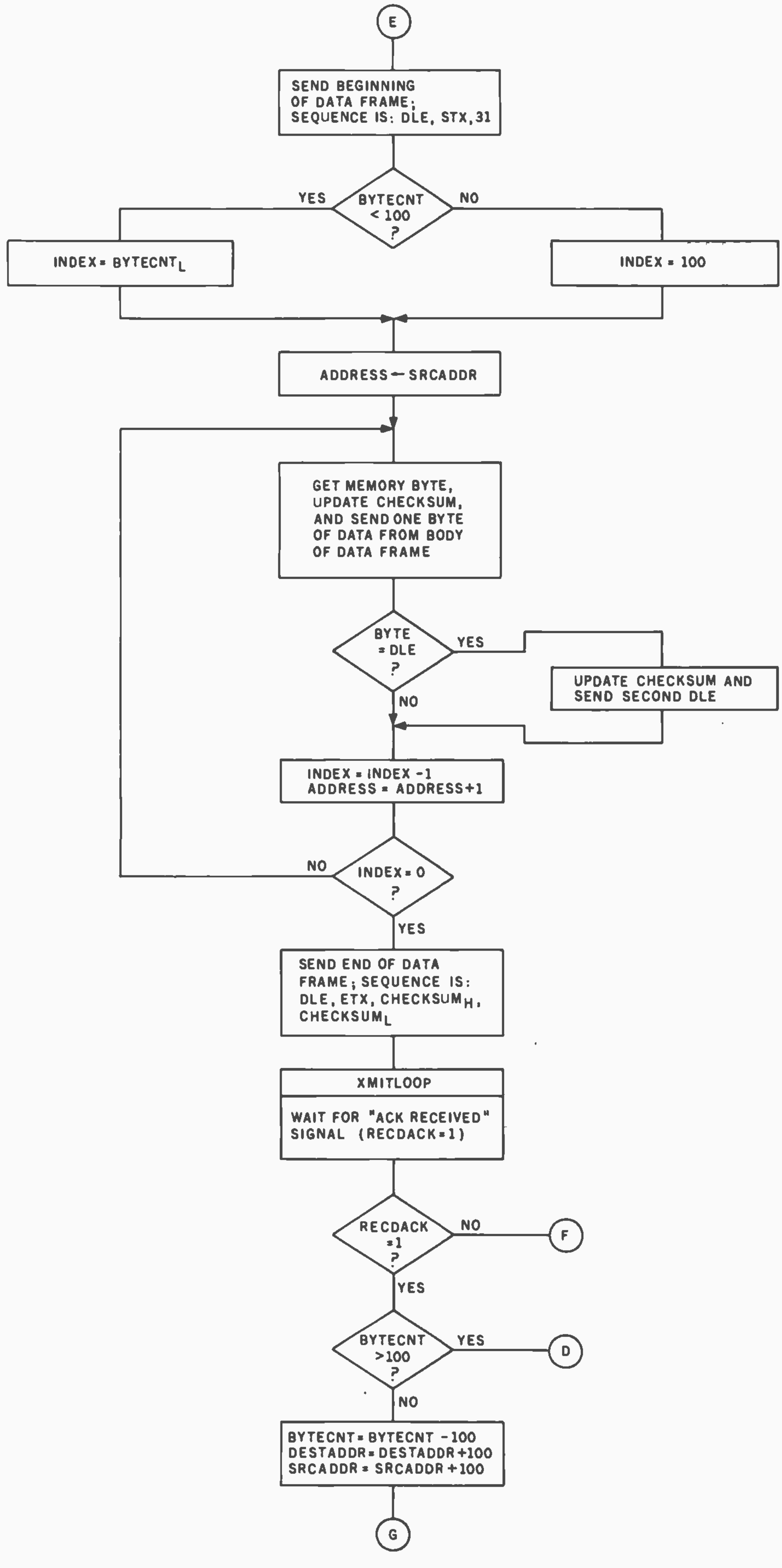

**Figure 8:** *Flowchart for the send module. This routine, when activated by the condition XMITFILE=1, causes the computer to transmit a block of data in the form of an address frame, followed by a data frame. It waits in a loop until XMITFILE is set to 1, signaling that a block of data is ready to be transmitted. It then sends the address data frames, waiting after each for an ACK frame response from the receiving computer. If either frame is received imperfectly, the process begins again with the address frame. Software limits repetition to a total of three tries. All numbers used in this figure are hexadecimal. Also, the variables ADDRESS, BYTECNT, CHECKSUM, DESTADDR, INDEX, and SRCADDR are all 2-byte variables. The subscripts H and L refer to the high and low bytes, respectively, of a 2-byte variable. If the block to be transmitted is more than decimal 256 (hexadecimal 100) bytes long, it is transmitted in blocks of 256 bytes.*

## On Flowcharting Interrupt-Driven Routines

*The perceptive reader may notice that the flowchart of figure 9 (on page 266) does not have a return or end block. Although it may not be immediately obvious, the same is true of the flowchart in figure 8. (The one return block that does exist is used only when the XmitLoop routine is returning from calling itself.) The reason for this and other seeming omissions has to do with the function of interrupts in the data-link routines.*

*When the data-link software (see listing 1) is running, it is usually in the XmitLoop routine, repeating the wait loop marked in the flowchart of XmitLoop. (See figure 8.) If an interrupt comes from the keyboard, control transfers to the IOInt routine, flowcharted in figure 7, and returns to the routine that was executing before the interrupt.*

*If an interrupt comes from the serial line, control transfers to some location within the LineInput routine, but, instead of starting at the beginning of the routine (as is done with the IOInt routine), control transfers to the instruction directly after the "bsr GetByte" (branch to GetByte subroutine) instruction most previously executed. (See figure 9.) This can be accomplished because the GetByte subroutine stores the return address in the variable ACIAState; it is this address that is jumped to upon a serial line interrupt (see routine IOInt in listing 1).*

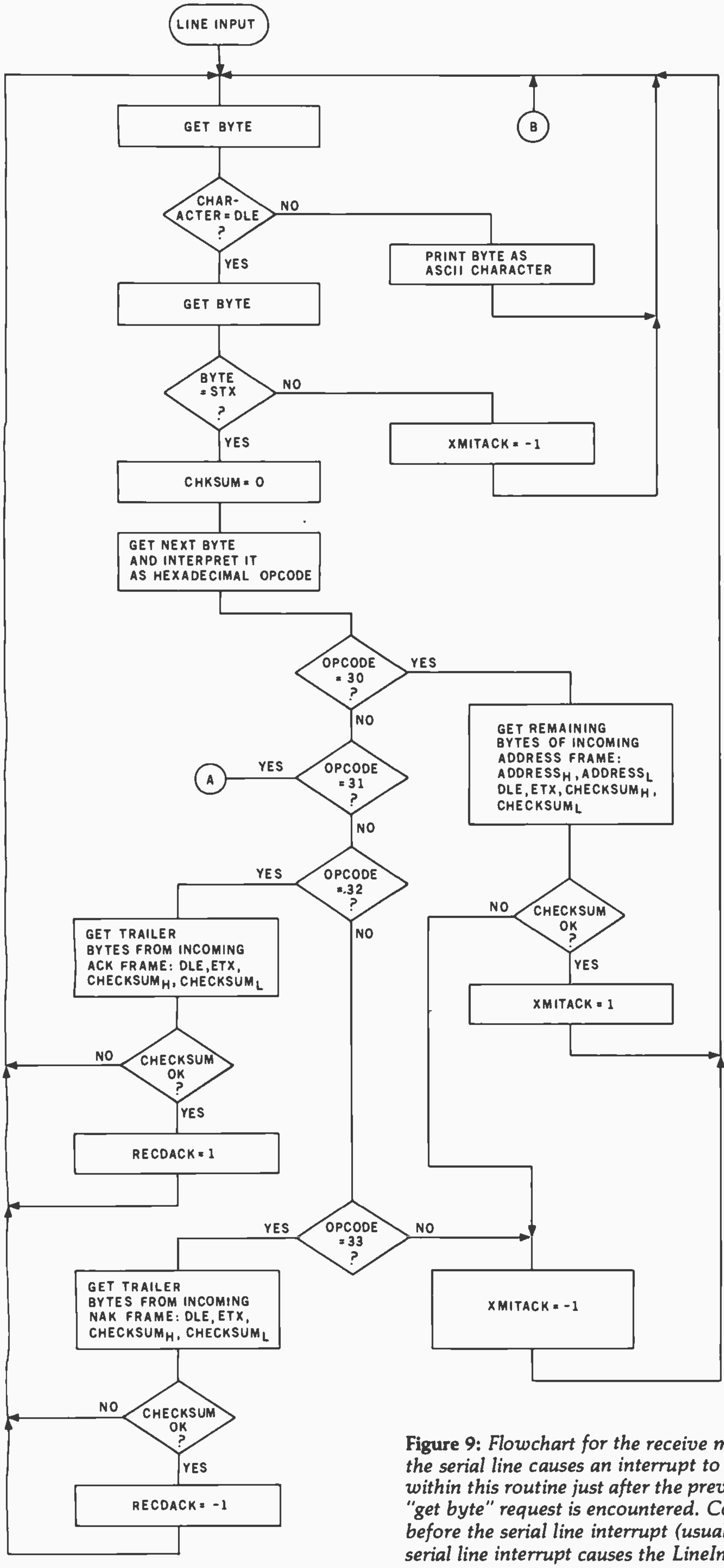

E
SEND BEGINNING OF DATA FRAME; SEQUENCE IS: DLE, STX, 31
BYTECNT < 100 ?
YES
NO
INDEX = BYTECNT$_L$
INDEX = 100
ADDRESS ← SRCADDR
GET MEMORY BYTE, UPDATE CHECKSUM, AND SEND ONE BYTE OF DATA FROM BODY OF DATA FRAME
BYTE = DLE ?
YES
UPDATE CHECKSUM AND SEND SECOND DLE
NO
INDEX = INDEX -1
ADDRESS = ADDRESS+1
INDEX = 0 ?
NO
YES
SEND END OF DATA FRAME; SEQUENCE IS: DLE, ETX, CHECKSUM$_H$, CHECKSUM$_L$
XMITLOOP
WAIT FOR "ACK RECEIVED" SIGNAL (RECDACK = 1)
RECDACK = 1 ?
NO
F
YES
BYTECNT >100 ?
YES
D
NO
BYTECNT = BYTECNT -100
DESTADDR = DESTADDR +100
SRCADDR = SRCADDR +100
G

*Text continued from page 260:*
the destination starting address, and the byte count. This code is activated by a control-F character depressed on the keyboard. The final carriage return sets the XMITFILE flag, which is polled by the background send routine.

## Command Interpreter Structure

Figure 7 presents the flowchart for the command interpreter, IOInt, which is driven by interrupt signals received from the keyboard.

Each character from the keyboard generates an interrupt, which starts the command interpreter. If the send module is currently sending a file, as evidenced by the relation "BLOCKKB > 0", then the character is to be ignored and is merely echoed as a bell.



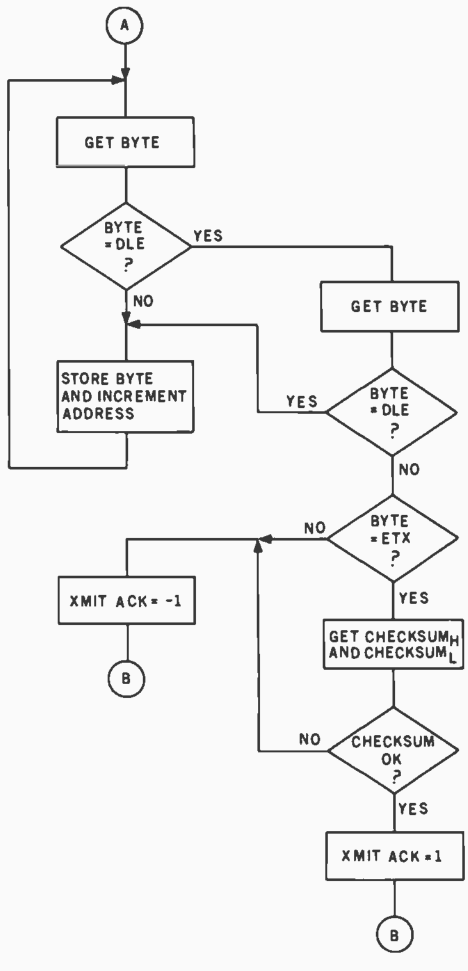




**Figure 9:** *Flowchart for the receive module, LineInput. Whenever an incoming byte on the serial line causes an interrupt to occur, control of the program transfers to a point within this routine just after the previous "get byte" request, and executes until another "get byte" request is encountered. Control then returns to the routine that was running before the serial line interrupt (usually the wait loop marked in figure 8) until another serial line interrupt causes the LineInput routine to resume execution where it stopped. This routine stops for every byte of an ACK, NAK, address, or data frame.*

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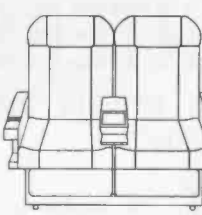

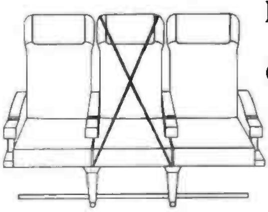

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The operation of the interpreter is a function of the state variable, KBSTATE. If the state is zero, the transparent mode case, the character is echoed locally and sent to the remote computer. Otherwise, the character is tested for being a carriage return (CR).

The carriage return causes the keyboard buffer (which collects address or byte-count hexadecimal characters) to be converted to a binary value. If the character is a control-X, the interpreter mode is aborted and KBSTATE is returned to zero.

If the character is a BS (backspace), the pointer into the keyboard buffer is decremented (after first checking for underflow). If none of the above is true, the character is checked for being a proper hexadecimal character and is then put in the keyboard buffer (after checking for overflow). The keyboard buffer holds as many as four hexadecimal characters, which is the largest buffer needed to specify a 16-bit address or a byte count.

The sequence of characters echoed on the terminal following the carriage return, as well as the location of the binary value, are dependent on the current state of the interpreter. After each carriage return, the state is incremented to ensure that the correct control path is executed for each of the three parameters collected. Finally, the last carriage return after the byte count specification sets the BLOCKKB flag and the XMITFILE flag. The BLOCKKB flag prevents any keyboard characters from appearing on the line during a file transfer. The XMITFILE flag tells the send module to begin sending the specified file.

### Send Routine Structure

The send module, XmitLoop, is responsible for sending address, data, ACK, and NAK frames to the remote receive module. Figure 8 shows the flowchart for the program flow of the send routine. This routine operates in background mode, testing three flags to see if any work is pending. If the XMITACK flag is −1, a NAK frame is sent; if it is +1, an ACK frame is sent.

If the RECDACK flag is not zero, and the send routine is waiting for an ACK or a NAK, then a return is made to the data transfer routine to complete the data or address frame transfer. (This will be explained in more detail later.) If the XMITFILE flag is non-zero, then file transfer begins.

As explained earlier, the address frame is sent first so that no buffering in the receiver is necessary in case of an address error. Once the address is correctly received and acknowledged, a data frame is sent. If the data frame is acknowledged, the next address and data frames are sent, and the process is repeated.

If a NAK frame is received, then the address frame received in error is retransmitted and verified before the data block is retransmitted. When sending either an address or a data frame, the send routine employs the same mechanism in waiting for an ACK or NAK. When the wait for an ACK or NAK signal is necessary, the send module XmitLoop calls itself by storing the return address on the stack and branching to the beginning of the routine. When the send routine finds that the RECDACK flag is set, control is returned to the proper location in the send routine via an RTS (return from subroutine) instruction. The RECDACK flag indicates whether a new frame should be sent or the old one retransmitted.

A retransmission index is maintained and decremented each time a frame retransmission is necessary, and no more than three retransmissions are allowed. (The number of retransmissions allowed is a parameter that is easily changed.) If more than three failures occur, an error message is typed on the sender's console and control returns to the transparent mode. When all of the file has been successfully transmitted, control returns to transparent mode and the keyboard is enabled.

In data frames, data bytes that happen to have the same hexadecimal value as the DLE code are doubled (repeated) so that a false end of frame is prevented; the receive routine drops the second DLE so that the data is received correctly. In the worst case, this has the effect of doubling the length of the frame.

### Receive Routine Structure

The flowchart for the receive program, named LineInput, is shown in figure 9. This routine handles the in-

*Text continued on page 286*

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**Listing 1:** *Software for data transfer between two 6800-based systems linked by a serial line. The software here consists primarily of a data-sending routine (labeled XmitLoop), a data-receiving routine (labeled LineInput), and a command interpreter (labeled IOInt). All numbers preceded by a dollar sign ($) are hexadecimal numbers. Also, references to '0, '1, '2, and '3 are actually to the characters "0", "1", "2", and "3". These characters, when represented in ASCII, have values of hexadecimal 30, 31, 32, and 33 and are referred to in text and in flowcharts as such. Flowcharts 7 thru 9 correspond to the code given in this listing.*

```
0090   dle          equ         $90          dle char
0083   etx          equ         $83          etx char
0082   stx          equ         $82          stx char
0007   bell         equ         7            bell char
0018   ^X           equ         $18          control X
0006   ^F           equ         6            control F
0008   bs           equ         8            backspace
000D   cr           equ         $d           carriage return
0018   IOPtr        equ         $18          I/O interrupt vector
F900   AciaCsr1     equ         $f900        Acia to terminal
F901   AciaData1    equ         $f901
F902   AciaCsr2     equ         $f902        Acia to modem
F903   AciaData2    equ         $f903
0050   SaveOpc      equ         $50          place to save opc
0051   AciaState    equ         $51          state of acia fsm
0054   SrcAddr      equ         $54          ftp source address
0056   DestAddr     equ         $56          ftp destination addr
0058   ByteCnt      equ         $58          ftp byte count
005B   BinVal       equ         $5b          place to save number
005D   KbPtr        equ         $5d          ptr into KbBuff
005F   KbBuff       equ         $5f          4 char buffer
0062   KbEnd        equ         $62          end of buffer
0063   ChkSum       equ         $63          xmit checksum, recv side
0065   RecdChk      equ         $65          recd checksum, recv side
006A   KbState      equ         $6a          state of kb handler
006B   RecdAck      equ         $6b          flag - recd ack
006C   XmitAck      equ         $6c          flag - send ack
006D   XmitFile     equ         $6d          flag - send file
006E   WaitFlag     equ         $6e          flag - wait for ack/nack
006F   BlockKb      equ         $6f          flag - blocks kb activ
0075   SaveSum      equ         $75          place to save checksum
0077   XChkSum      equ         $77          xmitted checksum
0079   Address      equ         $79          recv store address

1000                            org          $1000

                    * Entry point
1000   86 03        Start       lda a        #3          reset Acia's
1002   B7 F900                  sta a        AciaCsr1
1005   B7 F902                  sta a        AciaCsr2
1008   86 96                    lda a        #$96        /64,8 bits, interr
100A   B7 F900                  sta a        AciaCsr1
100D   B7 F902                  sta a        AciaCsr2
1010   CE 11CD                  ldx          #InzAcia    set up acia2 entry
1013   DF 51                    stx          AciaState
1015   CE 1102                  ldx          #IOInt
1018   DF 18                    stx          IOPtr
101A   86 06                    lda a        #6          clear the flags
101C   CE 006A                  ldx          #KbState    start of area
101F   6F 00        inzloop     clr          x
1021   08                       inx
1022   4A                       dec a
1023   26 FA                    bne          inzloop
1025   CE 005F                  ldx          #KbBuff     inz the buffer ptr
1028   DF 5D                    stx          KbPtr
102A   01                       nop
102B   0E                       cli

                    * Background routine - checks event entries
102C   96 6D        XmitLoop    lda a        XmitFile    xmit file event?
102E   26 2A                    bne          InzAddr
1030   CE 1267                  ldx          #NackFrm    ptr to Nack frame
1033   96 6C                    lda a        XmitAck     xmit ack/nack event?
1035   26 0F                    bne          GoAck
1037   D6 6B                    lda b        RecdAck     recd ack/nack event?
```

*Listing 1 continued on page 272*

*Listing 1 continued:*

```
1039  27 F1              beq     XmitLoop
103B  97 6B              sta a   RecdAck   clear the event
103D  96 6E              lda a   WaitFlag
103F  27 FB              beq     XmitLoop
1041  7F 006E            clr     WaitFlag  clear the flag
1044  17                 tba               reg a is ack/nack flag
1045  39                 rts               return to waiting routine

                * Routine for sending Ack/Nack frame
1046  2B 03    GoAck     bmi     Skpldx    send nack?
1048  CE 1260            ldx     #AckFrm   send ack!
104B  C6 07    Skpldx    lda b   #7        frame byte count
104D  A6 00    FrmLoop   lda a   x         get byte
104F  BD 10EA            jsr     SendChar  send out
1052  08                 inx
1053  5A                 dec b
1054  26 F7              bne     FrmLoop
1056  D7 6C              sta b   XmitAck   clear the event
1058  20 D2    Fin4      bra     XmitLoop

                * Routine for sending Address frame
105A  7F 006D  InzAddr   clr     XmitFile  clear flag
105D  DE 58              ldx     ByteCnt   check for null
105F  27 51              beq     LastBlk
1061  C6 03              lda b   #3        retransmission index
1063  37       GoAddr    psh b             save it
1064  C6 30              lda b   #'0       opcode byte
1066  8D 52              bsr     SendHdr   send dle,stx,opc
1068  96 56              lda a   DestAddr  send out addr bytes
106A  8D 73              bsr     UpdtChk
106C  96 57              lda a   DestAddr+1
106E  8D 6F              bsr     UpdtChk
1070  8D 59              bsr     SendT1    send dle,etx,cc - wait
                * there is a wait for ack/nack here
1072  33                 pul b             get retrans index
1073  4D                 tst a             check ack/nack flag
1074  2B 33              bmi     RetryBlk  branch if ack

                * Routine for sending block of data
1076  37       GoFile    psh b             save retrans index
1077  C6 31              lda b   #'1       opcode
1079  8D 3F              bsr     SendHdr   send dle,stx,opc
107B  5F                 clr b             inz byte count index
107C  96 58              lda a   ByteCnt   chk upper byte
107E  26 02              bne     SkipLd
1080  D6 59              lda b   ByteCnt+1 < 256 bytes left
1082  DE 54    SkipLd    ldx     SrcAddr
1084  37       SendBytes psh b             save it
1085  A6 00              lda a   x         get byte
1087  33                 pul b             restore
1088  8D 55              bsr     UpdtChk   update checksum, send
108A  81 90              cmp a   #dle      check for dle
108C  26 02              bne     FinDoub
108E  8D 4F              bsr     UpdtChk   update checksum, send
1090  08       FinDoub   inx
1091  5A                 dec b             check byte count
1092  26 F0              bne     SendBytes
1094  8D 35              bsr     SendT1    send dle,etx,cc - wait
                * there is a wait for ack/nack here
1096  33                 pul b             get retrans index
1097  4D                 tst a             check ack/nack flag
1098  2B 0F              bmi     RetryBlk  check for failure
109A  96 58              lda a   ByteCnt   check for done
109C  27 14              beq     LastBlk
109E  7A 0058            dec     ByteCnt   decrease by 256 bytes
10A1  7C 0056            inc     DestAddr  increase by 256 bytes
10A4  7C 0054            inc     SrcAddr   increase by 256 bytes
10A7  20 B1              bra     InzAddr
10A9  5A       RetryBlk  dec b
10AA  26 B7              bne     GoAddr
10AC  CE 126E  Error     ldx     #ErrorMsg print error msg
10AF  BD 11B2            jsr     OutText
```

*Listing 1 continued on page 274*

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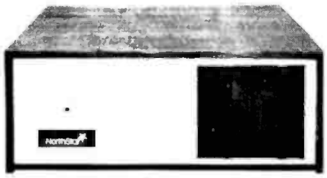

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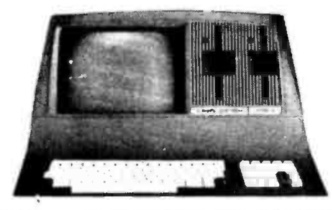

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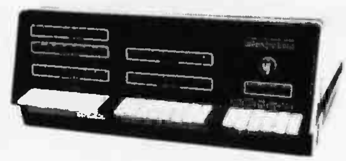

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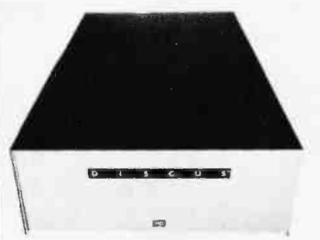

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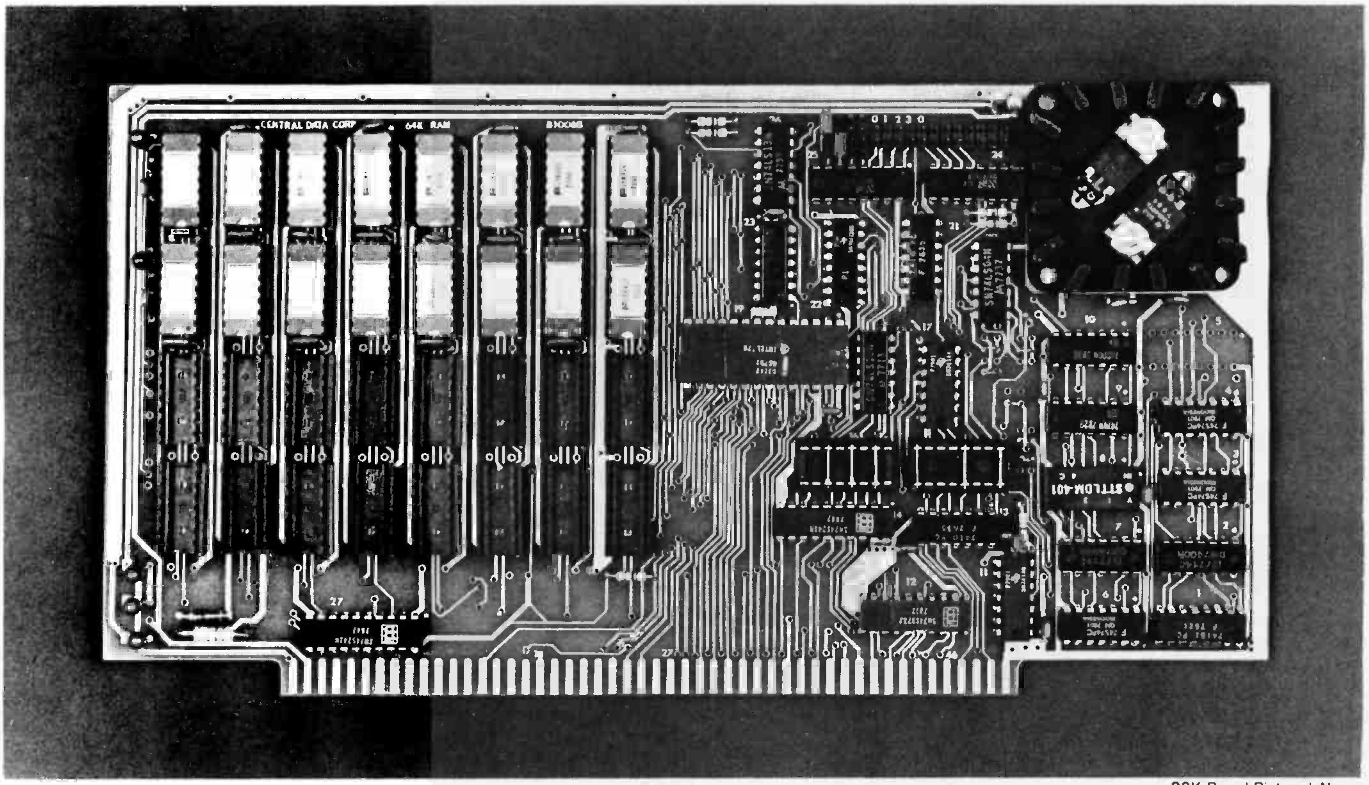
*Listing 1 continued:*

```
1082   86 07      LastBlk   lda a     #bell     ring the bell
1084   8D 41                bsr       SendTerm  send bell to term
1086   D7 6F                sta b     BlockKb   unlock the kb
1088   20 9E      Fin2      bra       Fin4      end of file xfer

                  * Subroutine which sends out dle,stx, and inz checksum
108A   86 90      SendHdr   lda a     #dle      dle char
108C   8D 2C                bsr       SendChar  send dle
108E   4F                   clr a
108F   97 77                sta a     XChkSum   inz checksum
10C1   97 78                sta a     XChkSum+1
10C3   86 82                lda a     #stx
10C5   8D 18                bsr       UpdtChk   send stx
10C7   17                   tba
10C8   8D 15                bsr       UpdtChk   send opcode
10CA   39                   rts

                  * Subroutine which sends out dle,etx,cc1,cc2
                  * and sets up wait for ack/nack
10CB   86 90      SendT1    lda a     #dle
10CD   97 6E                sta a     waitFlag  indicate waiting ack/nack
10CF   8D 0E                bsr       UpdtChk   send out dle
10D1   86 83                lda a     #etx
10D3   8D 15                bsr       SendChar  send out etx
10D5   96 77                lda a     XChkSum
10D7   8D 11                bsr       SendChar  send high byte
10D9   96 78                lda a     XChkSum+1
10DB   8D 0D                bsr       SendChar  send low byte
10DD   20 D9                bra       Fin2      go to idle loop

10DF   36         UpdtChk   psh a
10E0   9B 78                add a     XChkSum+1
10E2   24 03                bcc       SkpH
10E4   7C 0077              inc       XChkSum
10E7   97 78      SkpH      sta a     XChkSum+1
10E9   32                   pul a

10EA   37         SendChar  psh b               save it
10EB   F6 F902              lda b     AciaCsr2  get status
10EE   C4 02                and b     #2        test for xmit ready
10F0   27 F9                beq       SendChar+1
10F2   B7 F903              sta a     AciaData2
10F5   33                   pul b               restore reg
10F6   39                   rts

10F7   F6 F900    SendTerm  lda b     AciaCsr1  get status
10FA   C4 02                and b     #2        test for transmit rdy
10FC   27 F9                beq       SendTerm  wait for ready
10FF   B7 F901              sta a     AciaData1
1101   39                   rts

                  * Entry point for the I/O interrupt

1102   B6 F902    IOInt     lda a     AciaCsr2  get status
1105   2A 07                bpl       KbInt     chk for acia interr
1107   B6 F903    Acia2Int  lda a     AciaData2 get line data
110A   DE 51                ldx       AciaState
110C   6E 00                jmp       x         go to ACIA routine
110E   B6 F901    KbInt     lda a     AciaData1 get kb data
1111   84 7F                and a     #$7f      kill parity bit
1113   D6 6F                lda b     BlockKb   chk if sending file
1115   27 05                beq       ChkCli
1117   86 07      OutBell   lda a     #bell
1119   8D DC      OutTerm   bsr       SendTerm  send char to term
111B   3B                   rti                 return
111C   D6 6A      ChkCli    lda b     KbState
111E   26 13                bne       Cli
1120   81 06                cmp a     #^F
1122   27 05                beq       StartCli
1124   8D D1                bsr       SendTerm  send char to term
1126   8D C2                bsr       SendChar
1128   3B                   rti                 return
1129   CE 127B    StartCli  ldx       #SrcTxt   output S?
```

*Listing 1 continued on page 276*



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Circle 173 on inquiry card.

*Listing 1 continued:*

```
112C  BD 11B2            jsr     OutText
112F  7C 006A            inc     KbState
1132  3B                 rti                 return
1133  81 0D     Cli      cmp a   #cr         check for CR
1135  27 46              beq     Convert
1137  81 18              cmp a   #^X         check for ctrl x
1139  27 29              beq     Cancel
113B  81 08              cmp a   #bs         check for backspace
113D  27 32              beq     BackUp
113F  36                 psh a               save for display
1140  80 30              sub a   #$30        check for valid hex char
1142  2B 1D              bmi     BadChar
1144  81 09              cmp a   #9
1146  2F 0A              ble     CharOK
1148  81 31              cmp a   #$31
114A  2B 15              bmi     BadChar
114C  81 36              cmp a   #$36
114E  2E 11              bgt     BadChar
1150  80 27              sub a   #$27
1152  DE 5D     CharOK   ldx     KbPtr       check for overflow
1154  8C 0063            cpx     #KbEnd+1
1157  27 08              beq     BadChar
1159  A7 00              sta a   x
115B  08                 inx
115C  DF 5D              stx     KbPtr
115E  32                 pul a               get original char
115F  20 88              bra     OutTerm     echo for display
1161  32        BadChar  pul a               pull off stack
1162  20 83              bra     OutBell
1164  CE 1275   Cancel   ldx     #CRLF       output a cr, lf
1167  8D 49              bsr     OutText
1169  97 6A              sta a   KbState     clr KbState
116B  CE 005F   InzPtr   ldx     #KbBuff
```

*Listing 1 continued on page 278*

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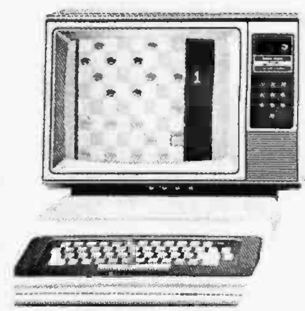

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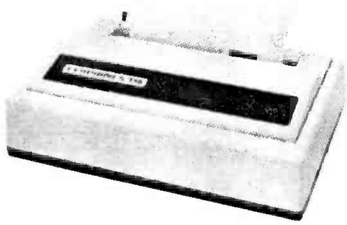

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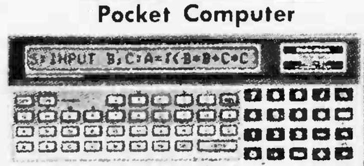

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Circle 175 on inquiry card.

*Listing 1 continued:*

```
116E  DF 5D               stx     KbPtr       inz ptr
1170  3B                  rti                 return
1171  DE 5D     BackUp    ldx     KbPtr       check for underflow
1173  8C 005F             cpx     #KbBuff
1176  27 9F               beq     OutBell
1178  09                  dex                 decr KbPtr
1179  DF 5D               stx     KbPtr
117B  20 9C               bra     OutTerm
117D  CE 005F   Convert   ldx     #KbBuff     point at buffer
1180  8D 3A               bsr     Byte        get a byte
1182  97 5B               sta a   BinVal      put in ms byte
1184  8D 36               bsr     Byte        get a byte
1186  97 5C               sta a   BinVal+1
1188  DE 5B               ldx     BinVal      get binary number
118A  96 6A               lda a   KbState     check fsm state
118C  81 01               cmp a   #1
118E  26 07               bne     Try2
1190  DF 54               stx     SrcAddr
1192  CE 127D             ldx     #DestTxt    display D:
1195  20 09               bra     DispText
1197  81 02     Try2      cmp a   #2
1199  26 0C               bne     Try3
119B  DF 56               stx     DestAddr
119D  CE 1282             ldx     #BCntTxt    display #:
11A0  8D 10     DispText  bsr     OutText
11A2  7C 006A             inc     KbState
11A5  20 C4               bra     InzPtr
11A7  DF 58     Try3      stx     ByteCnt     save byte count
11A9  7F 006A             clr     KbState
11AC  97 6D               sta a   XmitFile    set send file event
11AE  97 6F               sta a   BlockKb     lock the kb
11B0  20 B9               bra     InzPtr

11B2  A6 00     OutText   lda a   x           get char
11B4  27 13               beq     Retn6
```

*Listing 1 continued on page 280*





Circle 176 on inquiry card.

Circle 177 on inquiry card. →

*Listing 1 continued:*

```
11B6  BD 10F7           jsr     SendTerm  send char to term
11B9  08                inx
11BA  20 F6             bra     OutText

11BC  A6 00    Byte     lda a   x
11BE  08                inx
11BF  48                asl a
11C0  48                asl a
11C1  48                asl a
11C2  48                asl a
11C3  36                psh a
11C4  A6 00             lda a   x
11C6  08                inx
11C7  33                pul b
11C8  1B                aba
11C9  39       Retn6    rts
               * Routine which handles incoming ACIA characters
11CA  BD 124F  LineInput jsr    GetByte   get next char
11CD  81 90    InzAcia  cmp a   #dle      check for dle char
11CF  27 05             beq     FrameSt
11D1  BD 10F7  Out      jsr     SendTerm  send char to term
11D4  20 F4             bra     LineInput
11D6  8D 77    FrameSt  bsr     GetByte
11D8  81 82             cmp a   #stx      check for stx char
11DA  26 6D             bne     ErrNack
11DC  5F                clr b
11DD  D7 63             sta b   ChkSum
11DF  D7 64             sta b   ChkSum+1  zero the checksum
11E1  8D 6C             bsr     GetByte
11E3  97 5F             sta a   SaveOpc   save opcode
11E5  81 30             cmp a   #'0       check for addr frame
11E7  27 0E             beq     AddrFrm
11E9  81 31             cmp a   #'1       check for data frame
```

*Listing 1 continued on page 282*

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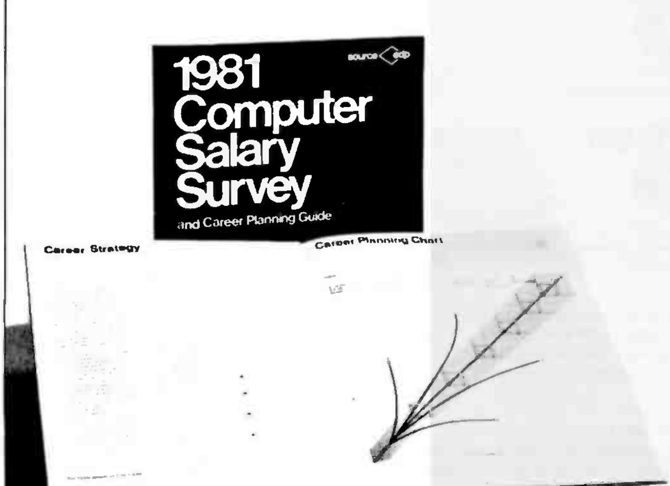


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Circle 179 on inquiry card.

*Listing 1 continued:*

```
11EB  27 43              beq     DataFrm
11ED  81 32              cmp a   #'2         check for ack frame
11EF  27 0E              beq     VerChk
11F1  81 33              cmp a   #'3         check for nack frame
11F3  27 0A              beq     VerChk
11F5  20 52              bra     ErrNack     bad frame
11F7  8D 56    AddrFrm   bsr     GetByte     get upper addr byte
11F9  97 79              sta a   Address
11FB  8D 52              bsr     GetByte     get lower addr byte
11FD  97 7A              sta a   Address+1
11FF  8D 4E    VerChk    bsr     GetByte     get dle
1201  8D 4C              bsr     GetByte     get etx
1203  DE 63    Verify    ldx     ChkSum      save the checksum
1205  DF 75              stx     SaveSum
1207  8D 46              bsr     GetByte     get upper checksum
1209  97 65              sta a   RecdChk
120B  8D 42              bsr     GetByte     get lower checksum
120D  97 66              sta a   RecdChk+1
120F  C6 01              lda b   #1          1 => Ack
1211  DE 65              ldx     RecdChk
1213  9C 75              cpx     SaveSum
1215  27 01              beq     SkpCrt
1217  50                 neg b               -1 => Nack
1218  96 50    SkpCrt    lda a   SaveOpc     get opcode
121A  84 02              and a   #2          ignore bit 0
121C  27 0E              beq     SendAck
121E  5D                 tst b
121F  2B 07              bmi     SetRAck     error => recd Nack
1221  96 50              lda a   SaveOpc     get opcode
1223  81 32              cmp a   #'2         check for recd Ack
1225  27 01              beq     SetRAck
1227  50                 neg b               -1 => recd Nack
               * RecdAck: 0 => nop, 1 => recd Ack, -1 => recd Nack
1228  D7 63    SetRAck   sta b   RecdAck
122A  20 9E    Fin3      bra     LineInput
```

*Listing 1 continued on page 284*

*Listing 1 continued:*

```
122C  D7 6C    SendAck   sta b     XmitAck
               * XmitAck: 0 => nop, 1 => xmit Ack, -1 => xmit Nack
122E  20 9A              bra       LineInput
1230  8D 1D    DataFrm   bsr       GetByte
1232  81 90              cmp a     #dle      check for doubled dle
1234  27 09              beq       ChkDble
1236  DE 79    OkDble    ldx       Address
1238  A7 00              sta a     x         store byte
123A  08                 inx
123B  DF 79              stx       Address
123D  20 F1              bra       DataFrm
123F  8D 0E    ChkDble   bsr       GetByte   throw away first dle
1241  81 90              cmp a     #dle
1243  27 F1              beq       OkDble
1245  81 83              cmp a     #etx      check for frame end
1247  27 BA              beq       Verify    frame error
1249  86 FF    ErrNack   lda a     #-1       send Nack event
124B  97 6C              sta a     XmitAck
124D  20 DB              bra       Fin3
               * Exit routine which saves the return address,
               *   updates the checksum, and does rti
124F  30       GetByte   tsx
1250  EE 00              ldx       x         get entry point
1252  DF 51              stx       AciaState save return addess
1254  31                 ins
1255  31                 ins                 get off stack
1256  9B 64              add a     ChkSum+1
1258  24 03              bcc       SkpUpper
125A  7C 0063            inc       ChkSum
125D  97 64    SkpUpper  sta a     ChkSum+1
125F  3B                 rti                 return

1260     90    AckFrm    fcb       dle,stx,'2,dle,etx,1,$44
1261     82
1262     32
1263     90
1264     83
1265     01
1266     44

1267     90    NackFrm   fcb       dle,stx,'3,dle,etx,1,$45
1268     82
1269     33
126A     90
126B     83
126C     01
126D     45

126E     20    ErrorMsg  fcc       / Failed/
126F     46
1270     61
1271     69
1272     6C
1273     65
1274     64
1275     0D    CRLF      fcb       $d,$a,0
1276     0A
1277     00
1278     20    SrcTxt    fcc       / S: /
1279     53
127A     3A
127B     20
127C     00              fcb       0
127D     20    DestTxt   fcc       / D: /
127E     44
127F     3A
1280     20
1281     00              fcb       0
1282     20    BCntTxt   fcc       / #: /
1283     23
1284     3A
1285     20
1286     00              fcb       0
                         end
```

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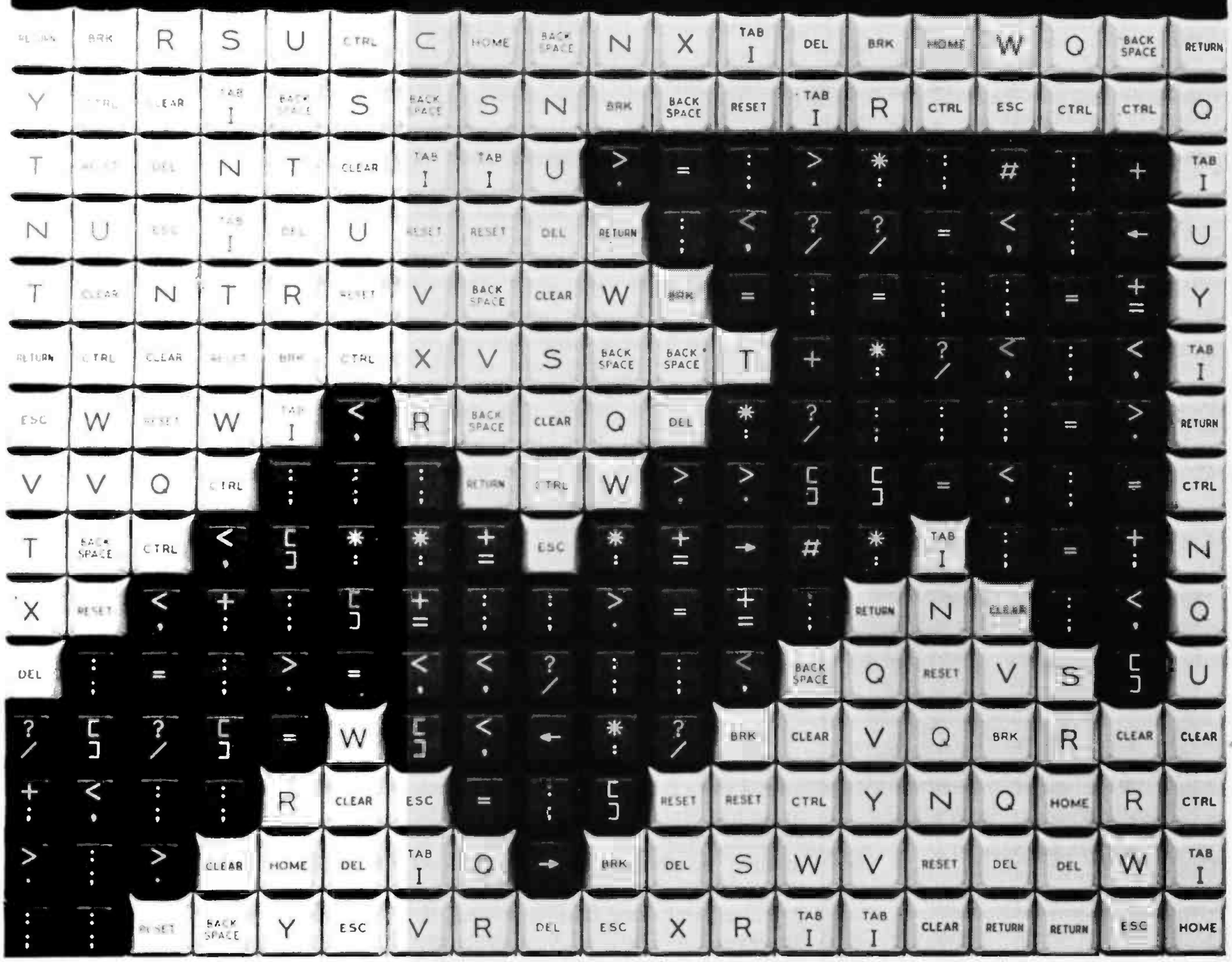

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NCC'81

Circle 182 on inquiry card.

*Text continued from page 268:*

put from the serial line; it detects frames, parses them, and performs the appropriate action. The state of the receive program is saved whenever calls to GETBYTE are made. (It is conceptually easier to imagine that a call to GETBYTE results in a wait followed by a return with the next input byte from the line. Actually, a call to GETBYTE results in the storing of the return address in ACIASTATE and the execution of a return from interrupt instruction. The next line input interrupt then causes a branch to the address in ACIASTATE, which reenters the receive routine at the right place to process the next incoming byte.)

Incoming bytes are first checked sequentially for the presence of DLE bytes. If a byte is not a DLE, it is printed on the local terminal. Otherwise, the DLE signals the beginning of a frame, and the STX and opcode bytes are received and checked.

An opcode of hexadecimal 30 implies that the next 2 bytes are to be stored in ADDRESS, high-order byte first. The checksum is then tested. If it is correct, the XMITACK flag is set to 1; otherwise, the XMITACK is set to −1. The send module will eventually notice this work request and issue either an ACK or a NAK frame.

An opcode of hexadecimal 31 implies a data frame. Since the start address has already been verified in the address frame, data bytes are stored in their proper memory locations as they arrive. When a DLE DLE is detected, only one DLE is stored. If, however, a DLE ETX is detected (denoting an end of frame), the checksum is verified and and XMITACK flag is set accordingly.

An opcode of hexadecimal 32 implies receipt of an ACK frame, and an opcode of hexadecimal 33 implies receipt of a NAK frame. Both are verified for accuracy by comparing the computed checksum to the received checksum, and the RECDACK flag is set accordingly. This informs the send module whether the next address or data frame may or may not be sent.

At the end of each frame, control returns to the beginning of the receive program so that the next frame (or stream of keyboard characters) may be properly interpreted.

## Debugging

Debugging is best accomplished if the code can be separated into modules that can be tested independently. As indicated earlier, there are three major modules: the command interpreter, the send routine, and the receive routine. I have found the following order to be the easiest way to debug the program routines:

- the transparent mode routine
- the receive routine
- the command interpreter
- the send routine

The computer was connected to itself, as described earlier, for testing purposes; this was done by connecting the transmit line of the send routine to the receive line of the receive routine. In this way, I was able to confine bugs to only one machine.

Proper operation of the transparent mode code is verified by the double echo on the terminal. Each character typed in is echoed on the console from the send routine. The character is then sent on the line, where it is received by the receive routine and again typed on the same console. When two separate computers are connected, of course, only one character is typed on each console.

The receive routine can be debugged independently by keying in protocol frames on the keyboard and observing what the receiver does with them. Normally, the DLE, STX, and ETX characters are defined with the high-order bit on, which precludes their generation by the keyboard. (This is to ensure that keyboards cannot accidentally send a protocol frame.) During debugging, however, the value of the DLE, STX, and ETX bytes can be changed to keyboard-generated characters, thereby allowing frame synthesis through the keyboard for debugging purposes only.

The send routine must be disabled during this stage of debugging by changing the BNE INZADOR at hexadecimal location 1045 to BRA XMITLOOP. This ensures that the XMITACK flag from the receive module does not cause an ACK or NAK to be sent, thus clearing the flag.

First, an acknowledge frame is

Circle 184 on inquiry card.

keyed in to test the receive routine's response. The RECDACK byte, as a result, should be set to a value of +1. Next, a NAK frame is keyed, which should get the RECDACK byte to −1. If these received frames do not result in the proper setting of the flags, then either the receive routine is faulty, or the frame was keyed incorrectly.

After a proper address frame is typed, the XMITACK flag should be set to 1; otherwise, it should be set to −1. Also, a proper address frame should put the address types in the 2-byte variable ADDRESS.

Finally, frames of varying length and content should be typed in, and memory should be checked to ensure that the data has been properly stored. Of course, the keyboard cannot generate bytes with the high-order bit on, but this should not affect the debugging process. A proper data frame should set the XMITACK flag to 1, while a bad frame should set it to −1.

The command interpreter is debugged next by typing a control-F character and noticing that an "S:" is typed on the console. Typing in four hexadecimal characters and a carriage return should result in a "D:" being typed on the console. The command interpreter checks for valid hexadecimal characters, which in this implementation are lowercase "0" thru "9" and "a" thru "f." Either typing in a bad character, or typing more than five characters, results in the ringing of the terminal's bell.

After the destination address is keyed, a "#:" should be typed on the console. When the byte count and a carriage return are typed, the user should cause system reset and go to the computer's monitor program (in my case, a Motorola MIKBUG). Locations SRCADDR, DESTADDR, and BYTECNT should contain the proper values of the three parameters just typed in. Also, the XMITFILE flag should be nonzero. If any of the above information is not correct, the command interpreter has errors and must be debugged.

The debugging of the send routine is the last and most difficult task. The patch introduced to disable the send routine must be deleted and the original code restored. The command interpreter is then used to set up the addresses and a byte count; a carriage return is struck to initiate the send routine. Normally, the send routine will send out an address frame and wait for the RECVDACK flag to indicate proper receipt of the frame. It will then send a data frame and again wait for the RECVDACK flag. Since the transmit line is connected to the receive line during these tests, a more complicated interaction occurs.

The interaction is as follows—the sender issues an address frame and the receiver, in turn, sets the XMITACK flag. The sender sees the XMITACK and sends an ACK frame, and the receiver receives the ACK and sets the RECVDACK flag. The sender, noticing the RECVDACK flag, sends a data frame. Errors result in up to three retransmissions before the file transfer is aborted and the computer returns to transparent mode. This sequence of events can be verified by disabling various portions of code and watching the flags change using a debugging routine (there is usually one in the computer's monitor program).

Once the software routines have been independently debugged as described above, there should be few problems when a final test is made with two computers linked by a serial line.

## Final Notes

Reliable data transmission between two computers over a noisy channel is a primary concern of communication engineers, who have developed a spectrum of elaborate protocols to ensure that errors are detected and corrected. The simple data link described here is not overly robust. For example, the computer will "hang up" waiting for a valid response when an ACK or a NAK is received in error and discarded. One solution is to include a timeout interrupt that causes the send routine to retransmit its data if an ACK or NAK is not received within a certain period of time. Although the routines shown here were written with simplicity and minimal software in mind, the reader is encouraged to add this feature.

The protocol presented here is computer independent and could just as well be implemented in the machine language of any microprocessor. As long as there is agreement on the electrical interface and on the data-transfer protocol, a computer can pass data of any kind to any other computer. ■

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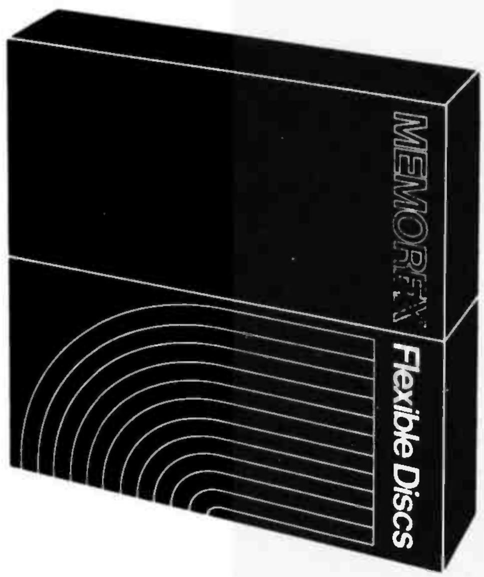


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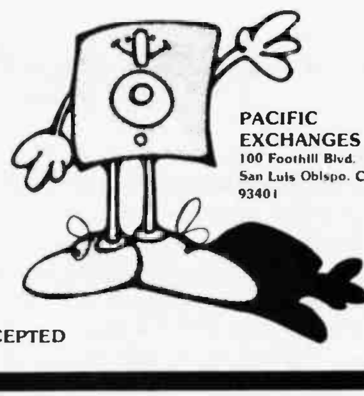

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# Three-Dimensional Computer Graphics, Part 2

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Ohio State University
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Columbus OH 43210

Last month, in Part 1, we examined almost every algorithm needed to display three-dimensional line drawings that represent solid objects modeled by polygons. I attempted to keep the procedures concise, at the occasional sacrifice of clarity or efficiency.

Listing 1 contains a complete Pascal program that incorporates the individual graphics procedures presented in Part 1. I have used this program with the Heath/Zenith H-19 video terminal (which has limited semigraphics) and the UCSD (University of California, San Diego) Pascal system. I have also used it (very satisfactorily) with a 500-line raster graphics display and a Pascal interpreter running under the UNIX operating system on a DEC (Digital Equipment Corporation) VAX 11/780 computer.

The program includes facilities for all of the basic functions necessary for three-dimensional representation:

- acquisition of machine-readable data
- transformation to the proper perspective
- scaling
- elimination of hidden lines and faces

In presenting this program, I have assumed that your display system can draw lines, as most systems that are capable of full graphics provide appropriate software. However, scan-conversion software is included to support the Heath/Zenith H-19 video terminal, and the routines Moveto and Drawto can be easily modified for any other raster display.

As designers continue to simplify the use of personal computers, the area of three-dimensional graphics software will be the next to receive significant attention. ■

**Listing 1:** *Complete UCSD Pascal three-dimensional graphics program that incorporates the ideas and procedures put forth in Part 1 (see March 1981 BYTE, page 54).*

```
Program HideLine;

const   DotsAcross = 79;
   DotsDown = 47;
   MaxPts = 200;
   MaxPols = 200;
   MaxVtx = 800;
   MaxSides = 8;    (* maximum sides on a polygon *)

type    counter = 0..MaxVtx;
   Point = record X,Y,Z : real end;
   Vertex = 0 .MaxPts;
   Polygon = record NumVtx : Vertex;  Start : counter;  end;
   OnePoly = array [1..MaxSides] of Point;

   Polygons : array [1..MaxPols] of Polygon;    (* original polygons   *)
   Vertices : array [1..MaxVtx] of Vertex;      (* original vertices   *)
   OutPolys : array [1..MaxPols] of Polygon;    (* displayed polygons  *)
   OutVtces : array [1..MaxVtx] of Point;       (* displayed points    *)
   EyeSpace : Matrix;                           (* eye space transform *)
   Window : OnePoly;                            (* display window      *)
   EyePt,CntrInt : Point;          (* eyepoint and center of interest  *)
   ScreenScale,ScreenCtr : Point;
   ScreenX,ScreenY : real;
   Screen : packed array [0..DotsAcross,0..DotsDown] of boolean;
   NumPols,NumVtces,NumPts,WindowSize,I : counter;
   NumDisplay,NumVtxOut : counter;
   CmdChar : char;
   FileName : string;
   Done : boolean;


(* ++++++++++++++  GetPlanes ++++++++++++++++++++++++++++ *)
procedure GetPlanes( var Poly : OnePoly; NumPts : counter );
var   I,LstI : counter;
 TmpPoly : OnePoly;

begin        (* compute plane equation coefficients for polygon edges *)
 LstI := NumPts;
 for I:=1 to NumPts do
begin
with Poly[I] do
    begin
    TmpPoly[I].X :=  Y * Poly[LstI].Z - Z * Poly[LstI].Y;
    TmpPoly[I].Y :=  Z * Poly[LstI].X - X * Poly[LstI].Z;
    TmpPoly[I].Z :=  X * Poly[LstI].Y - Y * Poly[LstI].X;
    end;
LstI := I;
end;     (* for loop *)
 for I:=1 to NumPts do   (* copy back to input *)
with TmpPoly[I] do
    begin  Poly[I].X:=X;   Poly[I].Y:=Y;   Poly[I].Z:=Z;   end;
 end;     (* GetPlanes *)


 (* +++++++++++++++++++ GetScreenScale +++++++++++++++++++++++ *)
 procedure GetScreenScale;   (* get window to screen scale factor *)
 var   I : counter;
```

Listing 1 continued on page 292

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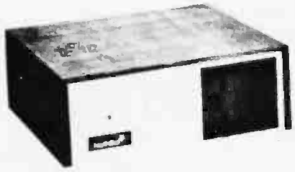

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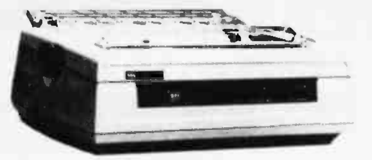

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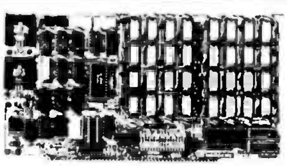

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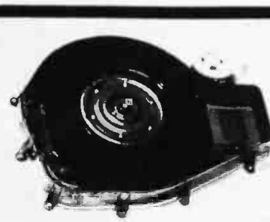

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*Listing 1 continued:*

```
  MaxX, MinX, MaxY, MinY : real;

 begin
 MaxX:=0.0; MinX:=0.0; MaxY:=0.0; MinY:=0.0;    (* window must include Z-axis
 for I:=1 to WindowSize do
with Window[I] do
     begin
     if X/Z > MaxX then MaxX := X/Z;
     if X/Z < MinX then MinX := X/Z;
     if Y/Z > MaxY then MaxY := Y/Z;
     if Y/Z < MinY then MinY := Y/Z;
     end;
 MaxX := MaxX - MinX;          MaxY := MaxY - MinY;
 if MaxY > (0.75 * MaxX)     (* standard display is 3 units high by 4 wide *)
 then ScreenScale.Z := (MaxY * 4 / 3 )
 else ScreenScale.Z := MaxX;
 ScreenScale.X := DotsAcross / ScreenScale.Z;
 ScreenScale.Y := ( DotsDown * 4 / 3 )  / ScreenScale.Z;
 end;     (* GetScreenScale *)


 (* ++++++++++++++++++ Initialize ++++++++++++++++++++ *)
 procedure Initialize;    (* set default parameter values *)
 begin
 Done := false;
 NumPols := 0;
 NumDisplay := 0;
 NumVtces := 0;
 NumPts := 0;
 with EyePt do begin X:=-5.0;   Y:=-5.0;   Z:=3.0;   end;
 with CntrInt do begin  X:=0.0;  Y:=0.0;   Z:=0.0;   end;

 WindowSize := 4;
 with Window[1] do begin  X:=-4.0;   Y:=-3.0;   Z:=16.0;   end;
 with Window[2] do begin  X:=-4.0;   Y:= 3.0;   Z:=16.0;   end;
 with Window[3] do begin  X:= 4.0;   Y:= 3.0;   Z:=16.0;   end;
 with Window[4] do begin  X:= 4.0;   Y:=-3.0;   Z:=16.0;   end;
 GetScreenScale;
 GetPlanes( Window,WindowSize );
 with ScreenCtr do begin  X:=DotsAcross/2;   Y:=DotsDown/2;   end;
 end;     (* Initialize *)


 (* ++++++ Start +++++++++++++++++++ *)
 procedure Start;
 var   I,J : counter;
 begin   (* clear screen *)
 for I := 0 to DotsAcross do
for J := 0 to DotsDown do Screen[ I,J ] := false;
 end;     (* start *)


 (* +++++++++++++++++ Finish ++++++++++++++++ *)
 procedure Finish;        (* display output for Zenith H-19 terminal *)
 var   I,J : counter;
 begin
 write(chr(27),'F');  (* put terminal into graphics mode *)
 write(chr(27),'p');  (* put terminal into reverse video *)
 write(chr(27),'w');  (* no wraparound at end of line    *)
 J := DotsDown;
 while J > 0 do
begin
for I := 0 to DotsAcross do
     if Screen[I,J] and Screen[I,J-1] then write('q')
     else if Screen[I,J-1] then write('l')
          else if Screen[I,J] then write('o')
               else write(' ');
if J > 1 then J := J - 2  (* count down by twos *)
          else J := 0;
if J > 0 then writeln;    (* CR/LF unless last line *)
end;
 readln; (* await <CR> before continuing (preserves screen) *)
 write(chr(27),'G'); (* exit graphics mode *)
 write(chr(27),'q'); (* exit reverse video *)
 end;     (* Finish *)


 (* +++++++++++++++ Moveto ++++++++++++++++++++ *)
 procedure Moveto( X,Y : real );
 begin
 ScreenX := X;        ScreenY := Y;
 end;     (* Moveto *)

 (* ++++++++++++++++++ Drawto ++++++++++++++++++ *)
 procedure Drawto( X,Y : real );
 var   I : counter;
  Dx,Dy,Length,StepX,StepY,Xpos,Ypos : real;

 begin   (* Drawto *)
 Dx := X - ScreenX;          Dy := Y - ScreenY;
 if abs(Dx) > abs(Dy) then Length := abs(Dx) else Length := abs(Dy);
 if Length < 1.0 then Length := 1.0;    (* catch zero-length lines *)
```

*Listing 1 continued on page 294*

*Listing 1 continued:*

```
StepX := Dx / Length;          StepY := Dy / Length;
Xpos := ScreenX;               Ypos := ScreenY;

 for I := 0 to trunc(Length) do
begin
Screen[round(Xpos),round(Ypos)] := true;
Xpos := Xpos + StepX;    Ypos := Ypos + StepY;
end;
 ScreenX := X;          ScreenY := Y;
 end;     (* Drawto *)


 (* ++++++++++++++++++ ReadObject +++++++++++++++++++++++ *)
 procedure ReadObject( FileName : string );       (* read in object from disk
 var   PtsObj,PolsObj,PtsPol,I,J : counter;
  Xpos,Ypos,Zpos : real;
  ObjFile : file of char;

 begin
 write('Position for ',FileName,' X Y Z : ');   readln(Xpos,Ypos,Zpos);
 reset(ObjFile,FileName);     (* open object file *)
 readln(ObjFile,PtsObj,PolsObj);
 for I:=1 to PtsObj do  with Points[I+NumPts] do
begin
readln(ObjFile,J,X,Y,Z);
X := X + Xpos;   Y := Y + Ypos;   Z := Z + Zpos;
end;
 for I:=1 to PolsObj do
begin
read(ObjFile,PtsPol);    (* read polygon vertex pointers *)
for J := 1 to PtsPol do
     begin
     read(ObjFile, Vertices[J+NumVtces] );
     Vertices[J+NumVtces] := Vertices[J+NumVtces] + NumPts;
     end;
readln(ObjFile); (* read past end of line *)
with Polygons[I+NumPols] do
     begin
     Start := NumVtces;
     NumVtx := PtsPol;
     end;


NumVtces := NumVtces + PtsPol;
end;
 NumPts := NumPts + PtsObj;
 NumPols := NumPols + PolsObj;
 end;     (* ReadObject *)


 (* +++++++++++++++++++ MakePicture +++++++++++++++++++++++++ *)
 procedure MakePicture;  (* transform and clip, then display polygons *)
 var    I,J,NumClp : counter;
  TmpPoly : OnePoly;

(* +++++++++++++ DotProd ++++++++++++++++++++ *)
function DotProd( Pt1,Pt2 : Point ) : real;
begin
DotProd := Pt1.X * Pt2.X + Pt1.Y * Pt2.Y + Pt1.Z * Pt2.Z ;
end;     (* DotProd *)


(* ++++++++++++++++++++ Ident +++++++++++++++++++++++*)
procedure Ident( var Mtx : Matrix );          (* initialize matrix *)
var    I,J : counter;
begin
for I:=1 to 4 do
     for J:=1 to 4 do
          if I = J then Mtx[I,J] := 1.0  else Mtx[I,J] := 0.0;
end;     (* Ident *)


(* ++++++++++++++++++++++ MatrixMult +++++++++++++++ *)
procedure MatrixMult( Mt1,Mt2 : Matrix; var Result : Matrix );
var    I,J,K : counter;
begin
for I:=1 to 4 do
     for J:=1 to 4 do
          begin
          Result[I,J] := 0.0;
          for K:=1 to 4 do
               Result[I,J] := Result[I,J] + Mt1[K,J]*Mt2[I,K];
          end;
end;     (* MatrixMult *)


(* +++++++++++++++++++ Transform ++++++++++++++++++++++++++++ *)
procedure Transform( Pt : Point; Mtx : Matrix; var NewPt : Point );
begin
NewPt.X := Pt.X*Mtx[1,1] + Pt.Y*Mtx[1,2] + Pt.Z*Mtx[1,3] + Mtx[1,4];
NewPt.Y := Pt.X*Mtx[2,1] + Pt.Y*Mtx[2,2] + Pt.Z*Mtx[2,3] + Mtx[2,4];
NewPt.Z := Pt.X*Mtx[3,1] + Pt.Y*Mtx[3,2] + Pt.Z*Mtx[3,3] + Mtx[3,4];
end;     (* Transform *)
```

*Listing 1 continued on page 296*

*Listing 1 continued:*

```
(* ++++++++++++++++++ GetEyeSpace +++++++++++++++++++++++++++ *)
procedure GetEyeSpace( EyePt, CntrInt : Point );
var   Mtx : Matrix;
      C1,C2 : Point;
      Hypotenuse,CosA,SinA : real;

begin
Ident(EyeSpace);          (* load eyepoint translation *)
with EyePt do
   begin EyeSpace[1,4]:=-X; EyeSpace[2,4]:= -Y; EyeSpace[3,4]:= -Z; end;
Transform( CntrInt,EyeSpace,C1 );  (* translate ctr. of interest *)

Ident(Mtx);     (* load rotation about Z-axis *)
with C1 do Hypotenuse := sqrt( X*X + Y*Y );
if Hypotenuse > 0.0 then
    begin
    CosA := C1.Y / Hypotenuse;        SinA := C1.X / Hypotenuse;
    Mtx[1,1] := CosA;        Mtx[2,1] := SinA;
    Mtx[1,2] :=-SinA;        Mtx[2,2] := CosA;
    MatrixMult( EyeSpace,Mtx,EyeSpace );
    end;
Transform( CntrInt,EyeSpace,C2 );  (* rotate ctr. of interest *)

Ident(Mtx);     (* load rotation about X-axis *)
with C2 do  Hypotenuse := sqrt( Y*Y + Z*Z );
if Hypotenuse > 0.0 then
    begin
    CosA := C2.Y / Hypotenuse;      SinA := -C2.Z / Hypotenuse;
    Mtx[2,2] := CosA;        Mtx[3,2] := SinA;
    Mtx[2,3] :=-SinA;        Mtx[3,3] := CosA;
    MatrixMult( EyeSpace,Mtx,EyeSpace );
    end;

Ident(Mtx);     (* load switch between Y and Z axes *)
Mtx[2,2] := 0.0;         Mtx[3,3] := 0.0;
Mtx[2,3] := 1.0;         Mtx[3,2] := 1.0;
MatrixMult( EyeSpace,Mtx,EyeSpace );
end;    (* GetEyeSpace *)


(* +++++++++++++++++ MakeDisplayable ++++++++++++++++++++ *)
procedure MakeDisplayable( var Pt : Point );     (* take to screen space *)
begin
Pt.X := ScreenScale.X * Pt.X / Pt.Z  + ScreenCtr.X;
Pt.Y := ScreenScale.Y * Pt.Y / Pt.Z  + ScreenCtr.Y;
end;    (* MakeDisplayable *)


(* +++++++++++++++++++++++ FacesEye +++++++++++++++++++++++++ *)
function FacesEye( Poly : OnePoly ) : boolean;

var   TmpPt : Point;
      TmpPoly : OnePoly;

begin
with Poly[2] do
    begin  TmpPt.X:=X;  TmpPt.Y:=Y;  TmpPt.Z:=Z;  end;
TmpPoly[1].X := Poly[1].X - Poly[2].X;
TmpPoly[1].Y := Poly[1].Y - Poly[2].Y;
TmpPoly[1].Z := Poly[1].Z - Poly[2].Z;
TmpPoly[2].X := Poly[3].X - Poly[2].X;
TmpPoly[2].Y := Poly[3].Y - Poly[2].Y;
TmpPoly[2].Z := Poly[3].Z - Poly[2].Z;
GetPlanes( TmpPoly,2 );
if DotProd( TmpPt,TmpPoly[1] ) <= 0.0
    then FacesEye := false
    else FacesEye := true;
end;    (* FacesEye *)


(* ++++++++++++++++++++++ ClipIn ++++++++++++++++++++++++++++ *)
procedure ClipIn(var Poly : OnePoly; var NumPts : counter);
var   I,J,LstJ,TmpPts : counter;
      D1,D2,A : real;
      TmpPoly : OnePoly;

begin
for I:=1 to WindowSize do        (* for each window edge *)
    if NumPts > 0 then
        begin
        D1 := DotProd( Poly[NumPts],Window[I] );
        LstJ := NumPts;
        TmpPts := 0;
        for J:=1 to NumPts do        (* for each polygon edge *)
            begin
            if D1 > 0.0 then         (* is leading vertex inside? *)
                begin
                TmpPts := TmpPts + 1;
                with TmpPoly[TmpPts] do
                    begin   (* copy leading vertex *)
                    X:=Poly[LstJ].X; Y:=Poly[LstJ].Y; Z:=Poly[LstJ].Z;
                    end;
```

*Listing 1 continued on page 298*

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Circle 193 on inquiry card.

*Listing 1 continued:*

```
                end;     (* if leading vertex inside *)

            D2 := DotProd( Poly[J],Window[I] );
            if D1 * D2 < 0.0 then    (* does edge straddle window? *)
                begin
                A := D1 / (D1 - D2);
                TmpPts := TmpPts + 1;
                with TmpPoly[TmpPts] do
                    begin
                    X := A * Poly[J].X + (1.0 - A) * Poly[LstJ].X;
                    Y := A * Poly[J].Y + (1.0 - A) * Poly[LstJ].Y;
                    Z := A * Poly[J].Z + (1.0 - A) * Poly[LstJ].Z;
                    end;
                end;
            LstJ := J;
            D1 := D2;
            end;     (* NumPts loop *)
        for J:=1 to TmpPts do    (* copy polygon back to input *)
            with TmpPoly[J] do
                begin  Poly[J].X:=X; Poly[J].Y:=Y; Poly[J].Z:=Z;   end;
        NumPts := TmpPts;
        end;     (* WindowSize loop *)
end;     (* ClipIn *)


(* ++++++++++++++++++++++ InsertSort ++++++++++++++++++++++++++++ *)
procedure InsertSort( Poly : OnePoly ; NumPts : counter );
var    I,J,K : counter;
       AvDepth : real;

begin        (* binary insertion sort on average depth *)
AvDepth := 0.0;
for I:=1 to NumPts do
    with Poly[I] do     (* store and find average depth *)
        begin
        OutVtces[NumVtxOut+I+1].X := X;
        OutVtces[NumVtxOut+I+1].Y := Y;
        OutVtces[NumVtxOut+I+1].Z := Z;
        AvDepth := AvDepth + Z;
        end;
AvDepth := AvDepth / NumPts;
OutVtces[NumVtxOut+1].Z := AvDepth;

J := 0;      (* initialize for insertion search *)
I := (NumDisplay + 1) div 2;
K := NumDisplay;

while (J <> I) do     (* binary search for insertion point *)
    if AvDepth < OutVtces[ OutPolys[I].Start ].Z
        then begin  K := I;  I := ( I + J ) div 2;   end
        else begin  J := I;  I := ( I + K + 1 ) div 2;   end;
for J:=NumDisplay downto I+1 do
    begin
    OutPolys[J+1].Start := OutPolys[J].Start;
    OutPolys[J+1].NumVtx:= OutPolys[J].NumVtx;
    end;
OutPolys[I+1].Start := NumVtxOut + 1;
OutPolys[I+1].NumVtx:= NumPts;
NumVtxOut := NumVtxOut + NumPts + 1;
NumDisplay := NumDisplay + 1;
end;     (* InsertSort *)

(* ++++++++++++++++++++++++ ClipOut ++++++++++++++++++++++++++++++ *)
procedure ClipOut( Poly : OnePoly; var NumPts : Vertex; Place : counter);
var I,LstI,NumDrawn : counter;
    Pt1,Pt2 : Point;
    Drawn : boolean;

    (* ++++++++++++++++++++ ClipAfter ++++++++++++++++++++++ *)
    procedure ClipAfter( Index : counter; Pt1,Pt2 : Point);
    var   I : counter;
          D1,D2,A : real;
          Out : boolean;
          Pt3 : Point;

    begin   (* recursively check polygons for overlap with input edge *)
    if Index < Place    (* is polygon closer than edge? *)
    then with OutPolys[Index] do
        begin
        I := Start + NumVtx;
        Out := false;
        repeat  (* for each polygon edge *)
            D1 := DotProd( Pt1,OutVtces[I] );
            D2 := DotProd( Pt2,OutVtces[I] );
            if (D1 <= 0.0) and (D2 <= 0.0)
            then begin  (* both points visible *)
                Out := true;
                ClipAfter( Index+1,Pt1,Pt2 );
                end
            else if D1 * D2 < 0.0
                then begin  (* one point visible *)
                    A := D1 / (D1 - D2);
```

*Listing 1 continued on page 300*

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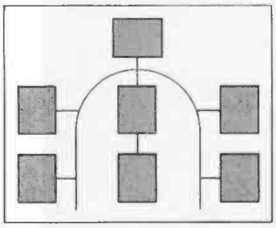

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Circle 195 on inquiry card.

*Listing 1 continued:*

```
                        Pt3.X := A * Pt2.X + (1.0-A) * Pt1.X;
                        Pt3.Y := A * Pt2.Y + (1.0-A) * Pt1.Y;
                        Pt3.Z := A * Pt2.Z + (1.0-A) * Pt1.Z;
                        if D1 < 0.0
                        then begin      (* Pt1 visible *)
                             ClipAfter( Index+1,Pt1,Pt3 );
                             with Pt3 do
                                 begin Pt1.X:=X; Pt1.Y:=Y; Pt1.Z:=Z; end;
                             end
                        else begin      (* Pt2 visible *)
                             ClipAfter( Index+1,Pt3,Pt2 );
                             with Pt3 do
                                 begin Pt2.X:=X; Pt2.Y:=Y; Pt2.Z:=Z; end;
                             end;
                        end;    (* one point visible *)
               I := I-1;
          until Out or (I = Start);  (* all visible or edges exhausted *)
          end
     else begin  (* reached end of list of closer polygons *)
          MakeDisplayable( Pt1 );     MakeDisplayable( Pt2 );
          Moveto( Pt1.X,Pt1.Y );      Drawto( Pt2.X,Pt2.Y );
          Drawn := true;       (* mark as displayed *)
          end;
     end;     (* ClipAfter *)


(* ClipOut procedure body *)
begin   (* clip each poly edge by all closer polys, draw whats left *)
NumDrawn := 0;
LstI := NumPts;
for I:=1 to NumPts do
     begin
     with Poly[LstI] do begin  Pt1.X:=X;   Pt1.Y:=Y;   Pt1.Z:=Z;   end;
     with Poly[I]    do begin  Pt2.X:=X;   Pt2.Y:=Y;   Pt2.Z:=Z;   end;
     Drawn := false;
     ClipAfter( 1,Pt1,Pt2 );  (* check closer polys, then display *)
     if Drawn then NumDrawn := NumDrawn + 1;
     LstI := I;
     end;     (* for loop *)
if NumDrawn = 0 then NumPts := 0;    (* mark as hidden *)
end;     (* ClipOut *)



 begin   (* MakePicture procedure body *)
 GetEyeSpace( EyePt,CntrInt );     (* get eyespace matrix *)
 NumDisplay := 0;  NumVtxOut := 0;    (* set output counters *)
 for I:=1 to NumPols do
with Polygons[I] do
     begin
     for J:=1 to NumVtx do   (* get polygon *)
          begin
          with Points[ Vertices[ Start + J ] ] do
               begin  TmpPoly[J].X:=X;  TmpPoly[J].Y:=Y;  TmpPoly[J].Z:=Z;   end;
          Transform( TmpPoly[J],EyeSpace,TmpPoly[J] );   (* transform *)
          end;
     if FacesEye( TmpPoly ) then
          begin
          NumClp := NumVtx;    (* protect original data *)
          ClipIn( TmpPoly,NumClp );    (* clip to view window *)
          if NumClp > 0 then InsertSort( TmpPoly,NumClp );
                                (* store in sorted order for display *)
          end;
     end;     (* loop for each polygon *)
 (* display surviving polygons, clipping each by closer polygons *)
 Start;  (* initialize and clear display *)
 for I:=1 to NumDisplay do
with OutPolys[I] do
     begin
     for J:=1 to NumVtx do

        with OutVtces[ Start + J ] do
            begin  TmpPoly[J].X:=X;  TmpPoly[J].Y:=Y;  TmpPoly[J].Z:=Z;   end;
    ClipOut( TmpPoly,NumVtx,I );   (* clip and display *)
    if NumVtx > 0 then
        begin
        GetPlanes( TmpPoly,NumVtx );      (* convert to planes *)
        for J:=1 to NumVtx do   (* copy back for later clipping *)
            with OutVtces[ Start + J ] do
                begin  X:=TmpPoly[J].X;  Y:=TmpPoly[J].Y;  Z:=TmpPoly[J].Z;
                end;
        end;
    end;     (* for loop (1 to NumDisplay) *)
Finish;      (* finalize picture *)
end;     (* MakePicture *)



begin   (* main program *)
Initialize; (* set up default view parameters *)
while not Done do
```

*Listing 1 continued on page 302*

*Listing 1 continued:*

```
begin
writeln('[read object, eyepoint, center of interest, start over,'
                    ,' window, picture, quit] ');
readln(CmdChar);
case CmdChar of
     'r' : begin write('file name : '); readln(FileName);
                 ReadObject(FileName);
           end;
     'e' : begin write('eyepoint, X Y Z : ');
                 with EyePt do readln( X,Y,Z );
           end;
     'c' : begin write('center of interest, X Y Z : ');
                 with CntrInt do readln( X,Y,Z );
           end;
     's' : begin NumPols := 0;    NumPts := 0;
           end;
     'w' : begin write('display window : how many sides? ');
                 readln(WindowSize);
                 for I:=1 to WindowSize do
                      begin
                      write('X Y Z : ');
                      with Window[I] do readln(X,Y,Z);
                      end;
                 GetScreenScale;      (* get window to screen scale *)
                 GetPlanes( Window,WindowSize );   (* get clipping planes *)
           end;
     'p' : MakePicture;
     'q' : Done := true;
     end;     (* case statement *)
end;     (* while loop *)
 end.     (* main program *)
```

# BYTE's Bugs

## Adventurous Bugs

As expected, many people called our offices with questions about the two Adventure programs in the December 1980 BYTE, "Pirate's Adventure" (by Scott Adams, page 192) and "Lost Dutchman's Gold" (by Bob Liddil and Teri Li, page 268). Although the authors found only two errors *per se*, the following notes are in order:

**Photo 1:** *Jon Swanson, BYTE drafting editor, finds a bug (shown in right hand) at the entrance to the Lost Dutchman Mine.*

In listing 2 of "Pirate's Adventure," page 210, line 1240 says:

```
1240 IF D <> -1 THEN
  1330 ELSE INPUT
  "READY DATA TAPE.
  HIT ENTER"; K$
```

while line 1330, the last line given in the listing, says simply:

```
1330 REM
```

According to Scott Adams, the listing is correct as stands, because D is set to −1 in line 20 of listing 2 (page 202) to denote a cassette-based program. The lines following line 1330 were deleted by Scott from an earlier version of the program, because they referred to disk commands only. Thus, the variable D should retain the value −1 throughout this program, thereby preventing a branch from line 1240 to line 1330.

There is an error in "Pirate's Adventure," but it affects you only if you tried to combine listings 1 and 2 into a single program for a 32 K-byte TRS-80 (as suggested in column 2 of page 212). The problem occurs when statements in what used to be listing 2 try to read the data directly from the DATA statements that used to be in listing 1. The full directions are:

1. Delete lines 6510 to 6790 of listing 1.
2. Append the remaining DATA statements from listing 1 to the end of listing 2, changing all occurrences *after line 1240* of INPUT#D to READ.
3. In listing 2, change line 1280 to:

```
1280 FOR X=0 TO
  CL:FOR Y=0 TO
  1:READ CA(X,Y):NEXT
  Y,X
```

4. In listing 2, change line 1290 to:

```
1290 FOR X=0 TO
  NL:FOR Y=0 TO
  1:READ NV$(X,Y):NEXT
  Y,X
```

In the listing for "Lost Dutchman's Gold," the lack of a closing quote at the end of line 36 (page 268) caused some confusion. However, the program will run without the quote, so that is not a problem. One occurrence of the invisible Control-D that editor Gregg Williams missed mentioning is on line 4130 (page 280), just before the first letter in the word DELETE.

The error in "Lost Dutchman's Gold" is in the last line of line 1287 (page 274). Change the part that reads "7$(J,3)" to read "O$(J,3)"—the character before the dollar sign is capital O.

Thanks to Bob Liddil, Scott Adams, and several other BYTE readers for calling these problems to our attention.■

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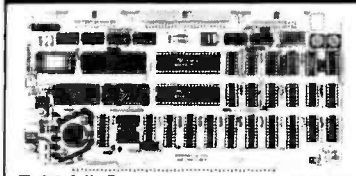

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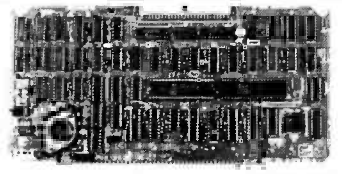

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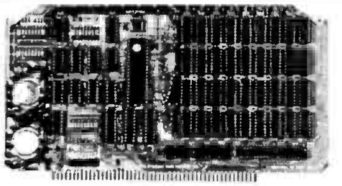

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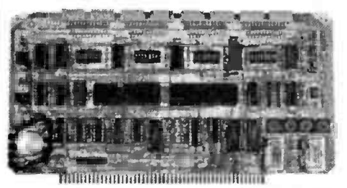

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# Technical Forum

# An ADM-3 Emulator for the Hazeltine 1500

Charles Shoemaker
2725 E Maplewood Ave
Littleton CO 80121

All Hazeltine 1500 owners seem to agree on two things: it is a very nice terminal; and they are frustrated that a good deal of the software available that uses cursor control has been written for the Lear Siegler ADM-3 terminal; consequently, it will not run properly on the 1500.

In my particular case, the problem came to a head as I was attempting to modify for my terminal a graphics game written in 8080 assembly language. Some of the cursor-movement control was not at all obvious, and I wasn't really willing to take the time to follow the entire structure of the program through just to play a simple game.

This, coupled with the fact that I'd have to do the same (disassembling system software where no source code is provided) for every program written for the ADM-3, led me to write this routine.

This routine is a patch to my CP/M operating system BIOS (I/O driver module). It can be placed in ROM (read-only memory) or programmable memory, but, if it is placed in ROM, the two temporary locations, MODE and Y, will have to be relocated somewhere in programmable memory. The routine is entered with the ASCII (American Standard Code for Information Interchange) character to be sent contained in the C register and the parity bit low. It assumes that the output status has been checked and that the output port is ready for a character. Registers A and C are altered on exit. Since this routine needs to send as many as four characters (I will explain that in a moment), there's a subroutine to wait for output status, which will have to be customized for other systems.

If the character to be sent comes in another register, the MOV instructions to and from C (and the PUSH B and POP B instructions, if the register is B) can be easily altered. For example, if the program sends the character in A, the following routine can be used:

```
PUSH B
MOV C,A
CALL EMULATOR
POP B
RET
```

Note that in the 8080 instruction set, the PUSH B and POP B instructions also do the same to C.

The code is twisty, and a little bit devious, as described below. I first attempted to fit it into 128 bytes, so that it would fit in one disk sector. Unfortunately, I didn't quite make it. Users with Z80 processors can take advantage of

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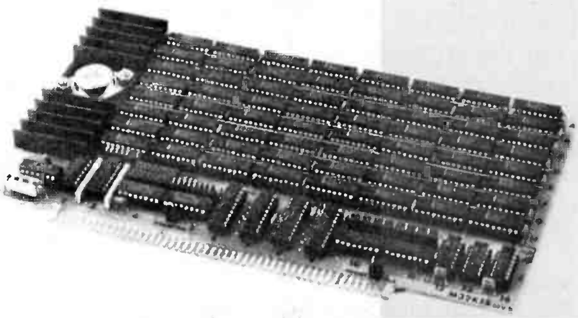

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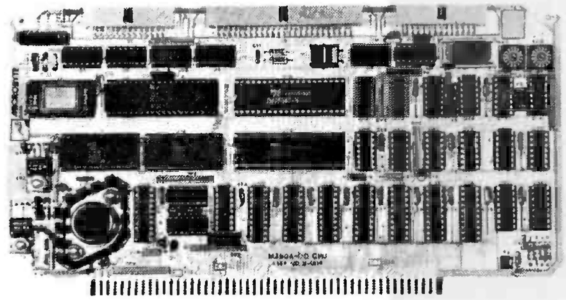

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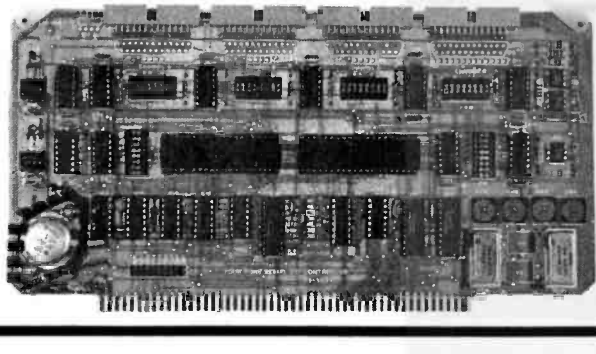

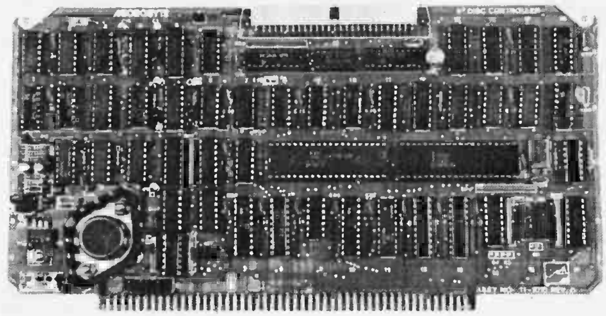

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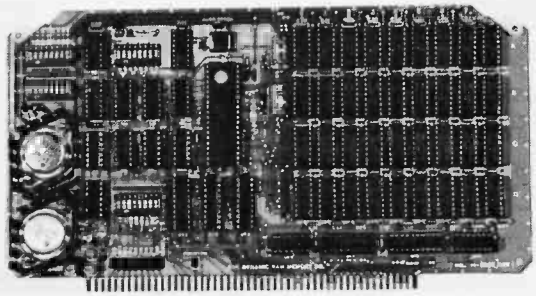

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their relative-jump capabilities and easily crunch it into 128 bytes.

## How It Works

On the ADM-3, cursor up, cursor right, home, and clear screen are simple control codes: 11, 12, 30, and 26 in decimal, respectively. The control codes for the two terminals are shown in table 1. These codes are converted in the routine called NORM (see listing 1). Noncontrol characters are shunted to be transmitted directly at the label

**Listing 1:** *The Lear Siegler ADM-3 emulator for the Hazeltine 1500. For a detailed explanation of the program, see the accompanying text.*

```
        ORG   7FB4H    ; FIX CPM OUTCH ROUTINE TO JUMP HERE
        JMP   ENTRY

        ORG   B000H    ; PUT AFTER BIOS

ENTRY:  LDA   MODE     ; ARE WE IN THE MIDDLE OF SOMETHING?
        ORA   A
        MOV   A,C      ; GET CHARACTER TO SEND, FOR COMPARES
        JZ    NORM     ; ORDINARY
        JPE   XY       ; IF JUMP TAKEN, NORM CONTAINS EITHER 3 OR 255

        CPI   '='      ; MIDDLE OF XY ADDRESS SEQUENCE
        MVI   A,0      ; PRESET ERROR CONDITION
        STA   MODE
        JNZ   ZAP      ; SOMETHING'S WRONG--PRINT IT AND GIVE UP
        MVI   A,3      ; FIX UP
        STA   MODE     ; TELL US NEXT TIME
        RET            ; AND BACK

NORM:   CPI   30       ; TEST FOR HOME CHARACTER
        JC    NTHOME
        JNZ   ZAP      ; NOT A CONTROL CHARACTER--SEND IT
        MVI   C,18     ; GET HAZEL'S HOME CHARACTER
        JMP   SPECL    ; DO IT
NTHOME: CPI   11       ; IS IT UP-CURSOR?
        JZ    SPECL-1  ; QUICK TRICK
        CPI   12       ; IS IT RIGHT-CURSOR?
        JNZ   NTRGHT   ; NO---
        MVI   A,16     ; HAZEL'S RIGHT-CURSOR
        JMP   ZAP
NTRGHT: CPI   27       ; IS IT ESCAPE-ADDRESS CURSOR?
        JNZ   NTESC
        MVI   A,1      ; TELL US NEXT TIME THROUGH
        STA   MODE
        RET

NTESC:  CPI   26       ; IS IT CLEAR SCREEN?
        JNZ   OUTCH    ; NO, MUST BE SOME OTHER CONTROL CHARACTER
        INR   C        ; MAKE 28, HAZEL'S CLEAR SCREEN CHARACTER
        INR   C
SPECL:  MVI   A,126    ; GET HER ATTENTION
        CALL  ZAP      ; SEND THE FIRST CHARACTER RIGHT AWAY
OUTCH:  MOV   A,C      ; RETRIEVE ORIGINAL CHARACTER
        PUSH  PSW      ; STOW IT AWAY
        IN    10H      ; GOTTA CHECK STATUS
        ANI   2
        JZ    OUTCH+2
        POP   PSW      ; GET IT BACK
ZAP:    OUT   11H      ; SEND IT
        RET            ; FINALLY, RETURN TO CALLER

XY:                    ; WE KNOW WE HAVE 'ESC' '=' SEQUENCE
        JM    FINAL    ; SEE IF THIS IS X OR Y CHARACTER
                       ; TAKE THE JUMP IF THIS IS X
        MOV   A,C      ; JUST GET Y CHARACTER
        STA   Y        ; AND SAVE IT
        MVI   A,0FFH   ; LET US KNOW WHAT TO DO NEXT TIME
        STA   MODE
        RET            ; AND BACK

FINAL:  PUSH  B        ; SAVE X CHARACTER A MINUTE
        MVI   C,17     ; GET HAZEL'S ATTENTION
        CALL  SPECL
        POP   B        ; GET'M BACK
        MOV   A,C      ; GET X COORDINATE
        SUI   32       ; GET RID OF ADM-3 BIAS
        CPI   31       ; FIX HAZEL'S BIAS
        JNC   SENDX    ; OK AS IS
        ADI   96       ; HAZEL LIKES THIS BETTER
SENDX:  CALL  OUTCH+1  ; SEND X
        XRA   A        ; FIX MODE UP--BACK TO NORMAL
        STA   MODE
        LDA   Y        ; ADM-3 BIAS OK FOR HAZEL
        JMP   OUTCH+1  ; SEND IT AND GO HOME

MODE:   DB    0
Y:      DB    0

        END

A>
```

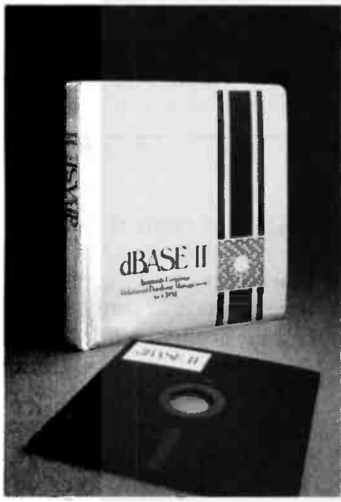
# dBASE™ II vs. the Bilge Pumps.

*by Hal Pawluk*

We all know that bilge pumps suck.

And by now, we've found out—the hard way—that a lot of software seems to work the same way.

So I got pretty excited when I ran across **dBASE II**, an assembly-language relational Database Management System for CP/M. It works! And even a rank beginner like myself got it up and running the first time I sat down with it.




If you're looking for software to deal with your data, too, here are some tips that will help:

## Tip #1: Database Management vs. File Handling:

Any list or collection of data is, loosely, a data base, but most of those "data base management" articles in the buzzbooks are really about file handling programs for specific applications. A real Database Management System gives you data and program independence (no reprogramming when data changes), eliminates data duplication and makes it easy to turn data into information.

## Tip #2: Assembly Language vs. BASIC:

This one's easy: if you're setting up a DBMS, you're going to be doing a lot of sorting, and Basic sorts are s-l-o-w. Run a benchmark on a Basic system like S*-IV against a relational DBMS like **dBASE II** and you'll see what I mean. (But watch it: I've also seen one extremely slow assembly-language file management system.)

## Tip #3: Relational vs. Hierarchal & Network DBMS.

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## dBASE II vs. everything else.

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| Action | ADM-3 | H-1500 |
|---|---|---|
| Cursor Up | 11 (Control-K) | 126, 12 (~, Control-L) |
| Cursor Down | 10 (line feed) | 10 (line feed) |
| Cursor Left | 8 (backspace) | 8 (backspace) |
| Cursor Right | 12 (Control-L) | 16 (Control-P) |
| Clear Screen | 26 (Control-Z) | 126, 28 (~, Control-shift-L) |
| Cursor Home | 30 (Control-shift-N) | 126, 18 (~, Control-R) |

**Table 1:** *The control codes for the Lear Siegler ADM-3 and the Hazeltine 1500 terminals. The numbers are the decimal values for the ASCII codes shown in parentheses.*

ZAP. The control codes are detected with a series of compare operations, and the proper code for the Hazeltine placed in the C register. The Hazeltine's 126 function-lead-in code is sent, if necessary, by the jump to SPECL. Other control codes (carriage return, line feed, backspace, etc) fall through and are sent unchanged.

The two-coordinate direct cursor addressing is more complicated. For both terminals, X is the horizontal position, from 0 thru 79, and Y is vertical, from 0 thru 23. The ADM-3 must receive the sequence ESC (ASCII 27), "=" (ASCII 61), Y+32, and X+32. The H-1500 requires the tilde (~, ASCII 126), ASCII 17, then X, then Y+32. In addition, if X is in the range 0 thru 31, then 96 should be added, although the terminal will accept 0 thru 31.

The routine collects all four characters from the host software, then sends the Hazeltine control sequence. Since the emulator is called four times before it can complete the direct-cursor addressing sequence, we need some way to know where we are in the sequence and what action needs to be taken in each case. The temporary byte, MODE, is the key to what happens. Its four states are as follows:

- MODE=0: We are not in the middle of a direct-cursor-address sequence. NORM gets control. If NORM detects ESC, it sets MODE to 1 and returns.
- MODE=1: ESC has been detected. If "=" is the current character, MODE is set to 3 and the routine returns. Otherwise, MODE is reset to 0 and the character is sent.
- MODE=3: This character is the Y coordinate. The byte is stored in variable Y, and MODE is set to 255.
- MODE=255: The byte to be sent is the X coordinate. The byte is processed for the Hazeltine and the lead-in and control bytes are sent. X is recovered and sent, then Y is recovered. No processing for the 1500 is needed here. MODE is reset to 0 and Y is transmitted.

These values for MODE were chosen so that a four-way branch could be taken from one test, the ORA A instruction at the top of the routine. The zero flag is tested first, and the jump-on-zero instruction branches to NORM. The 1 condition is separated by the JPE, as it is the only condition with odd parity. The 3 and 255 are differentiated with the sign flag.

The kind of multiway branching I've used here is worth a little study. It could be useful in a number of applications.■

# Technical Forum

# Challenger Writes on Comprint

Edward H Carlson, 3872 Raleigh Dr, Okemos MI 48864

I use an Ohio Scientific C2-4P for word processing and text editing. I selected the Comprint 912 as a printer because of its legibility (9 by 12 dot matrix), speed (3 lines per second), quietness (electrostatic printing, not impact), and low cost. The choice of the parallel-interface model reduced costs further. I want to show you a 6502 assembly-language program that interfaces a 6522 VIA (versatile interface adapter) parallel port to the Comprint 912.

The Model 500 main processor board of an OSI Challenger II has a provision for a 6820, a 6520, or a 6521 PIA (peripheral interface adapter) containing two 8-bit parallel ports. The 6522 VIA enhances the PIA functions with extra handshake options and two timers. I had already added a 6522 to my processor board in the space for the PIA. A little extra work was required because six pins have different functions on the 6522. I made the modification by changing only four lines on the Model 500 processor board. The price was a nonstandard naming of the address lines to the sixteen registers of the 6522. The address conversions needed are noted at the bottom of listing 1. The 6522 resides at hexadecimal location F7xx in memory.

The Comprint has several parallel I/O (input/output) options. I've used the *wide strobe/acknowledge* mode, enabled by pulling a jumper pin from the Comprint circuit board. Besides the seven lines of ASCII (American Standard Code for Information Interchange) data, there are three control lines. DAV is the strobe signal sent by the computer telling the printer that valid data is on the data lines. NDAC is the acknowledge signal sent by the printer telling the computer that the data has been accepted. NRFD is the busy line that the printer sets high when its data buffer is full and unable to accept further data.

At the 6522 end, the lines are assigned as follows: DAV is CB2, put high and strobed low when the 6502 processor writes data to port B of the 6522 VIA. It must be set high again before the next ASCII character is sent. NDAC is CB1, configured to detect the trailing edge, low-to-high transition, of the acknowledge signal sent from the printer. NRFD is pin PB7 of the eight-line parallel data. One wants to detect the high or low state of this line, not an edge as it makes a transition.

**Listing 1**: *After installing the 6522 VIA in the Model 500 processor board of the OSI Challenger II, this 6502 assembly-language program interfaces the 6522 parallel port to the Comprint 912.*

```
 10 C000                          * = $C000
 20 C000               ;                          PARALLEL PORT TO COMPRINT 912
 30 C000 48            OUTCHR     PHA                      A CONTAINS CHARACTER
 40 C001 A902                     LDA #$02                 ENABLE B PORT OF 6522
 50 C003 8D0EF7                   STA $F70E
 60 C006 A97F                     LDA #$7F                 DATA DIRECTION
 70 C008 8D08F7                   STA $F708
 80 C00B 8D07F7                   STA $F707                CLEAR INTERRUPT FLAGS
 90 C00E A990                     LDA #$90                 READY STROBE, PERIPHERAL CONTROL
100 C010 8D03F7                   STA $F703                CB1 TO GO LOW ON WRITE, DAV
110 C013 AD00F7        BUSY       LDA $F700                READ B PORT INPUT
120 C016 2980                     AND #%10000000           BIT 7 IS NRFD OF COMPRINT
130 C018 30F9                     BMI BUSY                 BUSY IF BIT 7 IS HIGH
140 C01A 68                       PLA
150 C01B 49FF                     EOR #$FF                 INVERT, DATA ACTIVE LOW
160 C01D 8D00F7                   STA $F700                OUTPUT TO PRINTER
170 C020 AD07F7        ACK        LDA $F707                LOOK FOR NDAC ON CB2
180 C023 2910                     AND #$10                 NDAC IS ACKNOWLEDGE FROM
190 C025 C910                     CMP #$10                   COMPRINT
200 C027 D0F7                     BNE ACK                  IF NOT FOUND, LOOK AGAIN
210 C029 A9F0                     LDA #$F0                 RESTORE CB1 TO HIGH, END DAV
220 C02B 8D03F7                   STA $F703
230 C02E 60                       RTS
235 C02F               ;                         Standard    Mine
240 C02F               ; B Port I/O Register         00       00
250 C02F               ; Auxiliary Control Register  0B       0E
260 C02F               ; Peripheral Control Register 0C       03
270 C02F               ; Interrupt Flag Register     0D       07
```

The subroutine to write one character to the printer is given in the listing 1. When called, accumulator A contains the character to be sent. The Comprint expects inverted data (ie: 1 to be low and 0 to be high). A hardware modification can be made to the Comprint 912 to accept noninverted data, but I elected to do the inversion in software with an exclusive-OR (XOR) instruction.

First, port B is enabled. Then data lines PB0 thru PB6 are assigned to output the ASCII character, and data line PB7 is assigned to input the busy signal. The interrupt-flag register is cleared (by writing 1s to it) so that it can detect transitions in CB1.

Next, a mask is written to the peripheral control register, which does two things:

1. requests an interrupt flag to be set for low-to-high transitions of the acknowledge line CB1;
2. requests CB2 to go low when the processor writes to the 6522, to make the beginning of the strobe signal DAV.

Port B is now ready to see if PB7 is high, denoting a busy signal. If not, the data is sent and the interrupt-flag register is repeatedly read to await the acknowledge signal before continuing. (Bit 4 is set by an active transition of CB1, not bit 3 as given in the old edition of the Osborne and Associates book *An Introduction to Microcomputers*.) This flag is reset by the next write to Port B.

Finally, the DAV line is set high again, to end the wide strobe pulse, and the subroutine is exited.

Some options that could be tried are: use of the *narrow-strobe/acknowledge* mode of the Comprint 912, use of port A of the 6522, or use of a PIA instead of the VIA. In each case, the program would need modifications. ■

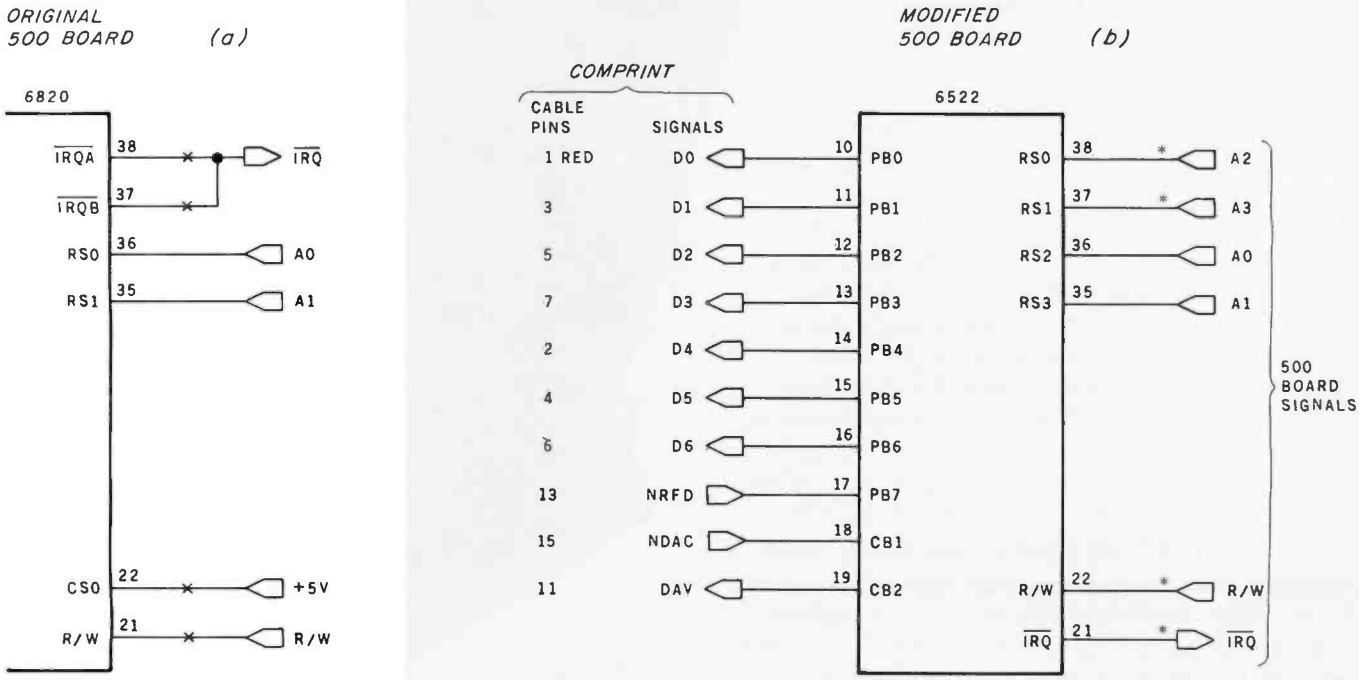
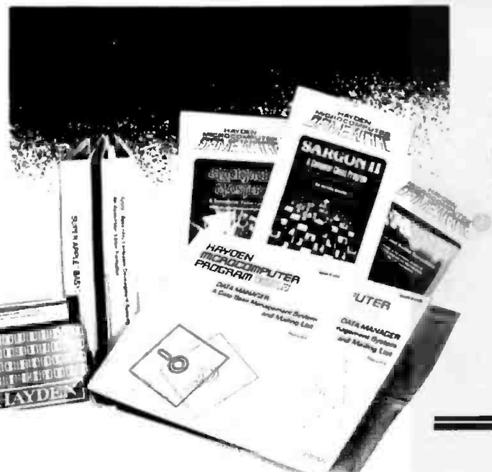



**Figure 1**: *The hardware modification that enables the Comprint 912 printer to work with the OSI Challenger II. When the 6820 position on the Model 500 processor board is modified to take the 6522 VIA, the four marked lines must be cut (the lines to pins 21, 22, 37, and 38, see figure 1a). New lines must be attached to these pins (denoted by asterisks in figure 1b). Note the nonstandard address-line assignments after the rewiring is completed.*



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# Technical Forum

## On the Use of Fourier Transforms to Explore Biological Rhythms

A J Owens, Bartol Research Foundation, University of Delaware, Newark DE 19711

In his editorial "Is Pseudoscience Done by Computer Pseudo-Computer-Science?" (November 1979 BYTE, page 6), Carl Helmers encouraged the analysis of numerical data to test the validity of the biorhythm hypothesis: that our lives are dominated by a few quasi-sinusoidal cycles. He suggested taking data on our personal lives, perhaps rating each day on a scale of 1 to 10, and then analyzing the time series using the fast Fourier transform (FFT).

Coincidentally, motivated by some biorhythm proponents in an introductory astronomy class that I was teaching, I have been carrying out exactly that program since January 1977. Through November 1979, my data set consisted of 1024 consecutive daily ratings of my personal well-being, recorded by me each evening on a scale of 1 to 10.

While reading Mr Helmers' editorial, I decided to program my AIM-65 microcomputer to analyze the data. (I had previously analyzed 256- and 512-day subsets of the data as they became available, using a FORTRAN program run on a minicomputer.)

With only 4 K bytes of user memory, my AIM-65 could barely run the program to analyze 256 data points

**About the Author**

*A J Owens is a research physicist and professor at the Bartol Research Foundation of the Franklin Institute, which is located at the University of Delaware. He received his postgraduate degrees from the California Institute of Technology in the field of theoretical physics. Although he uses mainframe computers for his astrophysical research, he claims to be a novice in dealing with microcomputers, having graduated downward from time-sharing systems and minicomputers. He currently uses a Rockwell AIM-65 linked to a BETA-1 digital cassette system.*

**Technical Forum** is a feature intended as an interactive dialog on the technology of personal computing. The subject matter is open-ended, and the intent is to foster discussion and communication among readers of BYTE. We ask that all correspondents supply their full names and addresses to be printed with their commentaries. We also ask that correspondents supply their telephone numbers, which will not be printed.

—in fact, the comments had to be deleted to fit the program into the memory. The FFT algorithm used here was originally written for a Digital Equipment Corporation time-sharing computer, and the only modifications are the small input routine and the calculation of the power spectrum at the end. The fast Fourier transform routine for 256 data points takes about 3 minutes to run.

It is of crucial importance in any time-series analysis to understand (and report) details concerning the statistical uncertainty in the results that are obtained. Otherwise, the importance of an insignificant wiggle in the Fourier transform at the "right" place can be blown far out of proportion. Fortunately, information scientists have studied the problem of extraction of signals from noise, and the basic concepts are not too difficult to grasp. For a complete (and technical) account, I suggest reading *Random Data: Analysis and Measurement Procedures*, by J S Bendat and A G Piersol (Wiley-Interscience, New York, 1971).

Suppose that you begin with $N$ data points, each a sample from some process that is random or noisy. Obviously, no matter how you "massage" the data, you have only $N$ independent samples. In the fast Fourier transform, the $N$ data points sampled at intervals of time separated by $\Delta t$ are transformed into $N$ Fourier coefficients in the frequency domain, one each for the sine and the cosine terms corresponding to frequencies $1/N\Delta t$, $2/N\Delta t$, . . . , $(N/2\text{-}1)/N\Delta t$, $1/2\Delta t$. For random data, the Fourier coefficients have random phases, so one usually reports the *power spectrum*, which is the sum of the squares of the sine and the cosine terms (altered by a multiplication constant used to normalize the result). The original $N$ data points give $N/2$ power spectral estimates in frequency space, each with two degrees of freedom—one each from the sine and cosine terms.

Inasmuch as each raw-power spectral-density estimate has only two degrees of freedom, it is rather poorly determined. In only two-thirds of the cases can one expect the "true" power spectral level to be in the interval between zero and two times the measured power spectrum.

To improve the accuracy of the estimates, one *averages* the power spectrum. One method of doing this, the one that I applied, is to divide the total data set into smaller groups of points, calculate the power spectrum for each subset, and then average the power spectra from each group. For example, my set of 1024 days was divided into four groups of 256 points each. Power spectra for each of the four groups were calculated, and the resulting four spectra were averaged at each of the 128 power spectral points in frequency space.

A second approach is to calculate the power spectrum of the entire record (eg: 1024 days). One then averages the several adjacent frequency bins (eg: four) to get a smaller number of more accurately known power spectral estimates.

In either case, averaging four spectra (or frequency bins), each with two degrees of freedom, gives power spectral estimates with eight degrees of freedom. As a result, we expect that, in two-thirds of the cases, the "true" power spectrum at a given frequency will then lie between 0.5 and 1.5 times the measured value. In general, the fractional uncertainty in each estimate is $\pm\sqrt{(2/D)}$,

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where $D$ is the number of degrees of freedom.

The BASIC computer program shown in listing 1 is quite simple. The routine in lines 100 thru 180 allows the data to be entered. Because the input data are real (ie: they have no imaginary component), they are stored in the one-dimensional array X, and the one-dimensional

**Listing 1:** *Power spectrum calculation program. This program was used to calculate the data points plotted in figures 1 and 2.*

```
1 REM          PROGRAM FFTPOW
2 REM          POWER SPECTRUM USING FFT
3 REM               A. J. OWENS 16-NOV-79
6 REM          REAL PART OF FUNCTION IN X, IMAG IN Y
10 DIM X(256),Y(256)
20 REM
25 REM         INPUT ROUTINE GIVES DATA X AND Y AND NUMBER
27 REM         OF DATA POINTS, N, A POWER OF 2.
29 REM         INPUT ROUTINE IS IN LINES 100-199.
30 REM         FFT CALCULATION ROUTINE IS IN LINES
32 REM         200-590.  PRINTOUT OF THE POWER SPECTRUM
34 REM         IS IN LINES 591-800.
100 REM        INPUT ROUTINE
150 N=256
160 FOR I=1 TO N
170 INPUT X(I)
175 Y(I)=0
180 NEXT I
200 REM BEGIN FFT CALCULATION
202 G=INT(LOG(N)/LOG(2)+1.00000E-06)
203 P=2*3.14159/N
204 FOR L=0 TO G-1
206 G1=2^(G-L-1)
208 M=0
210 FOR I=1 TO 2^L
220 K1=INT(M/G1)
230 GOSUB 530
240 Y1=COS(P*K2)
250 Y2=-SIN(P*K2)
260 FOR J=1 TO G1
270 Y3=X(M+G1+1)*Y1-Y(M+G1+1)*Y2
280 Y4=X(M+G1+1)*Y2+Y(M+G1+1)*Y1
290 X(M+G1+1)=X(M+1)-Y3
300 Y(M+G1+1)=Y(M+1)-Y4
310 X(M+1)=X(M+1)+Y3
320 Y(M+1)=Y(M+1)+Y4
330 M=M+1
340 NEXT J
350 M=M+G1
360 NEXT I
370 NEXT L
380 FOR I=0 TO N-1
390 K1=I
400 GOSUB 530
410 IF K2>=I THEN 480
420 K3=X(I+1)
430 X(I+1)=X(K2+1)
440 X(K2+1)=K3
450 K3=Y(I+1)
460 Y(I+1)=Y(K2+1)
470 Y(K2+1)=K3
480 NEXT I
499 GO TO 591
500 REM STATEMENTS 500 TO 510 PRINT OUT RESULTS
501 REM OF THE FFT ITSELF; SKIPPED HERE
502 FOR I=0 TO N-1
504 PRINT I;X(I+1);'+I';Y(I+1)
506 NEXT I
520 GO TO 591
530 K2=0
540 FOR K=1 TO G
550 K3=INT(K1/2)
560 K2=2*(K2-K3)+K1
570 K1=K3
580 NEXT K
590 RETURN
591 REM PRINT OUT POWER SPECTRUM
593 PRINT 'STEP BETWEEN DATA POINTS';
595 INPUT T
599 PRINT 'NUMBER OF POINTS AVERAGED';
600 INPUT M
605 PRINT
610 PRINT ' FREQUENCY   POWER'
620 Q=2*T/(M*N)
630 FOR J=0 TO N/2 STEP M
640 S=0
650 FOR I=1 TO M
660 S=S+Q*(X(J+I+1)*X(J+I+1)+Y(J+I+1)*Y(J+I+1))
670 NEXT I
680 F=(2*J+M)/(2*N*T)
690 PRINT F,S
700 NEXT J
800 GO TO 599
999 END
```

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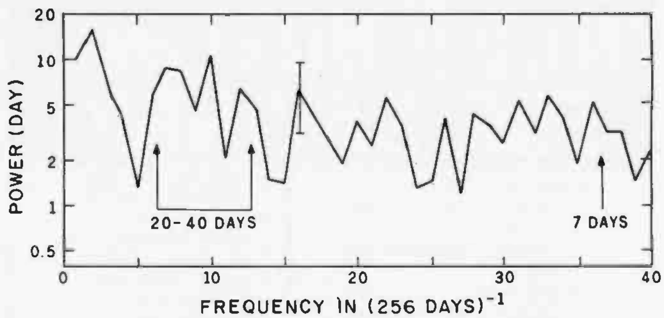


**Figure 1:** *A power spectrum chart averaging four periods of 256 days each. This figure of the low end of the full-power spectrum graph shows the relative intensities of sine waves of various frequencies. The range of values bracketed by the arrows labeled "20-40 days" represents the power of sine waves with periods between 20 and 40 days. If biorhythms were present in this power spectrum, they would have appeared as significant peaks at certain points within this range. The vertical line at frequency = 15 shows the possible variation of the point on the graph and is a measure of the possible error in measurement at that point.*

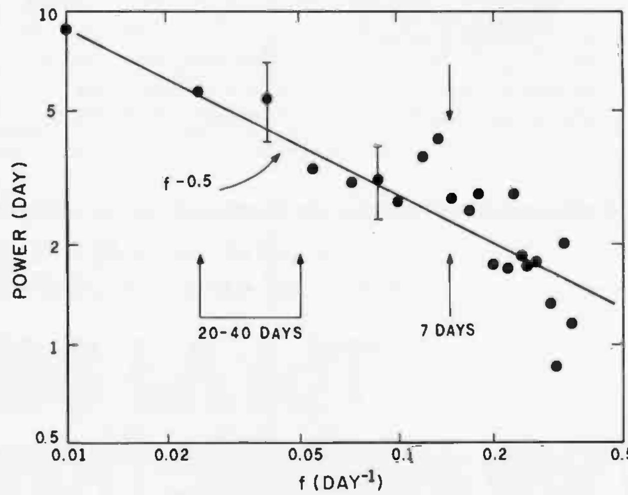


**Figure 2:** *A modified power spectrum chart. The data of figure 1 was averaged over four frequency bins, giving a more accurate set of data points, and plotted using logarithmic scales for both the frequency and power axes. The notation used is described in the caption for figure 1.*

array Y is set to zeros. Lines 200 thru 590 perform an $N$-point fast Fourier transform:

$$F_n = \sum_{k=0}^{k=N-1} Z_k \exp(-2\pi ikn/N)$$

where $Z_k = X_k + iY_k$ is the (complex) input vector and $F_n$ is the complex Fourier transform ($i = \sqrt{-1}$ and is the unit measure along the imaginary axis when dealing with complex numbers). The real (cosine) part of F is placed in X and the imaginary (sine) part in Y by the routine. The $n$th frequency, corresponding to the Fourier coefficient $F_n$, is $f_n = n/(N\Delta t)$. The power spectrum is calculated in

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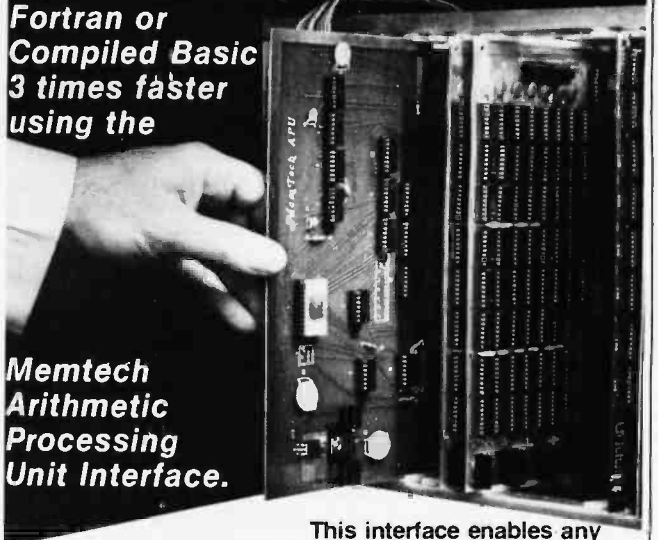

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| 25 | 0.17 |
| 26 | 0.58 |
| 27 | 0.08 |
| 28 | 0.62 |
| 29 | 0.53 |
| 30 | 0.42 |
| 31 | 0.72 |
| 32 | 0.47 |
| 33 | 0.74 |
| 34 | 0.57 |
| 35 | 0.27 |
| 36 | 0.70 |
| 37 | 0.48 |
| 38 | 0.49 |
| 39 | 0.12 |
| 40 | 0.49 |

**Table 1:** *Table of values for the power spectrum chart of figure 1. The second column of numbers is the base-10 logarithm of the value of the power. For example, for point 20, $10^{0.56}$ equals 3.63, which is the value plotted in figure 1 at the point frequency=20. The marks for 7, 20, and 40 days in figure 1 correspond to frequency values (with units of (256 days)$^{-1}$) of 36.6, 12.8, and 6.4, respectively. The logarithm of the variation of the error mark at frequency=16 is +0.18 and −0.30 from the recorded value of 0.79.*

lines 591 thru 800, using the relation:

$$P_n = (2\Delta t/N)|F_n|^2$$

The program allows averaging of the power over any specified number of frequency bins. If $M$ frequency estimates are averaged, the number of degrees of freedom in the single power spectrum is $D=2M$ and the fractional statistical uncertainty is $\pm\sqrt{(2/2M)} = \pm\sqrt{(1/M)}$.

As mentioned above, I scored 1024 consecutive days on a scale of 1 to 10 and analyzed the data in 256-day groups. The average scores for the four groups were 5.1, 4.6, 4.5, and 4.6, indicating a mean near 5 with a hint of a long-term decline. The day-to-day variation (standard deviation) was close to 1 for each of the four periods.

Averaging the power spectra for the four periods, I ob-

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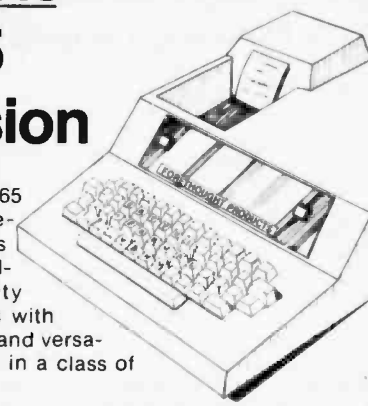


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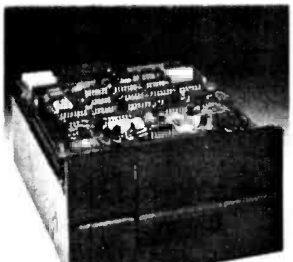
# The DataTrak™ 5 Floppy Disk Drive The DataTrak™ 8 Floppy Disk Drive from Qume® Distributed by asap



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

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

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

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

**Design Features**

Expanded storage capacity
- Two-sided, double density

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

Precise lead screw actuator
- Fast access time - 20 ms track-to-track
- Low friction and minimum wear
- Low power dissipation

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

**Product Specifications**

Performance Specifications
Capacity
Unformatted: 437.5K or 500K bytes
Qume Formatted: 286.7K or 327.7K bytes
Recording Density: 5456 BPI
Track Density: 48 TPI
Cylinders: 35 or 40
Tracks: 70 or 80
Recording Method: FM or MFM
Rotational Speed: 300 RPM
Transfer Rate: 250K bits/second
Latency (avg.): 100 ms
Access Time: Track-to-track 20 ms
Settling 15 ms
Head Load Time: 50 ms

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

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

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

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

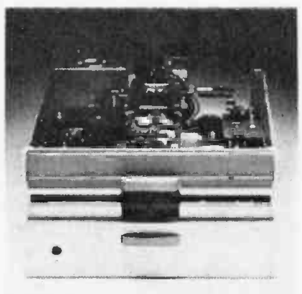
**Design Features**

Expanded storage capacity
- Two-sided, double density

Fully IBM compatible
- IBM 3740 and System 32 drives
- IBM 3600 and 4964 drives
- IBM Sytem 34 drives

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

Fast, precise steel belt drive
- Fast access time - 3 ms track-to-track



- Low friction and minimum wear
- Low power dissipation

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

**Product Specifications**

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

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| Point Number | $\log_{10}(f)$ | $\log_{10}$ (Power) |
|---|---|---|
| 1 | -2.01 | 0.96 |
| 2 | -1.60 | 0.78 |
| 3 | -1.39 | 0.75 |
| 4 | -1.25 | 0.53 |
| 5 | -1.14 | 0.49 |
| 6 | -1.06 | 0.50 |
| 7 | -0.99 | 0.43 |
| 8 | -0.92 | 0.55 |
| 9 | -0.87 | 0.61 |
| 10 | -0.82 | 0.42 |
| 11 | -0.78 | 0.39 |
| 12 | -0.74 | 0.45 |
| 13 | -0.70 | 0.24 |
| 14 | -0.67 | 0.22 |
| 15 | -0.64 | 0.45 |
| 16 | -0.61 | 0.26 |
| 17 | -0.59 | 0.24 |
| 18 | -0.56 | 0.24 |
| 19 | -0.54 | 0.11 |
| 20 | -0.51 | -0.07 |
| 21 | -0.49 | 0.30 |
| 22 | -0.47 | 0.06 |

**Table 2:** *Table of values for modified power spectrum of figure 2. Here, both columns of numbers are the base-10 logarithms of their respective values as plotted in figure 2. For example, for point 2, $10^{-1.60}$ and $10^{0.78}$ give values of 0.025 and 6.026, which can be read off the horizontal and vertical axes of figure 2. The marks for 7, 20, and 40 days in figure 2 correspond to frequency values (with units of (days)$^{-1}$) of 0.141, 0.050, and 0.025, respectively. The logarithm of the variation of the error mark as shown in figure 2 is +0.10 and −0.12.*

tained the power spectrum, the low-frequency part of which is shown in figure 1. Note that the power spectrum's vertical axis is logarithmic; this makes the size of the statistical uncertainty in each point the same. A typical error flag at *frequency* = 15 is shown. A few relevant cyclic periods are shown, including the week (seven days) and the canonical biorhythm periods (twenty to forty days).

The safest thing to say is that there is no evidence whatsoever for enhancements above the background noise level in the biorhythm range. Even if *all* the variation in the six power spectral points in the twenty- to forty-day range is attributed to biorhythms, the contribution is only about fifteen percent of my total variance from day to day. But there is no evidence for any periodicities in this region, and the noise in the biorhythm range looks similar to that at both lower and higher frequencies.

The perceptive reader may notice that the power spectrum shown in figure 1 is not flat, as would be the case for perfectly "white" or uncorrelated noise. This implies that there is some temporal structure in my day-to-day feeling of well-being. To investigate this more closely, I averaged the data in figure 1 over four adjacent frequency bins, to give power spectra with thirty-two degrees of freedom. The results are shown in figure 2, given as a log-log plot. The solid line shows that the power spectrum is well fit by a power law spectrum, $P(f) \propto f^{-0.5}$. This is an unusual power spectrum. White noise has a flat spectrum, and random-walk noise has a $f^{-2}$ spectrum. Electrical "flicker

noise" has an $f^{-1}$ spectrum. My biorhythms, instead of producing quasi-periodic "music of the spheres," seem to be more in the nature of a slightly colored and unique random hiss! ■

### Biorhythms and Fourier Transforms

*Proponents assert that the relative strength and weakness of mankind in areas roughly described as "physical," "emotional," and "intellectual" vary in cycles of twenty-three, twenty-eight, and thirty-three days, respectively, with each of the curves approximating sine waves of equal amplitude. Of course, the effects of each influence are added together, so that an overall index of a particular day's merit (as the author recorded by assigning each day a number between 1 and 10) would not readily show the presence (or absence) of these sinusoidal waves.*

*This is where Fourier transforms (either fast or discrete) come in. In theory, any complex periodic waveform can be shown to be the sum of a number of sine waves of differing frequencies and amplitudes. The Fourier method transforms an amplitude-versus-time waveform into its equivalent amplitude-versus-frequency waveform—ie: the transformed waveform tells the relative strengths of the different frequency sine waves that, when added together, will give the original amplitude-versus-time waveform.*

*Once this is understood, it becomes apparent that, if a specified waveform contains definite twenty-three-, twenty-eight-, and thirty-three-day cycles, these cycles should cause visible peaks in the appropriate places on the frequency (horizontal) axis of the transformed waveform. The lack of such peaks would indicate that these frequencies contribute no more to the overall waveform than other frequencies do. A transformed wave that is roughly a flat horizontal line indicates that sine waves of all frequencies contribute equally to the original waveform. Such a waveform has no dominant frequencies. A signal consisting of random components with no discernible dominant frequencies is known as white noise.*

*Another verification of the transformed wave is concerned with the amplitude of existing peaks. In this situation, those peaks that correspond to the biorhythm cycles should be of equal amplitude, because the three biorhythm cycles are defined as being of equal amplitude.*

### Response by Carl Helmers

*This article suggests an approach to verification of any biological cycles hypothesis. It is not a controlled scientific experiment, and any conclusions are thus applicable only to this particular individual's characteristics.*

*By applying techniques of signal analysis to a broader population of individuals, it might be possible to design a scientifically valid experiment.*

References


Bendat, J S, and A G Piersol, *Random Data: Analysis and Measurement Procedures*, Wiley-Interscience, New York NY, 1971.

Stanley, W D, and S J Peterson,"Fast Fourier Transforms on Your Home Computer," December 1978 BYTE, pages 14 thru 25.

# Ask BYTE

Conducted by Steve Ciarcia

## 4116 Pointers

Dear Steve,

Being an ardent do-it-yourselfer, I'm currently in the process of designing a homebrew computer system. Since the 16 K-bit type-4116 dynamic memories are cheap, compact, and use little power, I have decided to use them as my main memory components. Designing the interface is no problem, but I'm all too aware of the 4116's cantankerous nature with respect to circuit-board layout, power-supply fluctuations, and so forth. What should I know about these devices?

**Ken McDonald**
**Yellowknife, NWT, Canada**

*The most important thing to remember when designing any computer that uses 4116s is that the power-supply voltages have to be turned on and off in sequence. To keep from blowing the 4116 on power-up, the −5 V supply must be turned on before the +5 V and +12 V supplies. On power-down, the −5 V has to remain on while the +5 and +12 are removed.*

*In lower-current power supplies (such as you will probably use), the sequencing can be accomplished through the time constants of the power supply itself; this technique is used in the TRS-80. By giving the −5 V section a very fast time constant compared to the other two supplies, it appears to come on first. On power-down, the sequence is reversed. Because the −5 V has such a low-current draw on it, it will stay up long after the other voltages have dropped.*

*Other than that, use prime components and stay away from surplus devices. For more information on refresh timing signals of dynamic memories, refer to my article in the March 1981 BYTE "Build the Disk-80: Memory Expansion and Floppy-Disk Control," on page 36....***Steve**

## Any Port in a Storm

Dear Steve,

I'm not sure if I understood the little that I read of your article "I/O Expansion for the TRS-80, Part 2: Serial Ports." (See the June 1980 BYTE, page 42.) Can I use the modem on my Radio Shack RS-232C port and my serial (Diablo) printer on your RS-232C port or vice versa? If so, are there any tricks to it?

**Stan**
**via The Source**

*You say that you already have an RS-232C interface, so I'll presume it is Radio Shack's TRS232, which is installed inside the TRS-80 Expansion Interface. Normally, only one interface can be accommodated, and it is hard-wire-addressed as port hexadecimal E8. Because the COMM-80 has selectable addressing, it can be added to your system and set for one of fifteen other addresses. With a software driver that directs any output to this second serial port, you can plug your Diablo into it and use both ports without conflict.*

*What you really need is a CHATTERBOX, which is a COMM-80 with an acoustic modem installed in the same enclosure. It is designed so that, when the modem is in use, the characters being transmitted and received are*

*sent out through the RS-232C connector. You can plug your Diablo directly into the CHATTERBOX and have a modem with a printer output. Absolutely no changes in any software are needed.*
...**Steve**

## TRS-80 Tape Formats

Dear Steve,

The TRS-80 has more software created for it than any other system. This software is usually transferred on a cassette that is readable only on

**Table 1**

**Tape Formats**

| | |
|---|---|
| **BASIC Tape Format** | |
| Leader | 256 zeros followed by an A5 sync byte |
| D3 D3 D3 | BASIC header |
| XX | Single-character file name |
| LOB (low-order byte) | Next line's address |
| HOB (high-order byte) | Pointer |
| LOB | Line number |
| HOB | |
| XX ... XX | Line contents |
| 00 | End-of-line marker |
| . | |
| . | |
| . | |
| 00 00 | End-of-file markers |
| **System Tape Format** | |
| Leader | 256 zeros followed by an A5 sync byte |
| 55 | System-format header byte |
| XX XX XX XX XX XX | 6-character file name |
| 3C | Data header |
| XX | Data length, 00 = 256 bytes |
| LOB | Loading |
| HOB | Address |
| XX ... XX | Actual line contents |
| XX | Checksum of line bytes and load address |
| . | |
| . | |
| . | |
| 78 | End-of-file marker |
| LOB | Entry |
| HOB | Address |
| **Editor/Assembler Source Tape Format** | |
| Leader | 256 zeros followed by an A5 sync byte |
| D3 | Source header |
| XX XX XX XX XX XX | File name |
| d1 d2 d3 d4 d5 | 5-digit line number in ASCII (bit 7 is set) |
| 20 | Data header |
| XX ... XX | Line (128 bytes maximum) |
| 0D | End-of-line marker |
| . | |
| . | |
| . | |
| 1A | End-of-file marker |
| **BASIC Statement Storage Format in Memory** | |
| LOB | Address of |
| HOB | next line |
| LOB | Line number in |
| HOB | binary form |
| XX ... XX | Line contents |
| 00 | End-of-line marker |
| . | |
| . | |
| . | |
| 00 00 | End-of-file marker |

a TRS-80. For people with other computers, this vast amount of software is unusable. Please tell me the data-storage format used by Tandy for its TRS-80.
**Paul Shields**
**Victor Harbor, S A, Australia**

*Table 1 on page 329 shows the various TRS-80 Model I cassette-recording formats*....**Steve**

## Problem With Light Controls

Dear Steve,

It seems that a lot of BYTE readers are interested in home control via the BSR System X-10. I've fooled around with computerized home-control devices for some time, and I think BYTE readers should be aware of one rather distressing trait of the light-control modules.

When an incandescent bulb burns out, the filament in the bulb falls across its supports creating a momentary short circuit across the A C line. I have had three BSR units damaged when a bulb has gone out. Once it involved a single table lamp with a 70-watt bulb. Another time the failure occurred in a wall-switch module controlling my outdoor-perimeter circuit of 400 watts.

This seemingly practical and low-cost method of home control becomes something of a folly when you find that you must replace a $16 control module because a $0.69 bulb has burnt out. I have not been able to return modules for replacements, because the salespeople accuse me of overloading the module.

In the future, I hope that the design of these modules will include protection against the surge that occurs when a light bulb fails. Until then, I don't think they are all that practical and probably should not be committed to serious uses (for which they are advertised), such as a burglar deterrent.
**Chris Gundlach**
**Huntington WV**

*I, too, have noticed that situation, and I've mentioned it to BSR. They are aware of the problem, but there isn't much that can be done to totally eliminate "zapping" the module except installing a 50 A triac (the cost would be prohibitive). There aren't too many ways to achieve fold-back current-limiting in a triac.*

*Don't feel too bad. I've lost seven modules and a controller because of various problems, such as transients and blown bulbs. While the BSR unit is still cost-effective in consumer applications, I would be wary of it in critical control situations.*

*A few companies have asked me about using the BSR for industrial remote-control and solar-hearing systems, and I told them essentially what you have said to me. The application, of course, determines the ultimate interface selection. When the alternative is a thousand-dollar computer front end, the BSR may still be the best choice—even if a receiver has to be replaced once in a while*....**Steve**

*The following is a letter sent to me concerning Mr Gundlach's problem, from BSR*....**Steve**

### BSR Responds to Criticism

Dear Mr Gundlach,

You are correct in your identification of the problem. All commercially available dimmers that contain triacs, as our lamp- and wall-switch modules do, are subject to zapping if a blown light-bulb filament falls in a "short circuit" position instead of open circuit.

Since the introduction of the System X-10 in the fall of 1978, all products have been updated and improved as necessary. We now use triacs that we feel are most resistant to zapping. Our overall return rate is quite low, and has steadily decreased with respect to blown triacs. This is substantiated in part by the fact that the major retail chains continue to buy our products in large quantities and would not do so if there were persistent problems.

We are shipping you replacements for your failed units at no charge. I would greatly appreciate any feedback on performance that you care to give...good or bad!

Sorry you had some difficulties.

**Peter A Lesser**
**Vice President**
**General Manager**
**X-10 Division**
**BSR Inc**

### The Two Can't Connect

Dear Steve,

I have an early (second year of production) Radio Shack TRS-80 Model I 16 K-byte Level II computer that I'm having trouble adding peripherals to. I have a Quick Printer II, an Exatron Stringy Floppy, and a typewriter interface, each of which can be plugged into the expansion connector of the TRS-80 keyboard unit.

I also have a 1-into-2 cable that should allow me to use two peripherals at once. However, if more than one peripheral is plugged into the cable, the computer randomly executes the initial power-up routine—destroying whatever I was working on.

It doesn't seem to matter which peripherals I try to combine, nor does it matter if one is off. I don't think the problem is in the cable, because it works well with each of the peripherals singly and in either connection.

What could this be? I'd like to use the system for text processing, but that's impossible right now.

**Ron Tye**
**Long Beach CA**

*The TRS-80 Model I sometimes does strange things when cables are connected to the keyboard. The longer the cables, the more likely the problem you described. With one peripheral installed, it may work properly, but when the load of another is added, the bus signals become sensitive to noise. Keeping the cables as short as possible helps.*

*The solution is to either add a circuit that buffers all the signals from the keyboard or, at the very least, actively terminate the extension cable.*

*If you do not mind a little soldering, you can try terminating your present cable. At the end of the cable, from each signal, attach a 1 k-ohm resistor to +5 V and a 470-ohm resistor to ground. You'll have to add a separate 5 V supply, since +5 V is not available on the keyboard connector....* **Steve**■

In "Ask BYTE," Steve Ciarcia answers questions on any area of microcomputing. The most representative questions received each month will be answered and published. Do you have a nagging problem? Send your inquiry to:

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c/o Steve Ciarcia
POB 582
Glastonbury CT 06033

If you are a subscriber to The Source, send your questions by electronic mail or chat with Steve (TCE317) directly. Due to the high volume of inquiries, personal replies cannot be given. Be sure to include "Ask BYTE" in the address.

## April 1981

*April-June*
**Microprocessor Software, Hardware, and Interfacing,** various cities throughout the United States. This hands-on course provides a foundation in the skills required for the design, programming, and real-world interfacing of microprocessor applications. For further details and a schedule of meeting places and times, contact Integrated Computer Systems Inc, 3304 Pico Blvd, POB 5339, Santa Monica CA 90405, (213) 450-2060.

*April-October*
**Computer Sales-Marketing Workshops,** various cities throughout the United States. These workshops are designed for retail salespeople and computer-marketing managers and their staffs. For a schedule of times and locations, contact Datasearch Inc, 4954 William Arnold Rd, Department C, Memphis TN 38117, (901) 761-9090.

*April 1-2*
**Communications in the Twenty-First Century,** Philip Morris Operations Center, Richmond VA. This conference will focus on technological advances and their economic, political, social, and psychological implications. Elie Abel, Professor of Communications at Stanford University, and Lord Briggs, provost of Worcester College, Oxford, England, are the keynote speakers. For information, contact the manager of Media Relations, Philip Morris Inc, 100 Park Ave, New York NY 10017.

*April 1-3*
**Assuring Quality in Electronic Data-Processing Applications,** McCormick Inn Hotel, Chicago IL. The objective of this conference is to explain the methods, tools, and techniques that are valuable in improving the quality of computerized applications. Tutorials cover the areas of quality assurance; managing structured design; and designing, implementing, and enforcing application standards. Contact DPMA Quality Assurance Conference, 12611 Davan Dr, Silver Spring MD 20904, (301) 622-0066.

*April 3-5*
**The Sixth West Coast Computer Faire,** Civic Auditorium, San Francisco CA. The Faire, a major personal-computing event, has continually attracted larger and larger numbers of exhibitors and attendees. A full program of talks plus a large display of hardware and software are featured. For more information, contact Computer Faire, 333 Swett Rd, Woodside CA 94062, (415) 851-7075.

*April 4*
**The Third Annual RAMS Spring Computer Show,** Perinton Square Mall, Fairport NY. This event is sponsored by the Rochester Area Microcomputer Society. For more information, contact RAMS, POB D, Rochester NY 14609.

*April 7-8*
**Top Secrets '81,** Pointe Resort, Phoenix AZ. Honeywell's annual computer security and privacy conference. Many data-security authorities will discuss the business and legal impact of the latest incidents in computer crime and abuse. The conference fee is $500. Contact the Security Symposium Registrar, Honeywell Information Systems, M/S T-99-4, POB 6000, Phoenix AZ 85005, (800) 528-5343; in Arizona (602) 249-7954.

*April 7-9*
**Computerized Office Equipment Expo—Midwest '81,** O'Hare Exposition Center, Rosemont IL. This exposition has exhibits and seminars on the use of computers and related equipment in business environments. For details, contact Industrial & Scientific Conference Management Inc, 222 W Adams St, Chicago Il 60606, (312) 263-4866.

*April 7-9*
**Electro/81,** New York Coliseum and Sheraton Centre Hotel, New York NY. Electro/81 will feature computers and computer-related equipment, plus seminars on components, devices, and materials; computer communications; memories; office automation; speech; and more. Contact Electronic Conventions Inc, 999 N Sepulveda Blvd, Suite 410, El Segundo CA 90245, (800) 421-6816; in California (213) 772-2965.

*April 9-12*
**Southwest Computer Show and Office Equipment Exposition,** Market Hall, Dallas Market Center, Dallas TX. Hardware and software for business, education, government, home and personal use will be featured. Mini- and microcomputers, office machines, supplies and services, graphics equipment, and word processing will also be exhibited. Contact National Computer Shows, 824 Boylston St, Chestnut Hill MA 02167, (617) 739-2000.

*April 10-11*
**The Eleventh Annual VCUC Conference,** Sheraton Red Lion Inn, Blacksburg VA. The VCUC (Virginia Computer Users Conference), a division of the ACM (Association for Computing Machinery), and the Computer Science Department of the Virginia Polytechnic Institute and State University are holding this conference. The themes are "Personal Computing" and "System Performance." Write to J Rosow or S Haldeman, VCUC 11, 562 McBryde Hall, VPI and SU, Blacksburg VA 24061.

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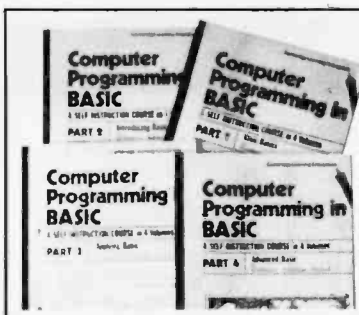


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**Digital Computer Logic and Electronics**
This course is designed as an introduction to digital electronics and is written at a pace that suits the raw beginner. No mathematical knowledge is assumed other than the use of simple arithmetic and decimals, and no electronic knowledge is expected at all. The course moves painstakingly through all the basic concepts of digital electronics in a simple and concise fashion: questions and answers on every page make sure that all the points are understood.
**Price: $14.95**

**Design of Digital Systems**
Written in a similar question and answer style to Digital Computer Logic and Electronics, this course moves at a much faster pace and goes into the subject in greater depth. Ideally suited for scientists or engineers wanting to know more about digital electronics, its six A size volumes lead step by step through number systems and Boolean algebra to memories, counters and arithmetic circuits and finally to an understanding of calculator and computer design.
**Price: $19.95**

$5.00 discount for orders over $30.00.
All prices include surface shipping
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**CAMBRIDGE LEARNING INC.**

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*April 13-14*

**The Executive Computer Conference**, Washington DC. The theme of this 2-day meeting is "Improving Organizational Productivity through Systems Technology." Special emphasis will be placed on management's perspective of the contributions the computer has made to organizational productivity. For information, contact Kendall E Burroughs, The Executive Computer Conference, 1730 N Lynn St, Suite 400, Arlington VA 22209, (703) 521-6209.

*April 13-16*

**The Fifteenth International Symposium on Minicomputers and Microcomputers, MIMI '81**, Sheraton Hotel, Mexico City, Mexico. The scope of this symposium covers hardware, software, distributed processor architecture, computer networks, telecommunications, real-time applications, education, and more. Contact Ing. Jorge Gil, Academic Secretary, MIMI Symposium, IIMAS-UNAM, Apartado Postal 20-726, Mexico 20 D F, Mexico.

*April 14-16*

**The Seventh Annual Federal DP Expo**, Sheraton Washington Hotel, Washington DC. This conference and exposition is for computer-system users in the US government. More than 150 exhibitors and over 100 speakers will highlight the event. Contact The Interface Group, 160 Speen St, Framingham MA 01701, (800) 225-4620; in Massachusetts, call (617) 879-4502.

*April 25-26*

**Trenton Computer Festival**, Trenton State College, Trenton NJ. This annual flea market and swap meet of personal-computer equipment also features speakers, user-group meetings, and an exhibit of commercial products. It is sponsored by the Amateur Computer Group of New Jersey, the Philadelphia Area Computer Society, and the Trenton State Computer Society. Contact TCF-81, Trenton State College, Trenton NJ 08625, (609) 771-2487.

*April 26-30*

**Saudibusiness '81**, Riyadh, Saudi Arabia. This show has been designed for the fast-growing Saudi Arabian business community. Pavilions by the United States, the United Kingdom, West Germany, France, Italy, and approximately fifteen other countries will be featured. For more information, contact Donald Ryan, Project Manager, Rm 3200, US Department of Commerce, Washington DC 20230, (202) 377-4652.

*April 27-30*

**National Design Engineering Show and Conference**, McCormick Place, Chicago IL. The theme of this show is "Computers Throughout the Design Function." Additionally, the principal areas of consideration are design management, computer-aided design, materials, mechanical components and systems, and electronics. Contact Clapp & Poliak Inc, 245 Park Ave, New York NY 10167, (212) 661-8410.

*April 30-May 1*

**An Assessment and Forecast of Computer Graphics**, Saddle Brook Marriott, Saddle Brook NJ. This annual conference will assess the present state of computer graphics and will evaluate hardware, software, systems services, and applications. The impact of new technologies on computer graphics and the role of graphics in business will be discussed. Contact Bob Sanzo, Frost & Sullivan Inc, 106 Fulton St, New York NY 10038, (212) 233-1080.

## May 1981

*May 2*

**National Computer Problem-Solving Contest for Junior and Senior High School Students**, throughout the US. Small teams of junior and senior high school students will compete for two hours on computer systems to solve five programming problems. Winners will be judged on whether their programs run properly using the test data supplied in the problem, are easy to read, and are logical, imaginative, and creative.

To receive a copy of the 1981 contest problems, local school directors should contact the University of Wisconsin—Parkside by April 4. Directors must agree to keep the problems confidential until the day of the contest. After that, any organization can use the problems to conduct its own contest. Local contest winners can enter the national and international contest. A national and worldwide ranking will be determined by a team of judges from the University of Wisconsin—Parkside. All interested schools or organizations can share the 1981 contest problems.

For additional information, write Dr Donald T Piele, Associate Professor of Mathematics, University of Wisconsin—Parkside, Kenosha WI 53141.

*May 4-7*

**National Computer Conference**, McCormick Pl, Chicago IL. Approximately 90,000 people are expected to attend this year's National Computer Conference (NCC). The use of robots and artificial intelligence will be among the program sessions at the Personal Computing Festival during the NCC. This will be the first time that personal-computing exhibits have joined the rest of the conference in the main exhibit area. Over thirty technical sessions will be held. All major companies will be represented. Contact the American Federation of Information Processing Societies Inc, POB 9658, 1815 N Lynn St, Arlington VA 22209, (703) 558-3617.

*May 5-8*

**INTELCOM 81/Paris**, Paris, France. INTELCOM (International Telecommunications and Computer Conference and Exhibition) 81/Paris is part of a program to promote an international dialogue on vital subjects in the telecommunications field. This conference attempts to guide the evolution of the computer and its technology by combining the efforts of private companies, government, and equipment users. For information about attending, presenting a paper, or exhibiting at INTELCOM 81/Paris, contact the Conference Affairs Group, Horizon House, 610 Washington St, Dedham MA 02026, (800) 225-9977; in Massachusetts (617) 326-8220.

*May 11-13*
**Fourth Annual Rosen Research Personal-Computer Forum**, Playboy Resort, Lake Geneva WI. This forum features guest speakers from all the major personal-computer hardware and software companies. The Rosen Forum is one of the most prestigious and important seminars in the industry. For further details on this 3-day session, contact Rosen Research Inc, 200 Park Ave, New York NY 10166, (212) 586-3530.

*May 11-13*
**Custom Integrated Circuits Conference, CICC'81**, Americana Hotel, Rochester NY. The CICC aims to bring together designers, producers, and users of custom integrated circuits to discuss recent developments and future directions in the field. Papers will be read on applications, algorithm-implementing integrated circuits, fabrication techniques, interfaces and interconnects, computer-aided design, and testing and qualification. Contact Dr Rajinder Khosla, General Chairman, Research Laboratories, B-81, Eastman Kodak Company, Rochester NY 14650, (716) 722-2525.

*May 11-13*
**The Thirty-First Electronic Components Conference**, Colony Square Hotel, Atlanta GA. Papers will be read on semiconductor-processing technology, optoelectronic devices, manufacturing technology, materials, hybrid microcircuits, discrete components, interconnections, reliability, and connectors. Contact T G Grau, Bell Laboratories, Whippany Rd, Rm 3B-312, Whippany NJ 07981; or Electronics Industries Association, 2001 Eye St NW, Washington DC 20006.

*May 14-16*
**The Tenth ASIS Mid-Year Meeting**, Fort Lewis College, Durango CO. The American Society for Information Science's (ASIS's) theme for this year's meeting is "Using Information." Among the topics to be addressed are user studies, decision making, organizational change, government, education, management, access to information, and designing information systems for use. For information, contact ASIS, 1010 16th St NW, Washington DC 20036, (202) 659-3644.

*May 17-20*
**Expo '81**, Loew's Anatole Hotel, Dallas TX. Expo '81 is a combination of exhibits and technical sessions. The exhibits cover everything from graphics systems to industrial computer-control systems. The technical sessions range from tool design, design engineering, and robotics to numerical control. For more information, contact Numerical Control Society, 519 Zenith Dr, Glenview IL 60025, (312) 297-5010.

*May 20-22*
**Joint Conference on Easier and More Productive Use of Computing Systems**, University of Michigan, Ann Arbor MI. This conference intends to combine the insights of the social sciences, humanities, computer science, and human-factors engineering. Contact Gregory A Marks, 4258 Institute for Social Research, University of Michigan, Ann Arbor MI 48106, (313) 763-3482.

*May 20-22*
**Videotex '81**, Royal York Hotel, Toronto, Ontario, Canada. Videotext information systems allow users to call up information, make

reservations, pay bills, exchange electronic mail, read an electronic newspaper, shop, and play video games. This conference will review videotext developments in Europe, Japan, and North and South America. Demonstrations of videotext systems will be given. Seminars on standards, legal aspects, and economic issues will be featured. Contact Videotex '81, 316 Lonsdale Rd, Suite 3, Toronto, Ontario, M4V 1X4, Canada, (416) 598-1981.

*May 21-23*
**Annual Conference of the Educational Computing Organization of Ontario,** Sheraton Centre and the Ontario Institute for Studies in Education, Toronto, Ontario, Canada. Exhibitions on the use of computers in schools and discussions on how to locate suitable educational materials will be featured. Contact the Conference Office, OISE, 252 Bloor St W, Toronto, Ontario, M5S 1V6, Canada.

## June 1981

*June 6-9*
**Atlanta Small Computer Show,** Atlanta Hilton, Atlanta GA. Producers of small computers, peripherals, supplies, and services will be exhibiting at this show. Business owners, corporate and government executives, data-processing managers, doctors, lawyers, and other professionals are expected to attend. Obtain additional information from The Atlanta Small Computer Show, 4060 Janice Dr, Suite C-1, East Point GA 30344, (404) 767-9798.

*June 9-11*
**Understanding and Using Computer Graphics,** Chicago IL. This seminar covers the latest in graphic-system technology, including hardware, software, and applications. Contact Bob Sanzo, Frost & Sullivan Inc, 106 Fulton St, New York NY 10038, (212) 233-1080.

*June 14-18*
**The Second National Conference of the National Computer Graphics Association,** Baltimore Convention Center, Baltimore MD. Computer-graphics demonstrations, exhibits, and workshops will be held. Contact the National Computer Graphics Association Inc, 2033 M Street NW, Suite 330, Washington DC 20036, (202) 466-5895.

*June 16-18*
**NEPCON East '81,** New York Coliseum, New York NY. This exposition is aimed at engineers, prototype developers, production specialists and testing personnel. Technical programs will be presented. Contact Industrial & Scientific Conference Management Inc, 222 W Adams St, Chicago IL 60606, (312) 263-4866.

*June 17-19*
**National Educational Computing Conference,** North Texas State University, Denton TX. This conference will provide a forum for individuals and institutions interested in educational computing. Computer literacy, computer education for teachers, and computers in education are some of the topics to be covered. Contact Dr Jim Poirot, NECC-81 General Chairman, Computer Sciences Department, North Texas State University, Denton TX 76203.

*June 20-22*
**The Fifth Annual Computerfest,** Franklin University, Columbus OH. Talks on robots and calculators will be featured. Microcomputers and small-business systems will be presented. This show is being sponsored by the Midwest Affiliation of Computer Clubs and Franklin University. Contact Computerfest '81, Paul Pittenger, 215 Delhi Ave, Apt J, Columbus OH 43202, (614) 224-6237.

*June 29-July 1*
**The Nineteenth Annual Meeting of the Association for Computational Linguistics,** Stanford University, Stanford CA. Syntax, parsing, and sentence generation, computational semantics, discourse analysis and speech acts, speech analysis and synthesis, machine and machine-aided translation, and mathematical foundations of computational linguistics are some of the topics to be discussed. Contact Don Walker, Artificial Intelligence Center, SRI International, Menlo Park CA 94025, (415) 326-6200, ext 3071.■

## BYTE's Bits

### Atari Slashes Prices

Atari Inc has reduced the price of the Atari 400 computer with 8 K bytes of memory to $530. The 16 K expanded version of the 400 is now selling for $630. Atari also reduced the Model 810 5¼-inch floppy-disk drive to $599.95.

On another front, Atari plans to begin selling a $150 word-processing program later this year.■

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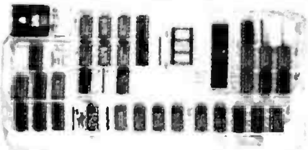
Circle 248 on inquiry card.



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**Advanced Z80A based CPU board**

S219 Assembled and Tested
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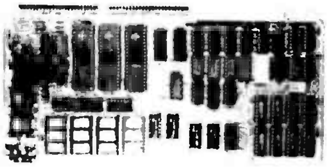
*Kit comes with all parts except chips connected to Interrupts.



"INTERFACE: 1"

**I/O, Memory Interface Board**

S229 Assembled and Tested
S169 Kit

Features: Model 3SPC
● 3 Serial w RS232C or 20ma Current Loop, 1 Parallel. ● 4K of EPROM/ROM and 4K of RAM (ROM/RAM not supplied). ● Built in Kansas City Standard Cassette interface usable to 1200 Baud. ● Generates all popular baud rates up to 19.2K baud, including 110 & 134.5. ● SW settable Address, Baud Rates, Ports.

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| DAN PAYMAR LOWER CASE ADAPTER | 45 | QUME SPRINT 5/45 PRINTER | 2,550 |

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

In the OFF-LINE mode, the EP-2A-87 will program, verify, test buffer, and load the buffer from the EPROM socket. During the programming cycle, the EPROM is checked before programming to insure that it is erased and after programming it automatically verifies that programming is correct. Power requirements are 115 VAC 50/60 Hertz at 15 watts.

| Part No. | Description | Price |
|---|---|---|
| EP-2A-87-1 | Programmer with 2K buffer | $575.00 |
| EP-2A-87-2 | Programmer with 4K buffer | 650.00 |
| | Non standard voltage option (220 v, 240 v, 100 v) | 15.00 |
| PM-0 | Personality Module, programs TMS 2708 | 18.00 |
| PM-1 | Personality module, programs 2708 | 18.00 |
| PM-2 | Personality module, programs 2732 | 34.00 |
| PM-3 | Personality module, programs TMS 2716 | 26.00 |
| PM-4 | Personality module, programs TMS 2532 | 34.00 |
| PM-5 | Personality module, programs 2716, TMS 2516 | 18.00 |
| PM-6 | Personality module, programs 2704 | 18.00 |
| PM-7 | Personality module, programs 2758, TMS 2508 | 18.00 |
| PM-8 | Personality module, programs Motorola MCM68764 | 36.00 |

**Optimal Technology, Inc.**
**Blue Wood 127**
**Earlysville, Virginia 22936**
**Phone (804) 973-5482**

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# Books Received

*Advanced Micro Devices Condensed Catalog*. Sunnyvale CA: Advanced Micro Devices Inc, 1981; 18 by 24.5 cm, 147 pages, softcover, no ISBN, free of charge.

*COBOL, A Vehicle for Information Systems*, Robert T Grauer. Englewood Cliffs NJ: Prentice-Hall Inc, 1981; 19 by 24.5 cm, 432 pages, hardcover, ISBN 0-13-139709-5, $18.95.

*The Creative Kid's Guide to Home Computers*, Fred D'Ignazio. Garden City NY: Doubleday & Company Inc, 1981; 16 by 24 cm, 130 pages, hardcover, ISBN 0-385-15313-9, $9.95.

*Digital Electronics Troubleshooting*, Joseph J Carr. Blue Ridge Summit PA: Tab Books Inc, 1981; 13 by 21 cm, 350 pages, softcover, ISBN 0-8306-1250-5, $9.95; hardcover, ISBN 0-8306-9677-6, $16.95.

*The Effective EDP Manager*, Michael R Frank. New York: AMACOM, 1980; 16 by 23.5 cm, 197 pages, hardcover, ISBN 0-8144-5635-9, $17.95.

*Experiments in Amplifiers, Filters, Oscillators, and Generators*, Morris Tischler. New York: McGraw-Hill Book Company, Gregg Division, 1981; 22 by 28 cm, 170 pages, softcover, ISBN 0-07-064780-1, $6.95.

*Experiments in General and Biomedical Instrumentation*, Morris Tischler. New York: McGraw-Hill Book Company, Gregg Division, 1981; 22 by 28 cm, 201 pages, softcover, ISBN 0-07-064781-X, $8.95.

*Experiments in Telecommunications*, Morris Tischler. New York: McGraw-Hill Book Company, Gregg Division, 1981; 22 by 28 cm, 186 pages, softcover, ISBN 0-07-064782-8, $7.95.

*The FORTRAN Cookbook*, Thomas P Dence. Blue Ridge Summit PA: Tab Books Inc, 1980; 13 by 21 cm, 334 pages, softcover, ISBN

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MICROSTAT sells for $250.00 and is supplied on 8" SD or 5¼" (North Star) disks. The user's manual sells for $18.00 and includes sample data and printouts. Please specify version when ordering. Foreign inquiries, please write directly to us.

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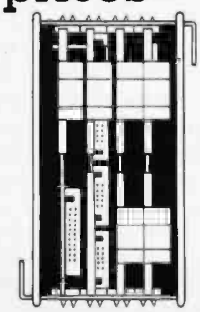

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## Books Received

0-8306-1187-8, $8.95; hardcover, ISBN 0-8306-9914-7, $14.95.

*Guide to Microcomputers*, Franz J Fredericks. Washington DC: Association for Educational Communications and Technology, 1980; 15.5 by 23 cm, 152 pages, softcover, ISBN 0-89240-038-2, $11.50.

*How to Build Your Own Working Microcomputer*, Charles K Adams. Blue Ridge Summit PA: Tab Books Inc, 1980; 13 by 21 cm, 308 pages, softcover, ISBN 0-8306-1200-9, $9.95; hardcover, ISBN 0-8306-9684-9, $16.95.

*Introduction to Computer Design and Implementation*, S Imtiaz and Kwok T Fung. Rockville MD: Computer Science Press Inc, 1981; 16 by 23.5 cm, 271 pages, hardcover, ISBN 0-914894-11-0, $19.95.

*Introduction to Computers and Data Processing*, Gary B Shelly and Thomas J Cashman. Fullerton CA: Anaheim Publishing, 1980; 21 by 27 cm, 498 pages, softcover, ISBN 0-88236-115-3, $15.95. Accompanying the textbook are a *Teacher's Guide and Answer Manual*, *Test Bank*, and transparency masters. *Student Workbook and Study Guide* for above, 21 by 27 cm, 247 pages, softcover, ISBN 0-88236-116-3, $5.95.

*Introductory Structured COBOL Programming*, Gary S Popkin. New York: Van Nostrand Reinhold Company, 1981; 19.5 by 24 cm, 471 pages, harcover, ISBN 0-442-26771-1, $18.95.

*The MC6809 Cookbook*, Carl D Warren. Blue Ridge Summit PA: Tab Books Inc, 1981; 13 by 21 cm, 176 pages, softcover, ISBN 0-8306-1209-2, $6.95; hardcover, ISBN 0-8306-9683-0, $11.95.

*Microprocessor Background for Management Personnel*, James Arlin Cooper. Englewood Cliffs NJ: Prentice-Hall Inc, 1981; 16 by 23.5 cm, 163 pages, hardcover, ISBN 0-13-580829-4, $14.95.

*Microcomputer Interfacing Handbook: A/D & D/A*, Joseph J Carr. Blue Ridge Summit PA: Tab Books Inc,

## Books Received

1980; 13 by 21 cm, 350 pages, softcover, ISBN 0-8306-1271-8, $8.95; hardcover, ISBN 0-8306-9704-7, $14.95.

*Motorola Optoelectronic Device Data*, Motorola Technical Information Center. Phoenix AZ: Motorola Inc, 1980; 17.5 by 23.5 cm, 302 pages, softcover, no ISBN, $3.25.

*Operating Systems*, Harold Lorin and Harvey M Deitel. Reading MA: Addison-Wesley Publishing, 1981; 17 by 24 cm, 378 pages, hardcover, ISBN 0-201-14464-6, $19.95.

*People and Project Management*, Rob Thomsett. New York: Yourdon Press, 1980; 15 by 23 cm, 106 pages, softcover, ISBN 0-917072-21-9, $10.50.

*PET/CBM Personal Computer Guide, Second Edition*, A Osborne and Carrol S Donahue. Berkeley CA: Osborne/McGraw-Hill, 1980; 16.5 by 23.5 cm, 501 pages, softcover, ISBN 0-931988-55-1, $15.

*The PLL Synthesizer Cookbook*, Harold Kinley. Blue Ridge Summit PA: Tab Books Inc, 1980; 13 by 21 cm, 279 pages, softcover, ISBN 0-8306-1243-2, $7.95; hardcover, ISBN 0-8306-9707-1, $13.95. ■

This is a list of books received at BYTE Publications during this past month. Although the list is not meant to be exhaustive, its purpose is to acquaint BYTE readers with recently published titles in computer science and related fields. We regret that we cannot review or comment on all the books we receive; instead, this list is meant to be a monthly acknowledgment of these books and the publishers who sent them.

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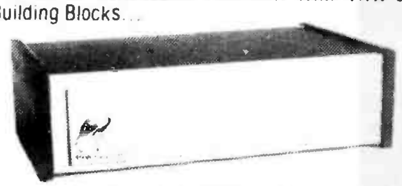


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# Software Received

This following is a list of software packages that have been received by BYTE Publications during the past month. The list is correct to the best of our knowledge, but it is not meant to be a full description of the product or the forms in which the product is available. In particular, some packages may be sold for several machines or in both cassette and floppy-disk format; the product listed here is the version received by BYTE Publications.

This is an all-inclusive list that makes no comment on the quality or usefulness of the software listed. We regret that we cannot review every software package we receive. Instead, this list is meant to be a monthly acknowledgment of these packages and the companies that sent them. All software received is considered to be on loan to BYTE and is returned to the manufacturer after a set period of time. Companies sending software packages should be sure to include the list price of the packages and (where appropriate) the alternate forms in which they are available.

## Apple

**ABM,** graphics arcade game for the Apple II. Floppy disk, $24.95. Muse, 330 N Charles St, Baltimore MD 21201.

**Action Sounds and Hi-Res Scrolling,** sound and graphics utility for the Apple II. Floppy disk, $15.95. Avant-Garde Creations, POB 30161, Eugene OR 97403.

**Animal Bingo,** nonviolent strategy game for the Apple II. Floppy disk, $9.95. Avant-Garde Creations (see above).

**Apex Handy Disk #1,** disk utilities for the Apex Operating System (on the Apple II). Floppy disk, $39. Apparat Inc, 4401 S Tamarac Pky, Denver CO 80237.

**Asteron,** game for the Apple II. Floppy disk, $27.50. Western Microdata Enterprises Ltd, POB 633, Postal Station G, Calgary, Alberta, T3A 2G1, Canada.

*Courseware Magazine*, education programs and documentation for the Apple II. Cassette, $12.95 for a single issue or $50 for 5 issues. *Courseware Magazine*, School of Business, California State University, Fresno CA 93740.

**CRAE 2.0 (Co-Resident Apple Editor 2.0),** Applesoft program editor for the Apple II. Floppy disk, $24.95. Highlands Computer Services, 14422 S E 132nd St, Renton WA 98055.

**The Creativity Life Dynamic Book,** graphics-, music-, and poetry-generation game for the Apple II. Floppy disk, $19.95. Avant-Garde Creations (see above).

**Jungle Safari,** graphics game for the Apple II. Floppy disk, $9.95. Avant-Garde Creations (see above).

**Masterdisk,** disk-examination utility for the Apple II. Floppy disk, $29.95. Masterworks Software Inc, POB 7000-285, Rolling Hills Estates CA 90274.

**MCAT 2.0,** disk-catalog utility for the Apple II. Floppy disk, $19.95. Highlands Computer Services (see above).

**The Meaning Life Dynamic,** graphics-game package for the Apple II. Floppy disk, $15.95. Avant-Garde Creations (see above).

**The Mine Fields of Normalcy,** strategy game for the Apple II. Floppy disk, $9.95. Avant-Garde Creations (see above).

**Mystery Code,** strategy game for the Apple II. Floppy disk, $9.95. Avant-Garde Creations (see above).

**Oldorf's Revenge,** fantasy game for the Apple II. Floppy disk, $19.95. Highlands Computer Services (see above).

**Personal Property Inventory,** cataloging utility for the Apple II. Floppy disk, $14.95. Hayden Book Company Inc, 50 Essex St, Rochelle Park NJ 07662.

**The Prisoner,** strategy game for the Apple II. Floppy disk, $29.95. Edu-Ware Services Inc, 22035 Burbank Blvd, Suite 223, Woodland Hills CA 91367.

**Sentence Diagramming,** teaching program for the Apple II. Floppy disk, $19.95. Avant-Garde Creations (see above).

**Star Avenger,** graphics arcade game for the Apple II. Floppy disk, $27.50. Western Microdata Enterprises Ltd (see above).

**Tarturian,** fantasy game for the Apple II. Floppy disk, $24.95. Highlands Computer Services (see above).

**VU #3,** VisiCalc-based utility for the Apple II. Floppy disk, $69.95. Progressive Software, POB 273, Plymouth Meeting PA 19462.

**XPLO,** programming language for the Apple II. Floppy disk, $79. Apparat Inc (see above).

## TRS-80

**Attack Force w/Sound,** graphics arcade game for the TRS-80. Cassette, $14.95. Big Five Software, POB 9078-185, Van Nuys CA 91409.

**Beef Cattle Least-Cost Ration Program,** cost-analysis program for the TRS-80. Cassette, $5. Agricultural Software Consultants Inc, 1706 Santa Fe, Kingsville TX 78363.

**Blackjack Master,** blackjack strategy game for the TRS-80. Floppy disk, $24.95. Hayden Book Company Inc, 50 Essex St, Rochelle Park NJ 07662.

**Galaxy Invasion,** graphics arcade game for the TRS-80. Cassette, $14.95. Big Five Software (see above).

**Personal Property Inventory,** cataloging utility for the TRS-80. Floppy disk, $14.95. Hayden Book Company Inc (see above).

**Starclash,** strategy game for the TRS-80. Floppy disk, $16.95. Hayden Book Company Inc (see above).

## CP/M

**Communications Software Package,** utility for CP/M systems. Floppy disk, $60. Datastat Systems Inc, 631 B St, San Diego CA 92101.

**Datastar,** key-to-disk data-entry program for the CP/M operating system. Floppy disk, $350. MicroPro International Corporation, 1299 Fourth St, San Rafael CA 94901.

**Pascal/M,** programming language for the CP/M system. Eight-inch floppy disk, $175. Sorcim, POB 32505, San Jose CA 95152.

**Supersort I,** record-sorting utility for the CP/M operating system. Floppy disk, $250. MicroPro International Corporation (see above).

**WordMaster,** video-based text editor for the CP/M operating system. Floppy disk, $150. MicroPro International Corporation (see above).

**WordStar,** word-processing program for the CP/M operating system. Floppy disk, $495. MicroPro International Corporation (see above).

## Other Computers

**Budget Manager,** personal-utility program for the APF Imagination Machine. Cassette, $19.95. APF Electronics, 1501 Broadway, New York NY 10036.

**Full Screen Editor,** text-manipulation program for the Heath H-89. Floppy disk, $24.95. Heath Company, Benton Harbor MI 49022.

**Jinsam 8.0,** data-base-management program for the Commodore CBM 8032. Floppy disk, $175. Jini Micro-Systems Inc, POB 274, Kingsbridge Sta, Bronx NY 10463.

**Personal Business Machine,** personal-utility program for the APF Imagination Machine. Cassette, $29.95. APF Electronics (see above).

**Ramscan,** memory diagnostic test for the Atari 800. Floppy disk, $15. Axlon Inc, 170 N Wolfe Rd, Sunnyvale CA 94086.

**Space, Size, and Surface Guide,** personal-utility program for the APF Imagination Machine. Cassette, $29.95. APF Electronics (see above).■

## Results of "What Is It?" Contest

In the April 1980 BYTE, we announced a contest. In the "What's New?" section, on page 247, we printed a picture of an anonymous mechanical device and challenged readers to identify it. The first person to respond with the correct answer was to receive the device as a prize.

Tony Caloggero of Nahant, Massachusetts, won the contest. It is called Stepdozer, a product of the Gakken Company of Japan. The Stepdozer is part of a line of mechanical toys known as Space Mechanimals.

Other readers sent in varying descriptions of the beasty. Several readers stated that it was part of a cash register. One reader gave a specific description as a 1903 C L Smith adding machine, with the battery pack thrown in as a "red herring." Another reader guessed several possibilities: "a doughnut dunker, an automatic pitchfork, or a piece of my spaceship." Yet another suggested that it was a model of an oil pump. These descriptions were slightly off the mark.

Several readers came closer, by describing it generically as "a walking machine." One reader said that he recognized it instantly as a "Rien de Toot," and we received one letter identifying the device as a "mechanical Trojan horse."

Finally, we would like to quote extensively from a reader in University, Alabama, who wrote:

*Good heavens, any economist worth his salt knows the answer—it's a portable widget, with a self-contained power source. It's used as a product example in almost every freshman economics course in the country. Get with it—you folks are slipping! Next time, show us something really hard to guess, like an inversely truncated framistan!*

Only if we can find one.■

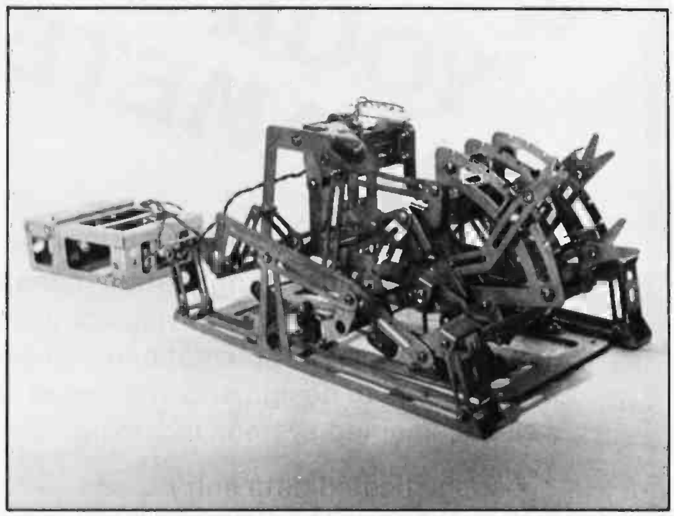

**Photo 1:** *A Stepdozer for Tony Caloggero. He guessed it, he got it.*

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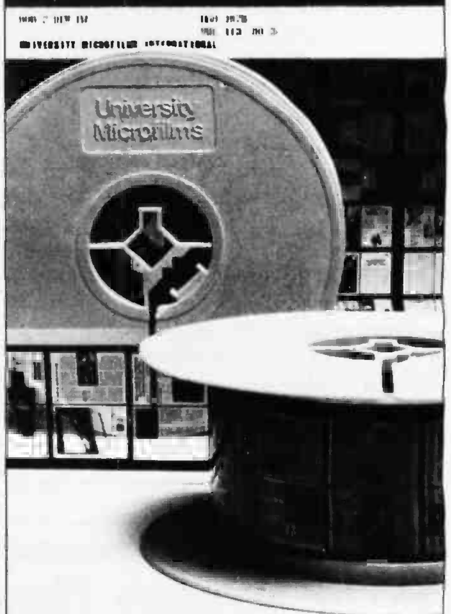


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# PADDLES

## Interfacing with Modular Breadboards

Roger J Combs and Paul E Field
Department of Chemistry
Virginia Polytechnic Institute
and State University
Blacksburg VA 24061

Often, microcomputer interfacing is a simple task requiring only a basic knowledge of digital electronics. The availability of breadboarding sockets has made building and testing of digital electronics circuits relatively easy. (Breadboard sockets considered here are the E & L Instruments SK-10 and the AP Products Super Strip.) The ease of digital-circuit testing with breadboards can be extended to microcomputer interfacing by use of *functional modules* which plug into these breadboards. We call these modules PADDLEs (Peripheral Analog/Digital Device-Logic Extensions).

**Breadboarding sockets have made building and testing digital electronics relatively simple.**

The various PADDLE modules perform the following functions: address decoding for device selection, D/A (digital-to-analog) conversion, A/D (analog-to-digital) conversion, displaying data, and debouncing switches. Once you have built these circuits in modular form, you will not have to build them from scratch for every breadboard project, and you will not have to use valuable breadboard space that could otherwise be delegated to the project at hand.

It is best to avoid constructing modules so complex that their use becomes cumbersome and their utility limited. For this reason, we shall consider building PADDLEs to perform only those functions which are often called for in digital circuits and which are easily integrated into prototype interface circuitry.

We have found a minimum configuration of five PADDLEs most useful both for interfacing projects and for instruction. These consist of (1) a set of three switch-debouncing circuits, (2) a set of eight logic switches having a latched-pulse output for interrupt generation, (3) a dual seven-segment display, (4) an A/D-D/A converter and comparator for either analog-to-digital or digital-to-analog conversion, and (5) a device decoder capable of generating eight unique outputs from an 8-bit input.

A single 8-bit address decoder PADDLE can be used to select devices, provided the microcomputer uses accumulator I/O (input/output). In order to decode a 16-bit memory address, two decoder PADDLEs would be necessary. Though the PADDLEs can be used with other microprocessors, our focus is on the 8080 family. In the following text we consider each of these PADDLEs in terms of function and design.

### Pulser PADDLE

This PADDLE (see figure 1) generates a digital pulse, either positive or negative, that is devoid of the bouncing (momentary intermittent contact) always found in mechanical switches. This is done by the use of an RS (set-reset) flip-flop. Often an RS flip-flop is constructed from two NAND gates; however, the same result can be obtained by the use of two inverters. Either a positive or negative pulse is available at the output of each RS flip-flop. With a single type-7404 hex inverter, three RS flip-flops can be constructed (rather than two using a single 7400 quad NAND gate).

The operation of an RS flip-flop constructed from either inverters or NAND gates is controlled by the current-sinking ability of a TTL (transistor-transistor logic) device output, since a floating input connected to an output that is low will also be pulled low. These pulsers are a means of manually generating signals that can be used to enable or clear such devices as monostable multivibrators (one-shots), counters, latches, and so on.

### Logic Switch PADDLE

As the name implies, the device in figure 2 allows definition of a logic 1 or 0 on each of eight parallel lines. A single-pulse switch is also provided to generate an interrupt pulse that is latched by a 7474 D-type latch. Each of the eight lines is three-state buffered and enabled by the same external pulse that clears the D latch. Used with an 8080A microprocessor, the output line marked P can be tied to INT (the processor's interrupt line) and the input-enable signal, labeled $\overline{E}$, can be connected to the microprocessor's interrupt-acknowledge line, $\overline{INTA}$. This allows the PADDLE to function as an interrupting device. Once INT has been accepted, $\overline{INTA}$ will gate the instruction defined by the logic switches (usually a special-restart subroutine call, RST *X*) onto the data bus.

| Number | Type | +5 V | GND |
|---|---|---|---|
| IC1 | 7404 | 14 | 7 |

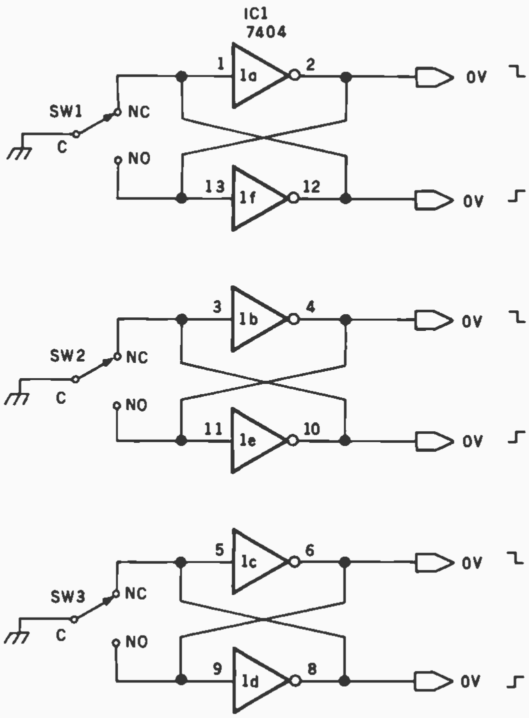



**Figure 1:** *Schematic of a PADDLE for manually producing bounceless pulses. SW1 thru SW3 are momentary-contact switches; A thru F are sections of a 7404 hex inverter integrated circuit.*

| Octal | BOC |
|---|---|
| 377 | 7.7. |
| 246 | 4.6 |
| 135 | 3 5. |
| 012 | 1 2 |

**Table 1:** *Examples of BOC (binary/octal code) coding using two seven-segment displays and their decimal points to represent an 8-bit number.*

A short program to test this function using RST 4 is given in listing 1. Alternately, the PADDLE can be used as an input device to the accumulator (by properly using $\overline{E}$ with device decoding), or $\overline{E}$ can be tied to ground and the logic switches used as individual switches.

## Display PADDLE

This device (see figure 3) displays an 8-bit word on seven-segment LED (light-emitting diode) displays in either the BCD (binary-coded-decimal) format or a BOC (binary/octal-code) format. The BCD format is actually the hexadecimal display obtained with the 7447 seven-segment decoder. Since the upper six digits of this code are not particularly useful, or at least not easily memorized, we have devised the BOC format in order to display an 8-bit word using the two seven-segment displays and their associated decimal points.

| Number | Type | +5 V | GND |
|---|---|---|---|
| IC1 | 7474 | 14 | 7 |
| IC2 | 74368 | 16 | 8 |
| IC3 | 74368 | 16 | 8 |

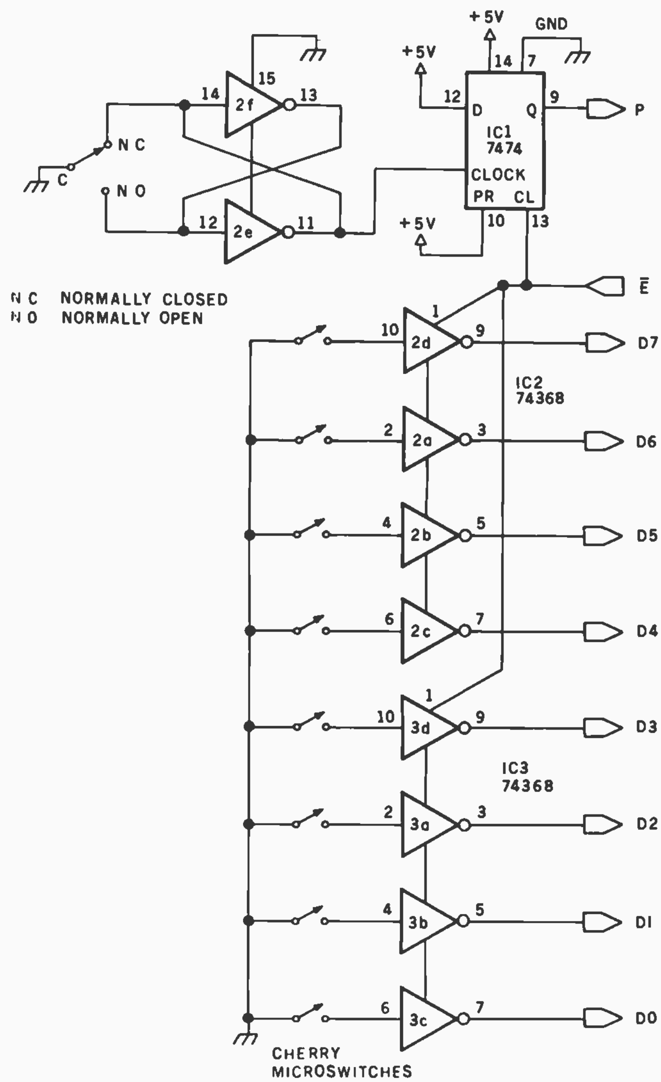
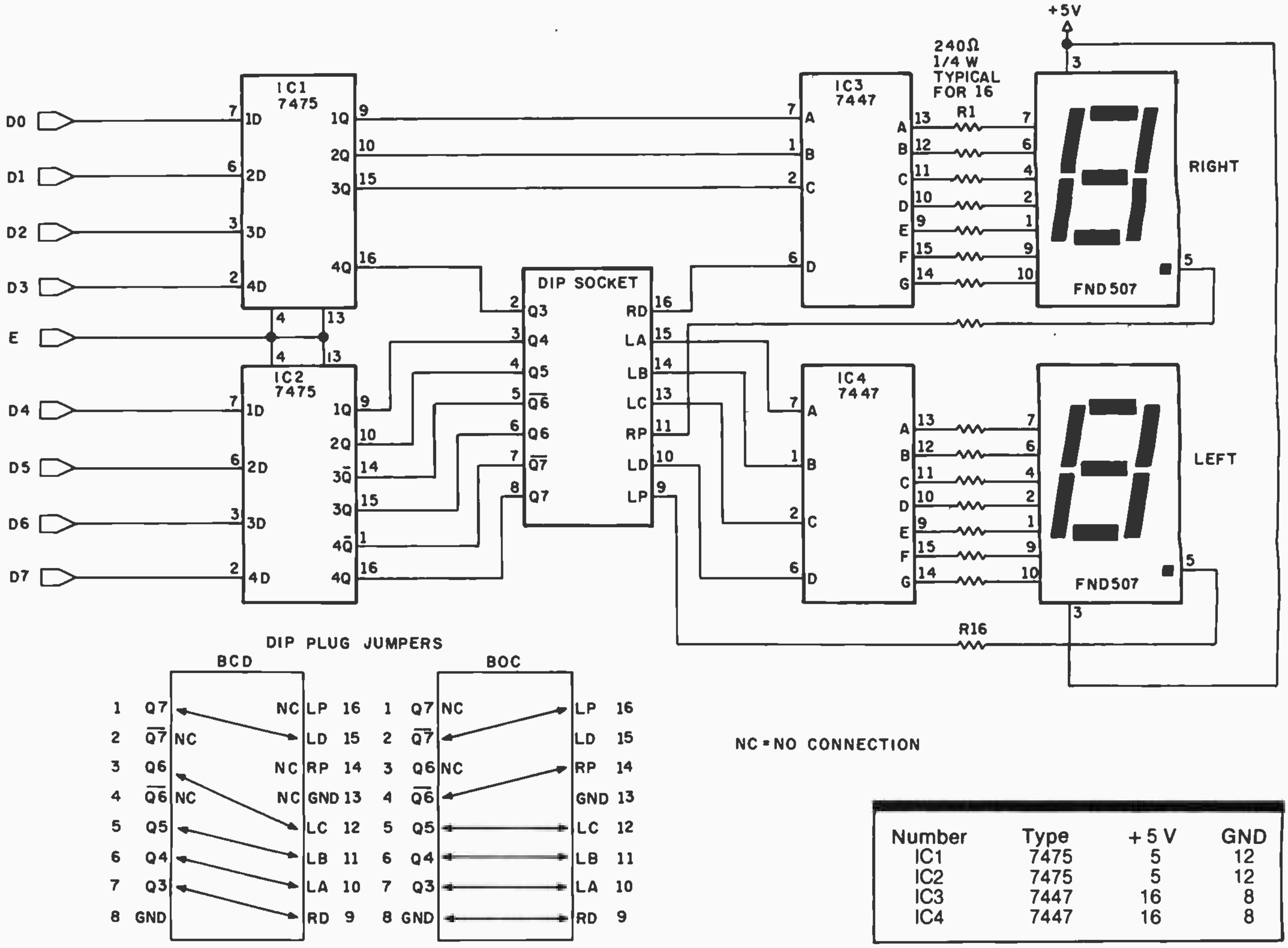



**Figure 2:** *This PADDLE circuit permits the sending of 8 bits of data to a processor by functioning as either an interrupt or an input device. Switch C is of the momentary variety, while the eight data switches are SPST (single pole, single throw).*

**Listing 1:** *Routine to exhibit function of the Logic Switch PADDLE as an interrupt device. An indefinite delay is generated by use of EI (enable interrupts) followed by HLT (halt). Each time an interrupt is generated the display will increment by one.*

```
          SUB A     /CLEAR ACCUMULATOR
AGAIN,    INR A
          OUT
          DISPLAY
          EI
          HLT       /INTERRUPT IS ENABLED

000 040,  POP H     /RESTORE STACK POINTER
          JMP       /RST 4 MUST BE JAMMED ON DATA BUS
          AGAIN     /AT TIME OF INTA IN ORDER TO RETURN
          PAGE      /TO NEW DELAY
```




| Number | Type | +5 V | GND |
|---|---|---|---|
| IC1 | 7475 | 5 | 12 |
| IC2 | 7475 | 5 | 12 |
| IC3 | 7447 | 16 | 8 |
| IC4 | 7447 | 16 | 8 |

**Figure 3:** *Binary data on lines D0 thru D7 can be displayed on two seven-segment LED (light-emitting diode) displays in either BCD (binary-coded-decimal) or BOC (binary/octal-code) format (see text) using the Display PADDLE. Resistors R1 thru R16 are 240-ohm ¼ W.*

Binary/octal-code format is *binary* in the sense that the two most significant bits are displayed on the decimal points, and it is *octal* since the remaining six bits are displayed as two octal digits on the seven-segment displays. BOC represents a substantial advantage over normal numeric display because only two rather than three displays and decoders are required. Although one could monitor the eight lines using alphanumeric hexadecimal displays, these are much more expensive than seven-segment displays with decimal points.

The ability to use the displays in either a BCD or BOC format is selected by using one of two jumper-wired dual-inline plugs inserted into a 14-pin DIP (dual-inline package) socket. The eight data-input lines, D0 thru D7, are brought to a pair of 7475 quad D latches. The outputs of the latches, Q0 thru Q7, $\overline{Q6}$, and $\overline{Q7}$, are routed via the DIP plug to obtain the selected display format. In either configuration, signals from Q0 thru Q2 bypass the DIP plug and connect directly to the three least significant inputs of the 7447 decoder-driver for the right-hand display.

In the BCD configuration, the DIP plug directs Q3 to the MSB (most significant bit) input of IC3, the right-hand 7447, and Q4 thru Q7 to the appropriate inputs of IC4, the left-hand 7447. The decimal points of the displays are not connected.

In the BOC configuration, the DIP plug directs Q3 thru Q5 to IC4, grounds the MSB inputs of both 7447s, and connects $\overline{Q7}$ and $\overline{Q6}$ directly to the left- and right-hand decimal points of the FND 507 LED displays. Use of the logical complements of Q6 and Q7 is necessary because the FND 507 is a common-anode display.

On the PADDLE module, the gating inputs to the 7475 quad D latches are tied together and labeled E (enable). When E is at logic 1, the data present on lines D0 thru D7 is displayed; on the 1-to-0 transition it is latched. In this manner the Display PADDLE can be used as an output device (provided proper address decoding is implemented to allow the 7475s to latch the data bus at the correct time).

## A/D-D/A PADDLE

The PADDLE in figure 4 can be used as either an A/D (analog-to-digital) converter or a D/A (digital-to-analog) converter. It consists of the following: a 7404 hex inverter, two 7475 quad D latches, a 1408L8 8-bit D/A converter, a 741 operational amplifier (op amp), and a 311 voltage comparator. Because the latter three devices re-

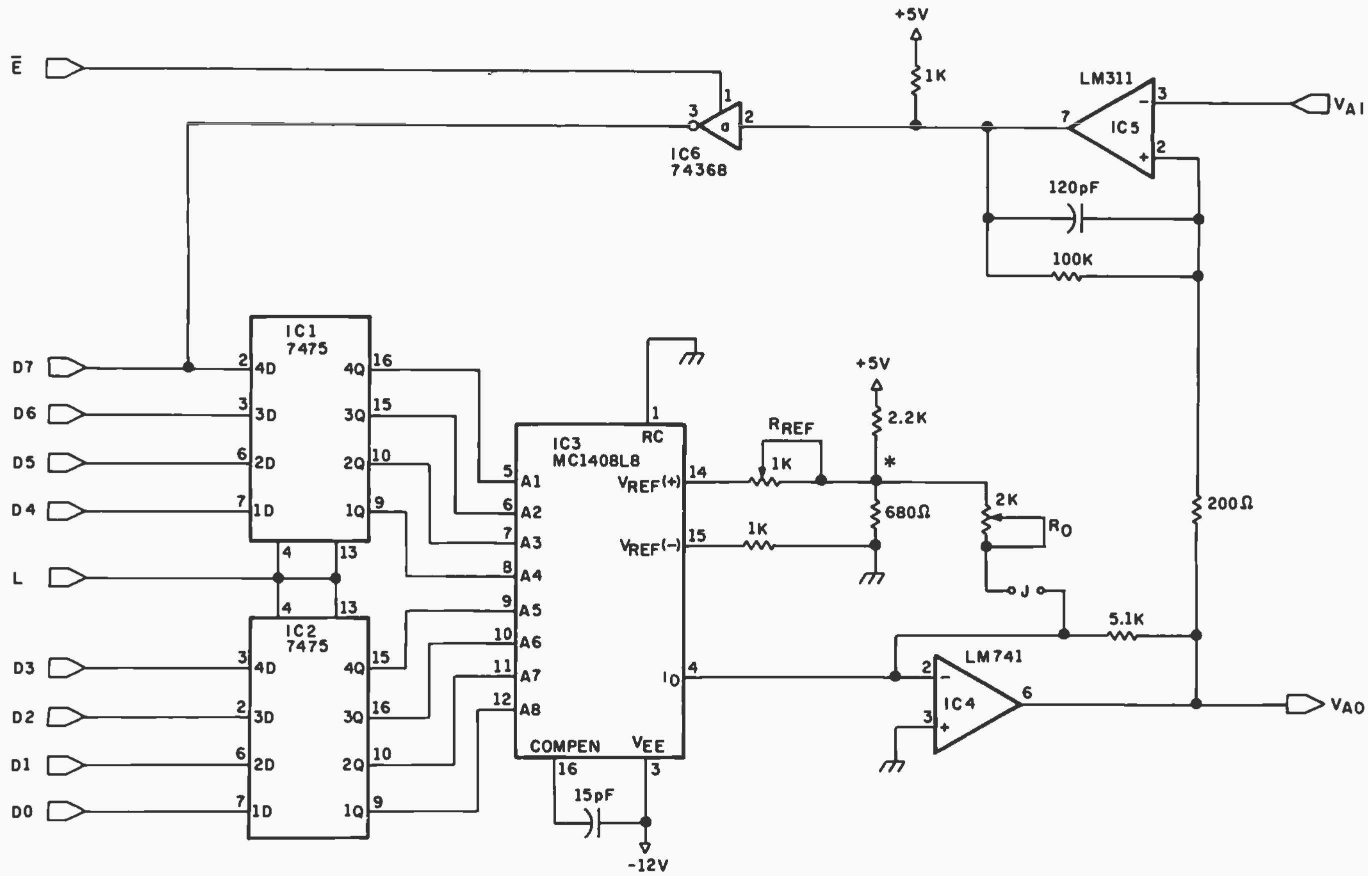



**Figure 4:** *Analog-to-digital and digital-to-analog conversion of data is performed by the A/D-D/A PADDLE in conjunction with the SAP program in listing 2. $V_{AI}$ and $V_{AO}$ are the analog input and output lines, respectively. The asterisk indicates the voltage reference point; jumper J allows generation of negative output voltages. IC 6 is one section of a 74368 integrated circuit.*

| Number | Type | +5 V | GND | −12 V | +12 V |
|---|---|---|---|---|---|
| IC1 | 7475 | 5 | 12 | | |
| IC2 | 7475 | 5 | 12 | | |
| IC3 | MC1408L8 | 13 | 2 | | |
| IC4 | LM741 | | | 4 | 7 |
| IC5 | LM311 | | 1 | 4 | 8 |
| IC6 | 74368 | 16 | 8 | | |

quire +12 V and −12 V, wire-insertion sockets labeled +V and −V are provided on the PADDLE for connection to an external power supply.

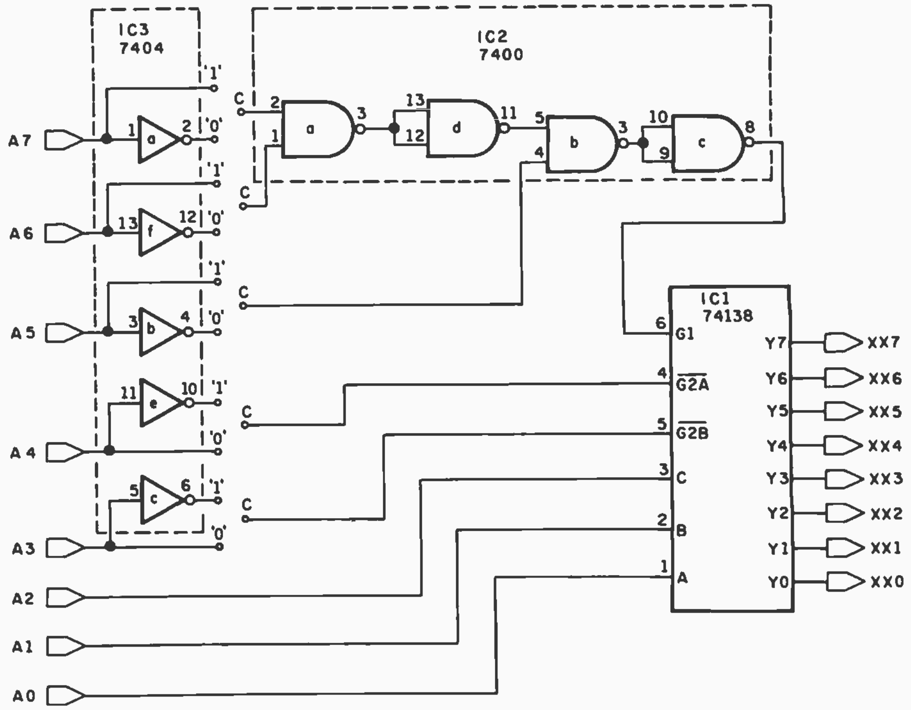
Let us first consider the use of this PADDLE as a D/A converter and note its limitations. The PADDLE is designed so that once an 8-bit word is latched by the 7475s, the 1408 D/A converter converts this byte into a proportional current. The 741 operational amplifier connected to the output of the D/A converter serves as a current-to-voltage converter. When the jumper shown in figure 4 is *not* inserted, the D/A converter is in a unipolar mode and can generate voltages between 0 and the positive external power-supply voltage. In the unipolar mode, the voltage range is dependent upon the reference current supplied to the D/A converter and the amplifier feedback resistance at the output of the D/A converter. The calculation of this voltage is based on the digital value of the 8 bits D0 thru D7:

$$V_{AO} = \frac{V_{ref}}{R_{ref}} R_f \left( \frac{D0}{2} + \frac{D1}{4} + \frac{D2}{8} + \frac{D3}{16} + \frac{D4}{32} + \frac{D5}{64} + \frac{D6}{128} + \frac{D7}{256} \right)$$

where $R_{ref}$ is the resistance provided by a 1 k-ohm potentiometer and $R_f$ is 5.1 K-ohms (from the amplifier feedback resistor). Note that $V_{ref}$ at the node labeled with the asterisk in figure 4 is determined by the voltage-divider circuit and is calculated to be 1.18 V. As $R_{ref}$ is reduced to zero, the voltage output goes to a minimum value of approximately +4.0 V. Based on the previous equation, we can infer that an impedance of about 500 ohms exists at pin 14 of the 1408L8.

To use the D/A converter in a bipolar mode requires insertion of a jumper on the PADDLE. This jumper connection is made between two wire-insertion sockets. It introduces an offset current via $R_0$ that permits negative output voltages to be obtained. Note that $R_{ref}$ as defined can be interpreted as a *scaling* factor because it approximately defines the range of voltage values possible at the output $V_{AO}$.

This only approximately defines the range in the bipolar mode because of the parallel resistance of $R_0$ introduced into the voltage-divider circuit. Because the inverting input of the operational amplifier is at virtual ground, the resistance from $V_{ref}$ to ground now becomes the 2.2 k-ohms of potentiometer $R_0$ in parallel with the 680-ohm resistor. Introducing the offset current ($V_{ref}/R_0$)




| Number | Type | +5 V | GND |
|---|---|---|---|
| IC1 | 74138 | 16 | 8 |
| IC2 | 7400 | 14 | 7 |
| IC3 | 7404 | 14 | 7 |

**Figure 5:** *Jumpers located at C allow the 8-Bit Address Decoder PADDLE to decode any eight consecutive addresses out of a possible 256.*

yields the bipolar voltage:

$$V_{AO} = \frac{V_{ref}}{R_{ref}} R_f \left( \frac{D0}{2} + \frac{D1}{4} + \frac{D2}{8} + \frac{D3}{16} + \frac{D4}{32} + \frac{D5}{64} + \frac{D6}{128} + \frac{D7}{256} \right) - \frac{V_{ref}}{R_0} R_f$$

As a result of the reference voltage's dependence on $R_0$, *both* the offset and scaling potentiometers must be adjusted to give a voltage symmetric about 0 V. The resolution of the D/A converter in either unipolar or bipolar mode is one part in 256, or 0.4%.

Now let us consider use of the PADDLE as an A/D converter. This is accomplished by using a software routine in conjunction with the D/A converter and the voltage-comparator integrated circuit. The 311 voltage comparator compares the analog input voltage, $V_{AI}$, to a reference voltage, $V_{AO}$, supplied by the D/A converter, derived from a program-generated digital input. The selection of inputs to the voltage comparator with $V_{AI}$ at pin 3 and $V_{AO}$ at pin 2 of the LM311 (IC5) is based on impedance matching (ie: pin 2 is a high-impedance input and avoids loading the analog-signal source).

**Listing 2:** *SAP, the successive-approximation program. Also see figure 6.*

```
SAP,    SUB A
        LXI B
        000Q
        200Q
        MVI D
        010Q
ADC,    ORA B
        MOV C,A
        OUT
        DAC
        IN
        FLAG
        ANI
        200Q
        JNZ
        WAIT
        PAGE
        MOV A,B
        XRA C
        MOV C,A
NEXT,   MOV A,B
        RAR
        MOV B,A
        MOV A,C
        DCR D
        JNZ
        ADC
        PAGE
        RET
WAIT,   NOP
        JMP
        NEXT
        PAGE
```

Now the two voltages are compared in relative magnitude and the result is reflected in the output (pin 7) of the comparator. If $V_{AI}$ is greater than $V_{AO}$ the output will be at the negative saturation voltage; conversely, if $V_{AI}$ is less than $V_{AO}$, the output will be at the positive saturation voltage. Because the LM311 has an open-collector output, the output voltage is made TTL-compatible by adding a pull-up resistor tied to +5 V.

The output is tied to D7 of the data bus through a three-state buffer, thus allowing the signal to be monitored by SAP (a successive-approximation program, given in listing 2, with the flowchart shown in figure 6). A logic state of 1 at D7 indicates that an output byte (ie: $V_{AO}$) is too low, while a logic 0 indicates that the byte is too high.

SAP starts with the most significant bit and either sets or clears it depending upon the status of D7. This process of setting or clearing successive bits is continued until all 8 bits have been tested. Therefore, if the analog input voltage is constant over the duration of the SAP execution time, it can be measured to within 0.4%. SAP takes eight steps to adjust $V_{AO}$ regardless of the value of $V_{AI}$. Thus, the rate of conversion is constant in this particular software version of an A/D converter. Calculating the maximum rate of conversion requires computation of the SAP execution time because each SAP step allows sufficient settling time for the D/A converter.

## 8-Bit Device Decoder PADDLE

This PADDLE uses one 7404 hex inverter, one 7400 quad NAND gate, and a 74138 3-to-8-line decoder (see figure 5). It allows generation of device-select pulses for use in accumulator I/O typical of the 8080 family of microprocessors. As a decoder, the PADDLE provides unique decoding for eight adjacent device codes from *XX*0 to *XX*7 over the range of 256 devices. This is done by

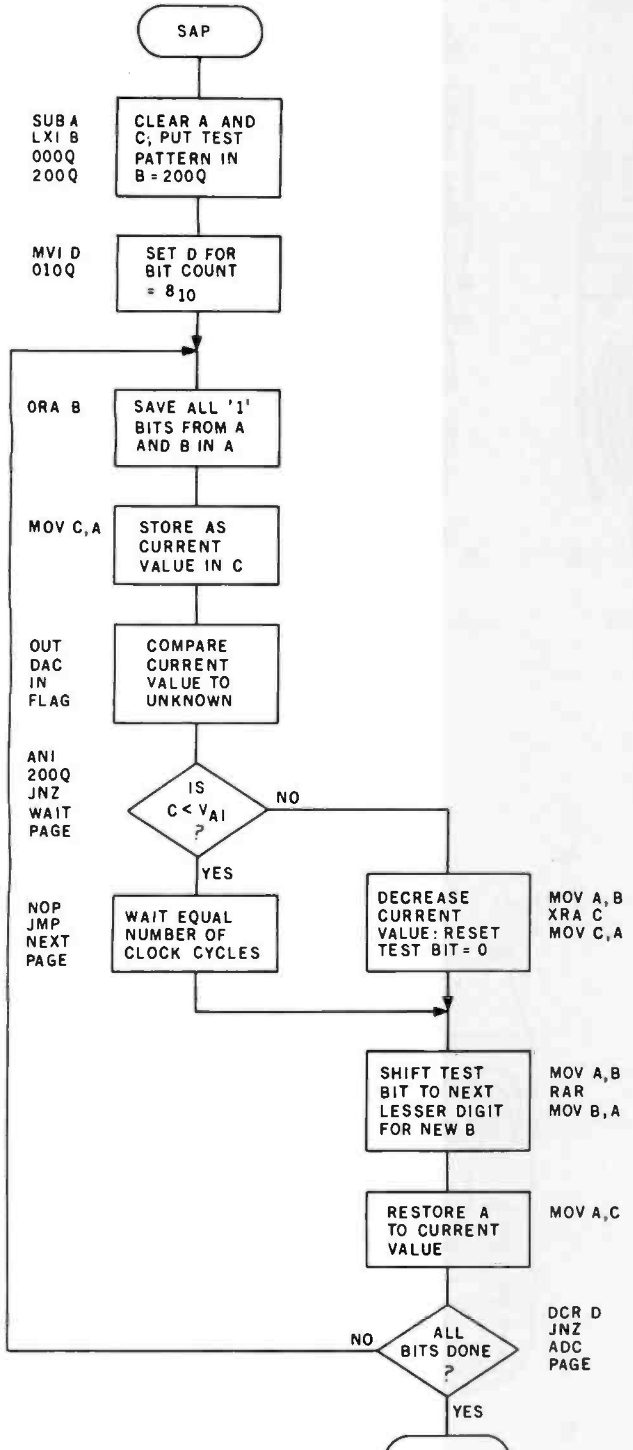



**Figure 6:** *A flowchart of SAP, the successive-approximation program of listing 2. The 8080 code is shown with each flowchart step.*

jumpers in wire-insertion sockets on the PADDLE, which select unique decoding for A7 thru A3 (or A15 thru A11) of the address bus lines.

Once a device code is generated, it must be ORed (off of the PADDLE module) with either $\overline{\text{I/OR}}$ (referred to as $\overline{\text{IN}}$ ) or $\overline{\text{I/OW}}$ ( $\overline{\text{OUT}}$ ) to create a device-select pulse for input or output, respectively. $\overline{\text{IN}}$ and $\overline{\text{OUT}}$ are obtained by NANDing the appropriate latched status bit with the control pulses DBIN (input) or $\overline{\text{WR}}$ (output) on an 8080 processor. In terms of the S-100 bus, $\overline{\text{IN}}$ is defined as sINP (pin 46) NANDed with pDBIN (pin 78), while $\overline{\text{OUT}}$ is $\overline{\text{PWR}}$ (pin 77) inverted and NANDed with sOUT (pin 45).

## Construction Details

The printed-circuit layouts for the five PADDLEs are presented in figure 7. Each board is 3 inches long and either 1½ or 2 inches wide. The extra section of the Display PADDLE which supports the seven-segment display at a comfortable viewing angle is 1⅛ inches long.

The component layouts for the PADDLEs are given in figure 8. Because the layouts are for single-sided copper foil, all jumpers, as well as all other components, were run parallel to the edges of the PADDLE, with none of the jumper wires crossing. Note that the pins for power and ground must be carefully aligned for insertion into the breadboard. The power bus is assumed to be the outer strip on the breadboard.

All circuit-board holes were drilled with a #65 drill bit (with the exception of holes for wire-insertion sockets; these required a #55 drill bit). The small switches used for the pulsers required that slots be cut with the wheel-cutter blade of a Dremel tool. Marks are provided on the switch pads for guide holes to be drilled at each end of the slots.

It was found convenient to mount the Display, 8-Bit Address Decoder, and A/D-D/A PADDLEs on the side of the breadboard away from the experimenter, while the Logic Switch and Pulser PADDLEs were plugged into the breadboard on the side nearest the experimenter (see photo 1). This accounts for the manner in which the PADDLEs were labeled in figure 7.

With this arrangement, switches and pulsers are close at hand and easy to manipulate, while the display is positioned to face the experimenter and the wire-insertion sockets and their associated jumpers are out of the way.

Once the circuit boards are etched, drilled, and tin-plated, the following steps provide the most systematic approach for assembly:

1. Spray-paint the component side of the board with enamel.
2. Label component side with transfer letters.
3. Spray labels with clear acrylic coating.
4. Insert wire jumpers; solder and trim leads.
5. Insert resistors; solder and trim leads.
6. Insert and solder IC sockets.
7. Insert and solder potentiometers.
8. Insert capacitors; solder and trim leads.
9. Using either wire-wrap posts or #24 gauge wire, mount breadboard-insertion pins so that they extend 0.3 inches below the board, solder, and trim flush on component side.
10. Insert and solder wire-insertion sockets.

*Text continued on page 356*

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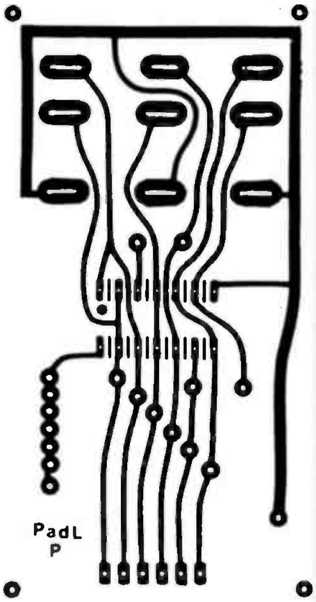
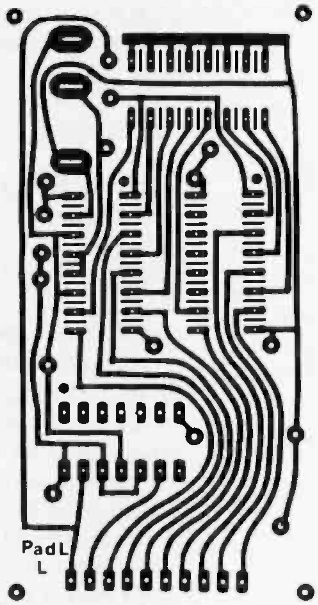
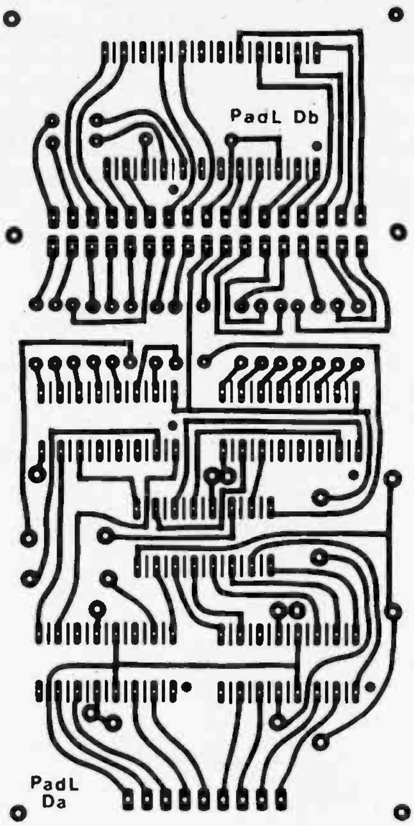



(a) Pulser PADDLE




(b) Logic Switch PADDLE




(c) Display PADDLE

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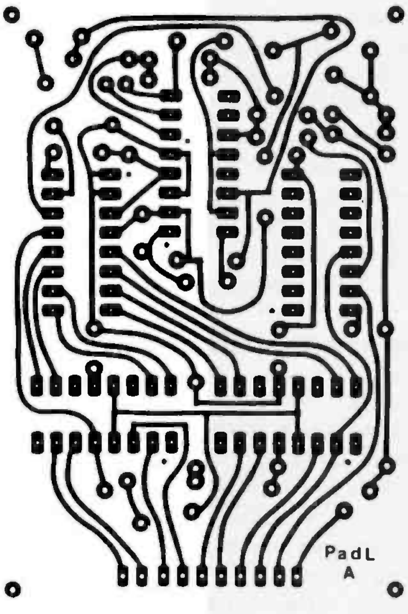
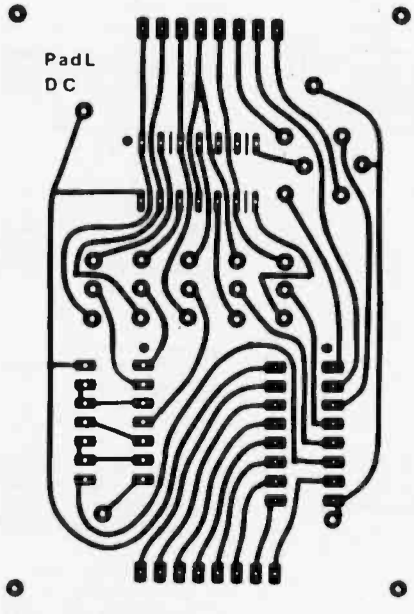



(d) A/D-D/A PADDLE




(e) 8-Bit Address Decoder PADDLE

**Figure 7:** *Full-size printed-circuit-board patterns for the five PADDLEs.*

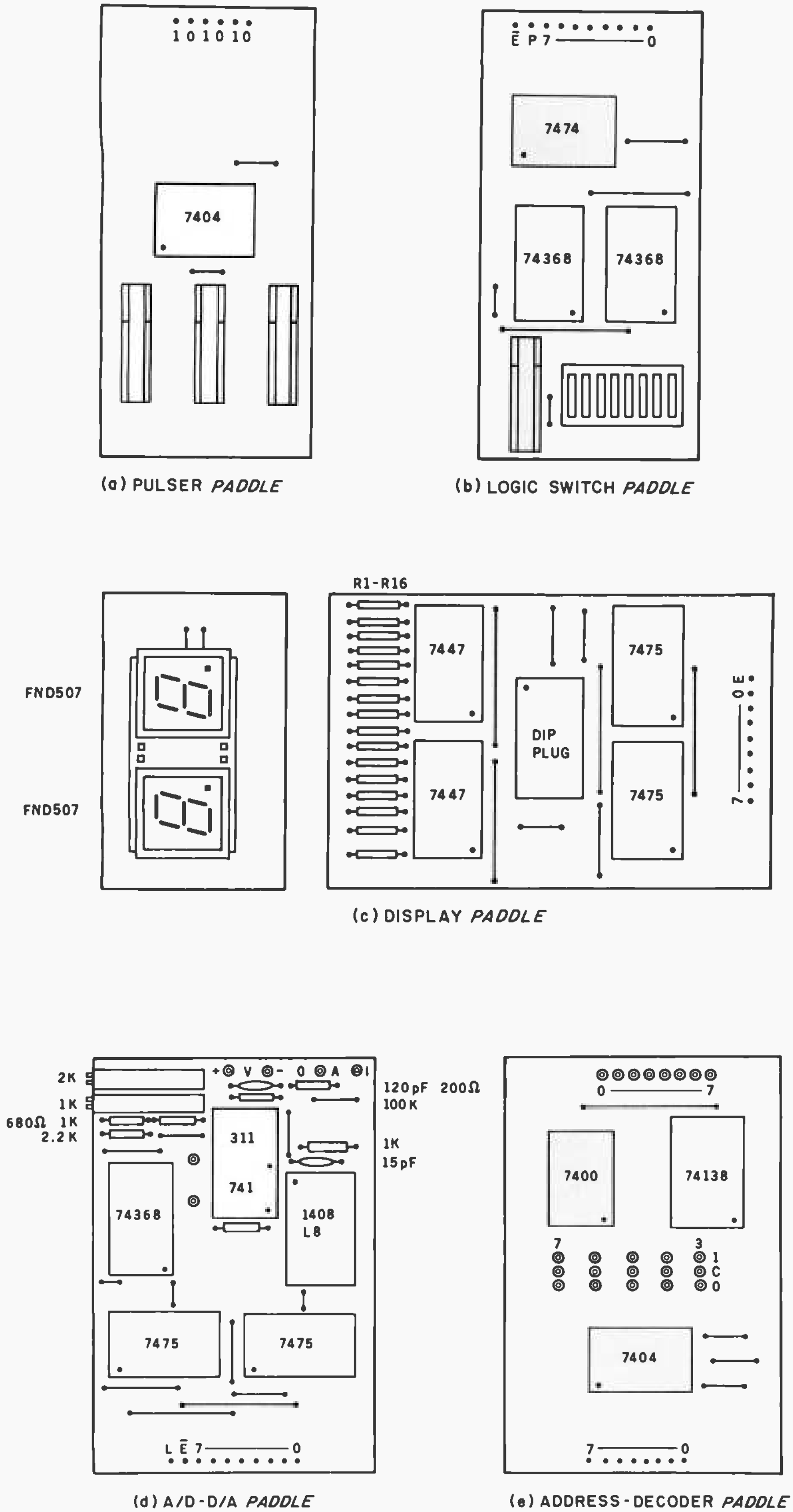



**Figure 8:** *Component view of the individual PADDLEs.*

| | | |
|---|---|---|
| Pulser PADDLE: Total | | $5.93 |
| 1 | 7404 | 0.18 |
| 1 | 14-pin IC socket | 0.20 |
| 3 | Cherry Microswitch | 1.85 |
| Logic Switch PADDLE: Total | | $2.37 |
| 1 | 7474 | 0.35 |
| 2 | 74368 | 0.69 |
| 1 | 14-pin IC socket | 0.20 |
| 2 | 16-pin IC socket | 0.22 |
| Display PADDLE: Total | | $7.87 |
| 2 | 7447 | 0.59 |
| 2 | 7475 | 0.49 |
| 2 | FND 507 | 0.99 |
| 2 | DIP plugs (16 pin) | 0.70 |
| 5 | 16-pin IC sockets | 0.22 |
| 1 | 24-pin IC socket | 0.38 |
| 16 | 240-ohm, ¼ W resistors | 0.05 |
| A/D-D/A PADDLE: Total | | $14.10 |
| 2 | 7475 | 0.49 |
| 1 | 74368 | 0.69 |
| 1 | LM311 | 0.90 |
| 1 | 741 | 0.35 |
| 1 | MC1408L8 | 5.75 |
| 5 | 16-pin IC sockets | 0.22 |
| 6 | wire insertion sockets | 0.23 |
| Resistors: | | |
| 1 | 680 ohm, ¼ W | 0.05 |
| 1 | 1 K, ¼ W | 0.05 |
| 1 | 2.2 k-ohm, ¼ W | 0.05 |
| 1 | 5.1 k-ohm, ¼ W | 0.05 |
| 1 | 100 k-ohm, ¼ W | 0.05 |
| 1 | 1 k-ohm potentiometer | 1.35 |
| 1 | 2 k-ohm potentiometer | 1.35 |
| Device Code PADDLE: Total | | $7.17 |
| 1 | 7400 | 0.16 |
| 1 | 7404 | 0.18 |
| 1 | 74138 | 0.69 |
| 2 | 14-pin IC sockets | 0.20 |
| 1 | 16-pin IC socket | 0.22 |
| 24 | wire insertion sockets | 0.23 |

**Table 2:** *Components necessary for each PADDLE and their approximate costs.*

**Listing 3:** *Program to log 256 points of an analog signal by calling SAP and then display the resultant conversions, used in conjunction with the PADDLE setup in figure 10.*

```
        LXI H    /INITIAL ADDRESS OF DATA TABLE
        TABLE
        PAGE
LAD,    CALL     /CONVERSION SUBROUTINE
        SAP      /RETURN WITH VALUE IN C
        PAGE
        MOV M,C  /PUT POINT IN TABLE
        INR L    /NEXT TABLE POSITION
        JNZ      /LOGGED 256 POINTS?
        LAD      /NO
        PAGE
DISC,   MOV A,M  /YES:GET POINT FROM TABLE
        MVI D    /SET DELAY FOR DISPLAY
        1DH
STALL,  OUT      /DISPLAY POINT
        DAC
        DCR D    /COUNTDOWN
        JNZ      /DELAY DONE?
        STALL    /NO
        PAGE
        INR L    /NEXT TABLE POSITION
        JMP      /ENDLESS DISPLAY
        DISC
        PAGE
```

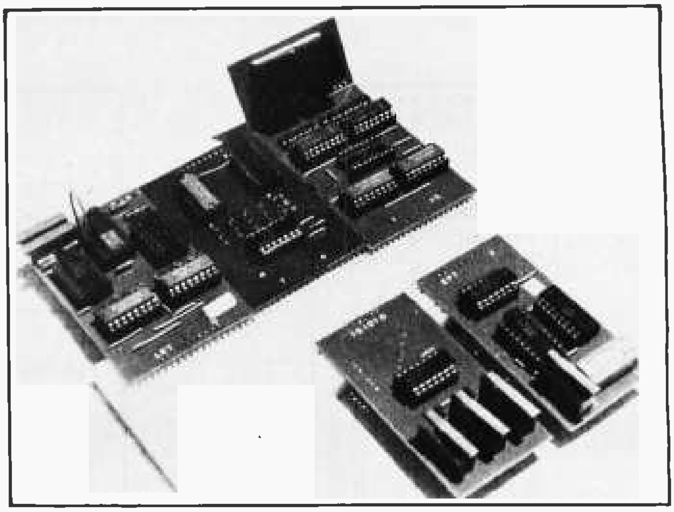


**Photo 1:** *Complete PADDLEs mounted on a breadboard socket. Starting at bottom center and moving counter-clockwise: Pulser, Logic Switch, Display, 8-Bit Address Decoder, and A/D-D/A.*

*Text continued from page 353:*
Table 2 lists the components necessary for each PADDLE module and their approximate costs.

## Experiments Using PADDLES

This quintet of PADDLEs defines a set of circuitry that is indispensable for most interfacing projects. Cost is minimal compared to the benefit derived from the modules. As stated above, usually only a few additional logic gates are required in order to use the PADDLEs as peripheral devices. Although we leave their applications to the needs and imagination of the user, a few elementary applications are described here. We have already discussed how to implement the Logic Switch PADDLE as a vectored-interrupt device to enter an RST instruction.

A second application for a simple I/O circuit can be constructed using the Address Decoder, Display, and Logic Switch PADDLEs as shown in figure 9. This circuit requires only four additional gates and an inverter for device-select-pulse generation. A program to test the circuit would contain a loop with instructions to receive input from the Logic Switch and send output to the Display.

A third application uses the A/D-D/A and Address Decoder PADDLEs to log and display 256 points of a 4 V peak-to-peak sine wave (100 Hz, see figure 10). A main program and subroutine are given in listing 2 and listing 3. Note that the successive-approximation program of listing 2 uses a subroutine that is discussed under the A/D-D/A PADDLE. The conversion rate from analog to digital can be found by calculating the execution time per point of the log-analog-data program. With an 8080A microprocessor operating at 2 MHz, this time is calculated to be 0.41 ms per point. (Displaying this signal on an oscilloscope in an undistorted digital form requires the same rate of display as conversion; this is done by use of the D register as a delay counter in the display-conversion program.)■

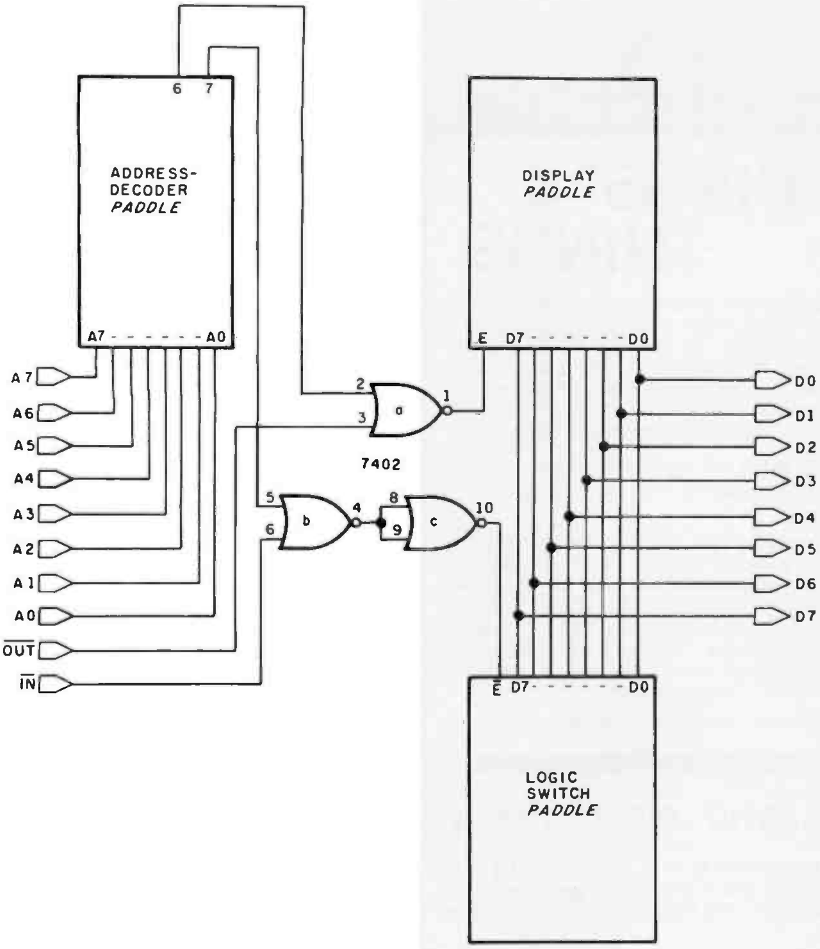



**Figure 9:** *Configuring three PADDLEs as an I/O (input/output) device for an 8080-type system requires a single 7402 inverter.*

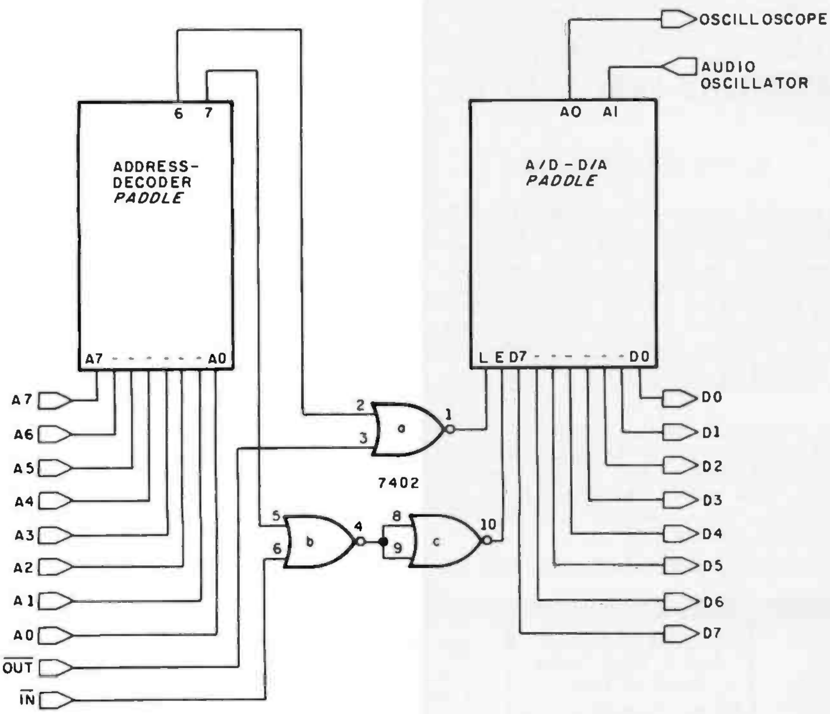



**Figure 10:** *PADDLE configuration to convert the output of an audio oscillator to digital form and back to analog for display on an oscilloscope.*

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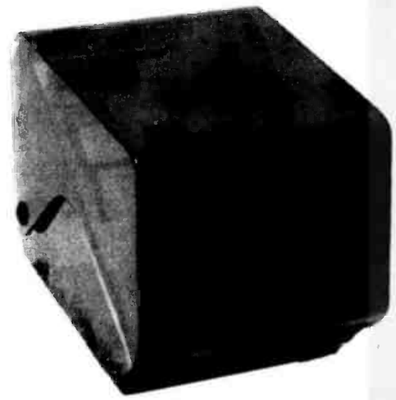

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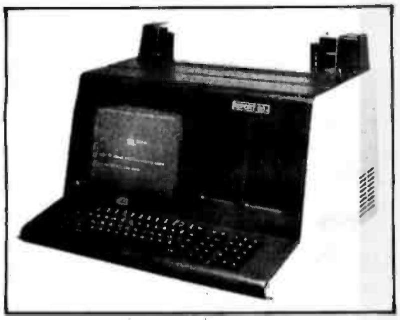
The information printed in the new products pages of BYTE is obtained from "new product" or "press release" copy sent by the promoters of new products. If in our judgment the information might be of interest to the personal computing experimenters and homebrewers who read BYTE, we print it in some form. We openly solicit releases and photos from manufacturers and suppliers to this marketplace. The information is printed more or less as a first-in first-out queue, subject to occasional priority modifications. While we would not knowingly print untrue or inaccurate data, or data from unreliable companies, our capacity to evaluate the products and companies appearing in the "What's New?" feature is necessarily limited. We therefore cannot be responsible for product quality or company performance.

# What's New?

## SYSTEMS

### Small Business System from Systel



The REPORT/80 is a portable business system for less than $10,000. It combines the 8085 and Z80 microprocessors, 64 K bytes of memory, a keyboard; a 12-inch, 80-column by 25-line video display, two 5-inch floppy-disk drives, a 9 by 7 dot-matrix printer, and two RS-232C serial ports in a single unit. CP/M is included. Systel offers a selection of business programs as an option. The Model 11 has a suggested retail price of $8950, and includes two double-sided, double-density drives. The Model 15 has two double-sided, quad-density drives, and costs $9950. For more information, contact Systel Computers Inc, 20370 Town Center Ln, Cupertino CA 95014, (408) 253-0992.

Circle 408 on inquiry card

### 6800/6809 Development Systems Can Offer 2-Megabyte Storage

The Scoutsystem development systems from SSB (Smoke Signal Broadcasting) are for 6800/6809 microprocessors. They provide 2 megabytes of floppy-disk storage and up to 64 K bytes of programmable memory. The series features a video display, dual 5- or 8-inch disk drives, plus SSB's Hunter debugging package, which allows memory, register, and stack contents to be inspected and changed. Software includes a macroassembler that provides relocatable code. An MDOS conversion package permits files generated under it to be read by SSB's DOS68 or DOS69 and vice versa. A text editor and text processor are available. The EPROM (erasable programmable read-only memory) programmer can handle 1 K-, 2 K-, or 4 K-byte EPROM s. An optional in-circuit emulator allows the host system to be tied into the target system. The Scoutsystem series also contains a diagnostic routine for identifying failed integrated circuits. Prices for the Scoutsystem series range from under $5700 to $7745. Contact Smoke Signal Broadcasting, 31336 Via Colinas, Westlake Village CA 91362, (213) 889-9340.

Circle 409 on inquiry card

### 6809 Board for the Apple II

The Mill is a 6809 microprocessor board that plugs into the Apple II. It can be used in manufacturing or laboratory process-control monitoring and concurrent programming tasks. Users can run existing 6502 programs, 6809 programs, or any software reassembled for the 6809 from existing 6800 source code. In operation, the 6809 and 6502 run concurrently, with the 6809 acting as the bus master during the 6502's bus accesses. Typically, the 6809 commands 80% of the available bus time for memory accesses and data transfers. The 6502 can stop the 6809 for time-critical I/O operations. Sections of 6502 programs can be recoded into 6809 machine language. The FLEX operating system can be employed with the Mill. The Mill features directly addressable stacks and the position independence of code, and it allows the Apple II to be used in a multiprogramming mode. The Mill is available from Stellation Two, POB 2342, Santa Barbara CA 93120, for $275.

Circle 411 on inquiry card

### Systems from Zeda

The 520 series of portable microcomputers feature a Z80A microprocessor, a video display, floppy-disk drive, and detachable keyboard. The series can be powered by standard 110 VAC current, 12 VDC, or optional internal batteries. You can order your system with either a 5-, 9-, or 12-inch video screen (ie: the Models 525, 529, or 522, respectively). The series has 48 K bytes of programmable memory, 2 K bytes of video programmable memory, a double-density floppy-disk-drive controller, and a 200 K-byte drive. A 400 K-byte quad-density drive is available. Up to three drives can be added to the system. A Centronics printer port, an RS-232C serial port, and a bar-code-reader port for a Hewlett-Packard HEDS-3000 digital wand are provided. The CP/M-compatible

ZEDOS operating system has all the CP/M and CDOS+ system calls, plus ZEDOS calls. A status line displays a program counter; disk-error information; a low-power indicator; a type-ahead buffer; system idle, screen frozen, and printer activated flags; and disk status. The prices are $4495 for the 522, $3995 for the 525, and $4195 for the 529. Contact Zeda Computers International Ltd, 1662 W 820 North, Provo UT 84601, (801) 377-9948.

Circle 410 on inquiry card

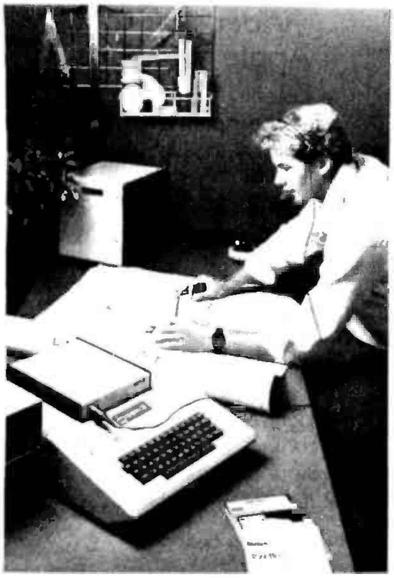
### 16 Megabytes of Storage on the QT

QT System+ can be used for accounting, word-processing, and scientific applications. It features a Z80 microprocessor, two 8-inch floppy-disk drives, a controller for double-sided, double-density 5- and 8-inch drives, and a Televideo 920C video terminal. There are 48 K bytes of dynamic programmable memory (expandable to 64 K bytes), a 2 K-byte monitor program and Disk BIOS (Basic I/O Subsystem) on an EPROM, two RS-232C ports, two parallel ports, a real-time clock, and the CP/M 2.2 or the MP/M operating systems.

The QT System+ comes in two versions. The 1-megabyte, single-sided, double-density system sells for $4295. The 2-megabyte, double-sided, double-density unit is priced at $4995. For complete details, contact QT Computer Systems Inc, 15620 S Inglewood Ave, Lawndale CA 90260, (800) 421-5150; in California (213) 970-0952.

Circle 412 on inquiry card

# PERIPHERALS



## Voice-Entry Terminal for the Apple II

The VET/2 voice-entry terminal plugs into any slot of a 48 K-byte Apple II. A direct keyboard link allows the user to choose keyboard or voice input at any time. Once a word has been entered into the program, whenever it is spoken, the function is performed. The VET/2 is supplied with preprocessor, interface board, software with demonstration programs, noise-canceling headset microphone, and a user's manual. The price is $895 from Scott Instruments, 815 N Elm, Denton TX 76201, (817) 387-9514.

Circle 413 on inquiry card

## Connect Your Selectric to a Computer

The Escon interface system includes all the electronics, connectors, and instructions necessary to convert an IBM Selectric typewriter into an output printer. Units have been designed for S-100 systems, and RS-232C serial, parallel, and IEEE-488 interfaces. No drilling or modification is required. The typewriter can still be used in a normal fashion, and its eligibility for IBM warranty and service will not be affected. Printing speed is 15 cps (characters per second), which is approximately 160 words per minute. Prices range from $595 to $675. For details, contact Ipex International Inc, 16140 Valerio St, Van Nuys CA 91406, (213) 781-0020.

Circle 414 on inquiry card

## Floppy-Disk Drives from Commodore

The 8060 series of 8-inch floppy-disk drives includes the CBM 8062, which can store 3.2 megabytes of data, and the CBM 8061, which handles up to 1.6 megabytes. The 8061 reads and writes one side of the disk, while the 8062 handles both sides. The drives and operating system are compatible with the IBM 3740 format and Commodore's other drives. For more information, contact Commodore Business Machines Inc, 950 Rittenhouse Rd, Norristown PA 19403, (215) 666-7950.

Circle 415 on inquiry card

## Video Terminal from Perkin-Elmer

The Perkin-Elmer Model 550S is a block mode/editing video-display unit. Three modes allow for conversational timesharing, transaction processing, and test manipulation or software development. The 550S offers an optional second page of scrolling memory. The 24-line screen windows into 48 lines by 80 columns of text. The standard keyboard has 83 keys, including a numeric pad and four program function keys. A serial printer port is standard, as well as automatic on/off host control over terminal block transmissions and half intensity, blink, nondisplay, and protected features. Transmission types included are: send all, send unprotected only, send line, send page, and send from home to stop code. The 550S is priced at $1189. Contact Perkin-Elmer, Terminals Division, 360 Rt 206 South, Flanders NJ 07836, (201) 229-6800.

Circle 416 on inquiry card


## Pitch Analyzer for Speech Synthesis

The Visi-Pitch extracts and measures vocal pitch in real time. The device provides visual or numerical descriptions of pitch variability, speech rhythm, and intonation contours. It can be used in the testing of speech synthesis and recognition systems, and in speech therapy. The Visi-Pitch interface can transfer frequency or period information to 8-bit parallel inputs. The period data is generated after each pitch period, and frequency data is generated every 0.5 seconds. The data output is 3-state 8-bit parallel. The price for the unit is $2410 from Kay Elemetrics Corporation, 12 Maple Ave, Pine Brook NJ 07058, (201) 227-2000.

Circle 417 on inquiry card

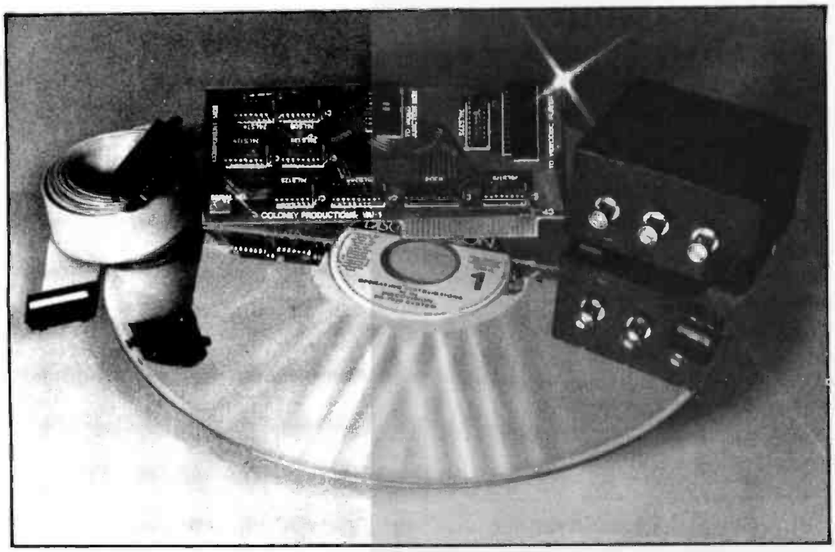
## 16 K-Byte Memory Card for the Apple II

RAMCard provides the Apple II 48 K computer with 16 K bytes of programmable memory. It's compatible with Microsoft's SoftCard. It can be used with all software available for the SoftCard, but it cannot be used in addition to the Apple Language Card. The price of the RAMCard is $195. For more details, contact Microsoft Consumer Products, 400 108th Ave NE, Suite 200, Bellevue WA 98004, (206) 454-1315.

Circle 418 on inquiry card

# What's New?

## PERIPHERALS



### Videodisk-to-Apple Interface

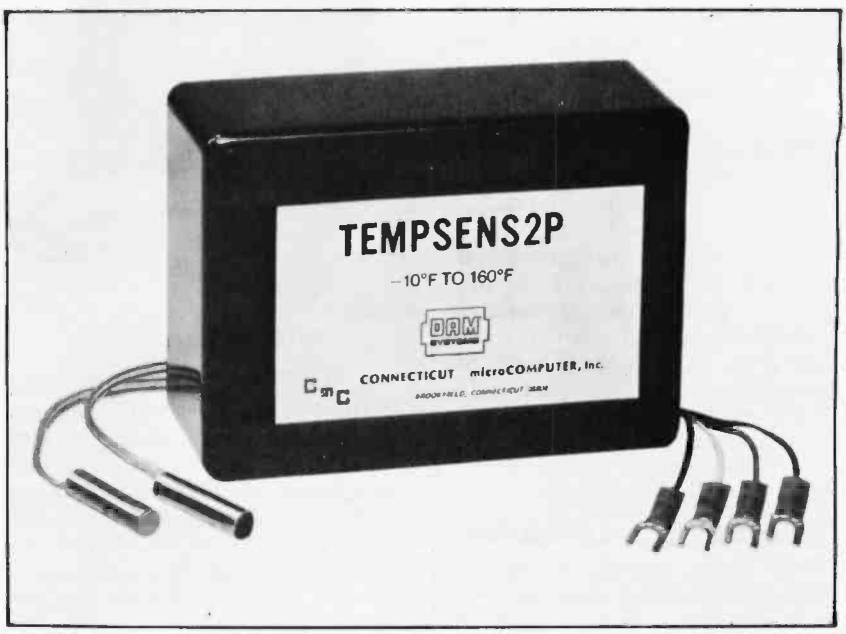
The Coloney VAI-1 interface board fits inside the Apple and allows complete control of the DiscoVision industrial videodisk player. In addition, the package provides circuitry to switch computer- or disk-generated video on a single television monitor. The packages sells for $525, and includes a manual, a controller card, junction box for video connections, control subroutines in assembly language and Pascal, cables, and a demonstration program. For additional information, contact Coloney Productions, 1248 Blountstown Hwy, Tallahassee FL 32304, (904) 575-0691.

Circle 419 on inquiry card

### Microcomputer-Compatible Temperature Probes

Tempsens provides direct temperature input for a variety of microcomputers, including the PET, the Apple II, and the TRS-80. Operating within a temperature range of −24°C to 72°C (-10°F to +160°F), each Tempsens module provides two temperature probes to the CmC (Connecticut microComputer) AIM16 analog input module using a CmC MANMOD1. The MANMOD1 will accept input from up to 8 Tempsens modules, for a total of 16 individual probes. The suggested retail price of a 2-probe Tempsens is $49.95. Contact Connecticut microComputer Inc, 34 Del Mar Dr, Brookfield CT 06804, (203) 775-4595.

Circle 420 on inquiry card




### Light Pen for OSI Computers

The L C S Light Pen Kit designed for OSI (Ohio Scientific) computers features a coiled cord and an easily disconnected plug. The light pen is manufactured by Lewis Computer Systems, and is distributed by Faragher Associates Inc, 7635 W Bluemound Rd, Milwaukee WI 53213, (800) 558-0870. The suggested list price is $29.95.

Circle 421 on inquiry card

### Color-Graphics Board for Heath Microcomputers

The HA-8-3 color-graphics board can be used with the Heath H-8 and All-In-One computers. The board uses a TI-9918 color video-display-generator integrated circuit. An AY-3-8910 programmable sound-generator circuit is also included. Four X,Y joystick consoles can be used with the board; each console has 4 bits of parallel I/O. A socket is provided for an AMD-9511 arithmetic processor circuit. The HA-8-3 can be used with most video monitors as well as other video accessories utilizing NTSC composite color video. Demonstration software on a 5-inch floppy disk is included. The board sells for $395. Contact Heath Company, Department 350-590, Benton Harbor MI 49022, (616) 982-3210.

Circle 422 on inquiry card

# What's New?

## MISCELLANEOUS

### This Black-Hole Diode Is User-Transparent


Another new addition in the small-components market is the 7N-∞ BHD (black-hole diode). This device has two inputs and no output. Care must be taken to shield this component appropriately or it may absorb the unit it is placed in. The 7N-∞ will accept any voltage or current value. It is useful for GI (garbage-in) applications. Due to the light-absorption qualities of the device, we could not provide a photograph. Contact Spatial Regression Ltd, POB 463, Paulborough NH 03458.

Circle 423 on inquiry card

### Software for the Hayes Micromodem II

Datacomm is a data-communications-software package for use with the Hayes Micromodem II for Pascal-equipped Apple II microcomputers. Datacomm consists of a terminal program that allows data and program exchange. It uses the Apple's Pascal routines for ease and accuracy, and Hayes Micromodem II routines are used so that a programmer can include data-communications commands in his or her Pascal program. Datacomm is available in retail computer stores for $50. Contact Hayes Microcomputer Products Inc, 5835 Peachtree Corners E, Norcross GA 30092, (404) 449-8791.

Circle 424 on inquiry card

### Low-Power 16 K-Byte Memory Board for S-100 Systems

This 16 K-byte programmable memory board for S-100-bus systems uses 650 mA at +5V, 90 mA at +12V, or 16 mA at −5V. Each 4 K-byte block is addressable to any 4 K boundary. The board uses NEC (Nippon Electric Company) UPD 410 D integrated circuits. This static memory board costs $350 in kit form, or $385 assembled. Contact Shell Electronics Company, M/S 1429, Sun Valley CA 91352, (213) 767-5597.

Circle 425 on inquiry card

### S-100 Error-Correcting Board

This 4 MHz S-100 error-correcting board monitors 64 K bytes of existing system programmable memory and intervenes to correct bus data before it is accepted by the microprocessor. The board corrects 1-bit memory errors and flags all 1- or 2-bit errors. All operations are performed through on-board hardware. The board immediately corrects memory problems, and latched displays show the address and bit in error. The price is $1295 from Correlation Systems, 81 Rockinghorse Rd, Rancho Palos Verdes CA 90274.

Circle 426 on inquiry card

### Z80 Monitor in an EPROM

SSM Microcomputer Products has a Z80 monitor in a single-voltage 2716 EPROM. Supporting SSM's CB2 Z80 microcomputer board, the monitor allows operators to display, substitute, or fill memory; perform hexadecimal arithmetic; establish two program breakpoints; set and examine registers; assign I/O devices; and input and output data to or from a port. The monitor can scan its memory and set its stack to avoid replacement or reprogramming of the EPROM. Documentation and software listings are provided with the monitor, which is priced at $89. Contact SSM Microcomputer Products, 2190 Paragon Dr, San Jose CA 95131, (408) 946-7400.

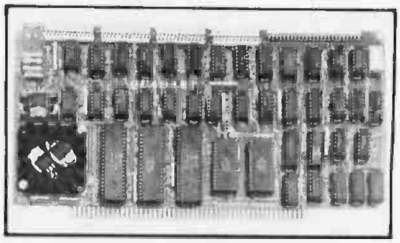
Circle 427 on inquiry card

### Apple II Display Board

The Apple II Display Board has a run-stop, single-step switch that simplifies identification of shorted lines between address or data bits and shows individual steps for teaching computer logic. The board has 16 address LEDs (light-emitting diodes), 8 data LEDs, and 1 ready LED. All lines are buffered. The board sells for $49.95 assembled and tested, $42.95 for the kit, and $25.95 for the bare board. Contact John Bell Engineering, POB 338, Redwood City CA 94064, (415) 367-1137.

Circle 428 on inquiry card

### Serial-Communications Card for S-100 Systems



Cromemco's Quadart serial-communications S-100 interface card has four serial channels. Any channel can support asynchronous or synchronous byte- or bit-mode communication protocols under software control. Handshaking is provided. The Quadart can connect an S-100 microcomputer and an IBM-type machine using Bisync or SDLC protocol. A loopback feature provides the capability to connect data from one channel or modem to another, or allows any modem/channel combination to be used. Data rates range from 0 to 300 k bps (bits per second). The interface supports the interrupt structure of the Z80A microprocessor. The Quadart has real-time clocking capability. Control for the board is from the C-Bus provided by Cromemco's Model IOP processor computer. The Quadart serial-communications board is available for $595. The IOP costs $695. For information, contact Cromemco Inc, 280 Bernardo Ave, Mountain View CA 94043, (415) 964-7400.

Circle 429 on inquiry card

### WordCheck Spots Misspellings in Documents and Letters

WordCheck interacts with WordPro 3 or 4 word-processing programs and checks every word for spelling or typographical errors. The program contains approximately 2000 of the most commonly used words and suffixes. Words that do not match this list appear on the screen. If you wish, these words can then be added to a 1000-word auxiliary spelling list. WordCheck is available for CBM and PET 32 K-byte microcomputers with floppy-disk drives. The list price is $200 from Micro Computer Industries Ltd, 1520 E Mulberry, Suite 110, Fort Collins CO 80524, (303) 221-1955.

Circle 430 on inquiry card

# What's New?

## MISCELLANEOUS

### Copy Stands for Computer Terminals

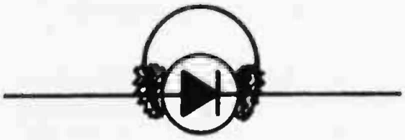
The Keyboard Companion copy stands keep work directly in front of the operator. They fit most terminals with detachable keyboards, including the Apple II. The units can support a telephone book and other heavy reference manuals or manuscripts. Installation is quick and easy. Prices begin at $19.95 for the 16-inch model. For information, contact PKay Corporation, POB 11463, Costa Mesa CA 92627, (714) 548-2081.

Circle 431 on inquiry card

### Zilog's New Microcomputer Systems

The MCZ 2/19 features a Z80A microprocessor, 64 K bytes of programmable memory, and 2.4 megabytes of floppy-disk storage that can be expanded to 4.8 megabytes with additional disk drives. The MCZ 2/49-1 system includes the MCZ 2/19 plus a video-display terminal, Zilog's RIO 3 operating system, and COBOL or BASIC. Zilog also has PLZ and a variety of business-application software packages available. In 50-unit quantities, the MCZ 2/49-1 costs $5890, and the MCZ 2/19 is $5270. For details, contact Zilog, 10340 Bubb Rd, Cupertino CA 95014, (408) 446-4666.

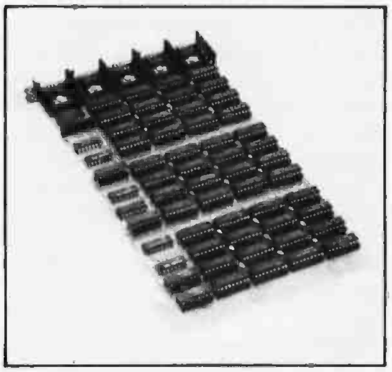
Circle 432 on inquiry card



### Noise-Emitting Diode from L O U D

The 3N120DB NED (noise-emitting diode) is a new development in indiscreet electronics. It is pictured in a DO-4 case. It is a low-voltage, high-power device with a +3dB signal-to-noise ratio. The NED is available from LOUD Electronics, POB 463, Wheelborough NH 03458.

Circle 433 on inquiry card



### Memory Board for SS-50 Bus Works with 1-Megabyte Memory Systems

A 24 K-byte static programmable memory board for SS-50 bus systems, the M24SS is available in 8 K-, 16 K-, and 24 K-byte configurations. The board is organized in 8 K-byte segments that can be located at any 8 K-boundary of a 64 K-byte memory space. The board uses standard 2114 integrated circuits. Access time is 300 ns. The 8 K-byte configuration is $199.95, the 16 K- is $349.95, and the 24 K- is $499.95. A memory expansion kit is available for $139.95. For complete details, contact Percom Data Company, 211 N Kirby, Garland TX 75042, (800) 527-1592; in Texas (214) 272-3421.

Circle 434 on inquiry card

### Control AC Circuit Devices from Your Apple II

This I/O (input/output) interface board for the Apple II can operate up to 256 BSR System X-10 AC control modules. Input communications come from the X-10 command console and temperature and security input modules, which will soon be available from Intelligent Control Systems. On-board software is provided to handle the AC I/O. The software also coordinates the background schedule-control process and sets, reads, and displays the real-time clock. Four selectable interrupt rates allow the simultaneous running of machine-language programs in the background and other programs in foreground. A rechargeable battery powers the clock when the Apple is off. The price is $185 from Intelligent Control Systems Inc, POB 14571, Minneapolis MN 55414, (612) 699-4342.

Circle 435 on inquiry card

### Multitasking System for Dynabyte 5000 Microcomputers

DOS Level 4 is a multitasking operating system for Dynabyte's Series 5000 microcomputers. This CP/M- and MP/M-compatible system is available on all Dynabyte microcomputers. It can handle up to 8 terminals and 16 printers, and any single terminal can run up to 8 simultaneous jobs. Any printer can be accessed from any terminal, and each terminal can have or share a single system spooler. Memory capacity is 400 K bytes.

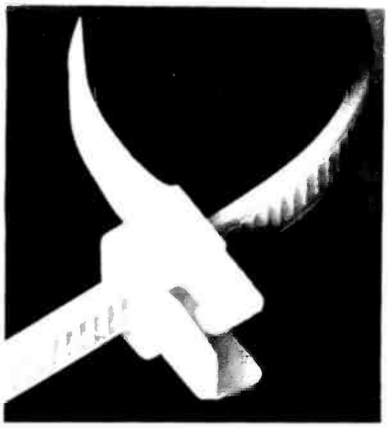
DOS Level 4 supports MBASIC, CBASIC, COBOL, FORTRAN, PL/I, and Pascal. The package includes interfacing software, a driver for a modem, and a utility to help programmers create interface drivers for special peripherals. For information, contact Dynabyte Inc, 115 Independence Dr, Menlo Park CA 94025, (800) 227-8300; in California (415) 329-8021.

Circle 436 on inquiry card

# What's New?

## MISCELLANEOUS

### Release Wire Ties



Courtesy Plastics has wire ties that feature release levers molded into locking heads. Squeezing this lever allows the tie to be adjusted or removed without damaging it. The tie can be reused later. These ties may be installed by hand or machine. They come in sizes for bundles up to 5 cm (2 inches) in diameter. The Release Wire Tie has a tensile strength of 50 lbs. For complete details, contact Courtesy Plastics, 250 Alice St, Wheeling IL 60090, (312) 541-7900.

Circle 437 on inquiry card

### Apple Users' Work Collected in Catalog

The Special Delivery Software Catalog program offers a selection of user-written programs for the Apple computer. This catalog program is designed by Apple to encourage people outside the company to develop software and to make their applications programs available to other Apple users. The first catalog contains 12 programs, including a personal-finance manager, a BASIC teaching program, stepwise multiple regression, programs for learning geometry and measurement, games, a Pascal animation package, a Pilot animation program, electronic music, and a US geography package. Software prices are in the $35 to $150 range. Apple plans to update the catalog three times annually. To order the free catalog or the software from it, call (800) 538-3088; in California call (800) 662-9256. To submit programs for evaluation by Apple, write to Special Delivery Software, 10260 Bandley Dr, Cupertino CA 95014.

Circle 438 on inquiry card

### Color Graphics Printer

The Model IS8001 is a color graphics printer produced by PrintaColor Corporation. The device contains a microprocessor and features a twelve-nozzle, three-color ink-jet printhead that can print seven colors using two- or three-color overlays. The print head has a resolution of 100 dots per inch. The microprocessor enables the unit to present minimal burden to the host computer. The IS8001 can print on 14⅞-inch paper with 70 characters per line. For further details on this $6000 color printer, contact PrintaColor Corporation, 5965 Peachtree Corners E, Norcross GA 30071, (404) 448-2675.

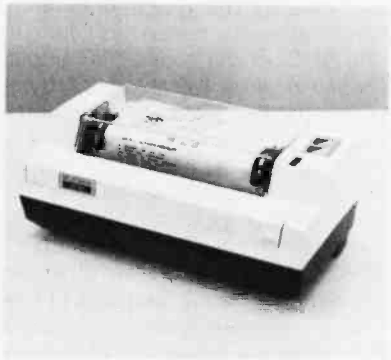
Circle 439 on inquiry card


### Touch-Sensitive Kits for Video Displays

Interaction Systems Inc's touch-sensitive add-on kits can be attached to any 12- or 15-inch (diagonal) video screen. Data can be entered on the screen by touching the appropriate area of the screen. The kits utilize a capacitance-sensitive faceplate, which is mounted in front of the video screen. Software and firmware allow the computer to identify and interpret the changes in capacitance. The faceplate interface uses a Z80 microprocessor. Custom configurations are available. The kits are priced under $300 in OEM (original equipment manufacturer) quantities. Contact Interaction Systems Inc, 24 Munroe St, Newtonville MA 02160, (617) 244-6825.

Circle 440 on inquiry card

### Inexpensive Dot-Matrix Printer



The GP-80M is an 80-column, 5 by 7 dot-matrix printer having an upper- and lowercase ASCII (American Standard Code for Information Interchange) set, double-width characters, and dot graphics modes. The printhead life is 30 million characters. Print speed is 30 cps (characters per second), with original-plus-two copies capabilities and adjustable tractors to accommodate paper widths up to 8 inches. It measures 171 by 328 by 127 mm (7 by 13 by 5 inches) and weighs 2.5 kg (5½ lbs). Parallel and serial interfaces are available. The suggested retail price is $425. Contact Watson, Burton, and Associates, Port POB 122, Yokohama 231-91, Japan, Telex 3822596.

Circle 441 on inquiry card

### Plug Centronics 737 Printer into the H89/Z89

This interface board allows the Centronics 737 printer to be used with the Heath/Zenith H89/Z89 microcomputer. It plugs into either machine's internal bus, and can use any of the four decoded I/O ports. The HDOS device driver provides access to the printer's features, which include underscoring; elongated, proportional, condensed, or standard print fonts; sub- and superscripting; backspace; and half or full, forward or reverse line feeds. The interface and HDOS device driver together are $64.95. Separately, the driver is $14.95, and the interface is $54.95. Order from FBE Research Company Inc, POB 68234, Seattle WA 98168.

Circle 442 on inquiry card

# What's New?

## MISCELLANEOUS

### Universal Peripheral Controller for the Z8000

Zilog's Z8090 Universal Peripheral Controller (Z-UPC) is designed for distributed processing and multitasking applications. The Z-UPC does arithmetic tasks, translation and formatting of data, and controls I/O (input/output) devices. It features 2 K bytes of internal ROM (read-only memory), externally expandable from 2 to 4 K. Also included is a 256-byte register file, three programmable 8-bit I/O ports, two counter/timers, and six levels of internal prioritized interrupts. The device is offered in four other versions, and all are priced at $117.36 each, in sample quantities of 10 to 99. For additional details, contact Zilog, 10340 Bubb Rd, Cupertino CA 95014, (408) 446-4666.

Circle 443 on inquiry card

### Atari 400 and 800 Screen Printer

The Macrotronics screen-printer package enables users to print an Atari 400's or 800's screen display onto a Trendcom 200 or IDS 440G Paper Tiger printer. Text, graphs, and drawings can be printed, and the image can be printed in gray-scale, black-and-white, and reversed image. LPRINT and LIST"P:" commands are used to print. The package includes a connector assembly with a cable and a 3 K-byte auto-loading program on floppy disk and cassette. Listings of sample programs are included in the user's manual. The package is priced at $139, from Macrotronics Inc, 1125 N Golden State Blvd, Suite G, Turlock CA 95380, (209) 667-2888.

Circle 444 on inquiry card

### Novation Has LSI Modem Modules

These modem modules can operate at rates up to 1200 bps (bits per second) and are designed for building-block applications within computers or terminals. The modules can provide Bell 202 half-duplex, Bell 103 answer/originate, CCITT European Standards V.21 or V.23, ViewData European Network, and interface with the deaf teletypewriter (TTY) network. Contact Novation, 18664 Oxnard St, Tarzana CA 91356, (213) 996-5060.

Circle 445 on inquiry card


### Extremely Fast Schottky PROMs

Using a titanium/tungsten technique, Monolithic Memories Inc has developed a series of fast Schottky 1 K- and 2 K-bit bipolar PROMs (programmable read-only memories). These devices use a programming technique that doesn't require a separate programming pin. Available in 256- by 4-bit, and 516- by 4-bit configurations, the PROMs feature PNP inputs for low-input current, full Schottky clamping, and three-state or open-collector outputs. They operate at 45 ns for commercial and 55 ns for military devices. In lots of 100, each 63S140/1 commercial 1 K-bit PROM costs $5; the military 53S140/1 is $7.50. In similar quantities, the 2 K-bit PROMs are $7.50 and $11.25 each. Contact Monolithic Memories Inc, 1165 E Arques Ave, Sunnyvale CA 94086, (408) 739-3535.

Circle 446 on inquiry card

### TI Extended BASIC and Memory Expansion Unit

TI Extended BASIC is an expanded version of the resident BASIC in Texas Instruments' TI-99/4 microcomputer. It features ACCEPT AT and DISPLAY AT statements, sprites (programmable moving objects), subprograms, and error-handling functions. Multiple statements can be written on the same line with tail-end remarks. Complex IF...THEN...ELSE statements can also be written.

The Memory Expansion Unit is exclusively designed for use with Extended BASIC or UCSD Pascal, Version IV, which is newly available. The unit adds 32 K bytes of programmable memory to the 16 K bytes resident in the TI-99/4. For more information, contact Texas Instruments Inc, Consumer Relations, POB 53, Lubbock TX 79408, (800) 858-4565; in Texas (800) 692-4279.

Circle 447 on inquiry card

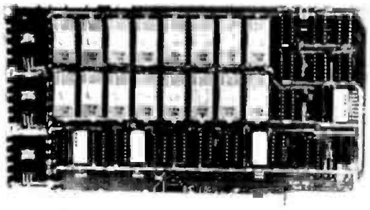
### Fujitsu America's 8-Inch Winchester Disk Drives

The Model 2311 8-inch Winchester disk drive stores 48 megabytes and the Model 2312 84 megabytes; both feature a 20 ms access time. The 2311 uses two hard disks for storage, and the 2312 stores its 84 megabytes on four disks, utilizing 589 cylinders at 20 K bytes per track. An SMD interface with data-separation circuitry and internally selectable fixed- and variable-length sector formats are provided. The price of the 48-megabyte 2311 is $3195 in OEM (original equipment manufacturer) quantities of 100, and the 84-megabyte 2312 drive is $3795 in the same quantities. The Fujitsu Model 2301 floppy-disk drive stores 11.7 megabytes and is priced at $1660 in OEM quantities of 100. The 2302 floppy-disk drive stores 23.4 megabytes and is priced at $2095 in OEM quantities. For additional information, contact Fujitsu America Inc, 2945 Oakmead Village Ct, Santa Clara CA 95051, (408) 727-4300.

Circle 448 on inquiry card

# DIGITAL RESEARCH COMPUTERS
(214) 271-3538

## 32K S-100 EPROM CARD
**NEW!**



**$74.95**
KIT

USES 2716's

Blank PC Board - $34

ASSEMBLED & TESTED
ADD $30

SPECIAL: 2716 EPROM's (450 NS) Are $11.95 EA. With Above Kit.

KIT FEATURES:
1. Uses +5V only 2716 (2Kx8) EPROM's.
2. Allows up to 32K of software on line!
3. IEEE S-100 Compatible.
4. Addressable as two independent 16K blocks.
5. Cromemco extended or Northstar bank select.
6. On board wait state circuitry if needed.
7. Any or all EPROM locations can be disabled.
8. Double sided PC board, solder-masked, silk-screened.
9. Gold plated contact fingers.
10. Unselected EPROM's automatically powered down for low power.
11. Fully buffered and bypassed.
12. Easy and quick to assemble.

## 32K SS-50 RAM

**$379.00** KIT

NEW!

For 2MHZ
Add $10

Blank PC Board
$50

For SWTPC
6800 - 6809 Buss

Support IC's
and Caps
$19.95

Complete Socket Set
$21.00

Fully Assembled,
Tested, Burned In
Add $30

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

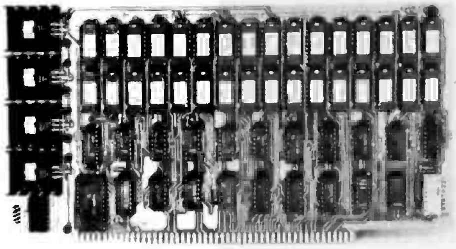
FEATURES:
1. Uses proven low power 2114 Static RAMS.
2. Supports SS50C - EXTENDED ADDRESSING.
3. All parts and sockets included.
4. Dip Switch address select as a 32K block.
5. Extended addressing can be disabled.
6. Works with all existing 6800 SS50 systems.
7. Fully bypassed. PC Board is double sided, plated thru, with silk screen.

## 16K STATIC RAM KIT-S 100 BUSS

PRICE CUT!

**$199.95** KIT

FOR 4MHZ
ADD $10



KIT FEATURES
1. Addressable as four separate 4K Blocks.
2. ON BOARD BANK SELECT circuitry (Cromemco Standard*) Allows up to 512K on line!
3. Uses 2114 (450NS) 4K Static Rams.
4. ON BOARD SELECTABLE WAIT STATES.
5. Double sided PC Board, with solder mask and silk screened layout. Gold plated contact fingers.
6. All address and data lines fully buffered.
7. Kit includes ALL parts and sockets.
8. PHANTOM is jumpered to PIN 67.
9. LOW POWER: under 1.5 amps TYPICAL from the +8 Volt Buss.
10. Blank PC Board can be populated as any multiple of 4K.

BLANK PC BOARD W/DATA-$33
LOW PROFILE SOCKET SET-$12
SUPPORT IC'S & CAPS-$19.95
ASSEMBLED & TESTED-ADD $35

OUR #1 SELLING
RAM BOARD!

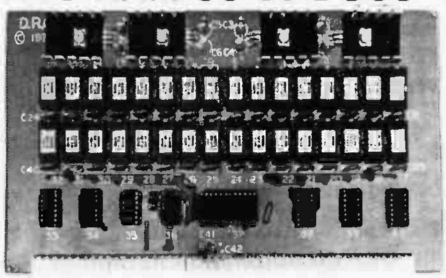
## 16K STATIC RAM SS-50 BUSS

PRICE CUT!

**$195** KIT

FULLY STATIC!

FOR 2MHZ
ADD $10



FOR SWTPC
6800 BUSS!

ASSEMBLED AND
TESTED - $35

KIT FEATURES:
1. Addressable on 16K Boundaries
2. Uses 2114 Static Ram
3. Fully Bypassed
4. Double sided PC Board. Solder mask and silk screened layout
5. All Parts and Sockets included
6. Low Power: Under 1.5 Amps Typical

BLANK PC BOARD—$35 COMPLETE SOCKET SET—$12
SUPPORT IC'S AND CAPS—$19.95

## STEREO! S-100 SOUND COMPUTER BOARD
NEW! NEW!

At last, an S-100 Board that unleashes the full power of two unbelievable General Instruments AY3-8910 NMOS computer sound IC's. Allows you under total computer control to generate an infinite number of special sound effects for games or any other program. Sounds can be called In BASIC, ASSEMBLY LANGUAGE, etc.

COMPLETE KIT!
**$84.95**
(WITH DATA MANUAL)

BLANK PC
BOARD W/DATA
$31

KIT FEATURES:
- TWO GI SOUND COMPUTER IC'S
- FOUR PARALLEL I/O PORTS ON BOARD
- USES ON BOARD AUDIO AMPS OR YOUR STEREO.
- ON BOARD PROTO TYPING AREA.
- ALL SOCKETS, PARTS AND HARDWARE ARE INCLUDED.
- PC BOARD IS SOLDERMASKED, SILK SCREENED, WITH GOLD CONTACTS.
- EASY, QUICK, AND FUN TO BUILD WITH FULL INSTRUCTIONS
- USES PROGRAMMED I/O FOR MAXIMUM SYSTEM FLEXIBILITY.

Both Basic and Assembly Language Programming examples are Included.

SOFTWARE:

SCL™ Is now available! Our Sound Command Language makes writing Sound Effects programs a SNAP! SCL™ also includes routines for Register-Examine-Modify, Memory-Examine-Modify, and Play-Memory. SCL™ is available on CP/M* compatible diskette or 2708 or 2716. Diskette - **$24.95** 2708 - **$19.95** 2716 - **$29.95**. Diskette Includes the source. EPROM'S are ORG at E000H.

## 4K DYNAMIC RAM BLOWOUT!
### SAME AS INTEL 2107B!
### 4K RAMS AT AN UNBELIEVABLE 50¢ EACH!!!

Prime, new, National Semi., 1979 date coded, full spec. parts. N.S. #MM5280-5N. Same as INTEL 2107B-4, T.I. TMS4060, NEC uPD411, etc. We bought a HUGE QTY. from a West Coast Distributor at truly DISTRESS PRICES! One of the most popular and reliable RAM's ever made. These parts have been used by almost all Major Computer Main Frame Mfg. the world over! Arranged as 4K x 1, 270 NS Access Time, 22 Pin Dip. These units DO NOT use multiplexed addressing, thus making REFRESH and other timing very simple. See INTEL MEMORY DESIGN HANDBOOK for full application notes. The NAT. SEMI. MEMORY DATA BOOK is available at most Radio Shack Stores. Prime units in original factory tubes!

(With Pin Out Data)

#5280-5N 4096 BITS x 1 270 NS ACCESS
8 FOR $4.95 32 FOR $16
FACTORY CASE (450 PCS) — $180

Sockets Special: 22 Pin Low Profile (With Purchase of 5280's) 8 FOR $1.

## COMPUTER PARTS SPECIALS

| | |
|---|---|
| 74LS175 - .99 | 8035 Intel Single Chip CPU 6.95 |
| 74LS240 - 1.19 | Signetics 2901 4 Bit Slice - 6.95 |
| 74LS241 - 1.19 | AMD 2903 4 Bit Super Slice - 12.50 |
| 74LS244 - 1.19 | AMD 29705 Dual Port RAM - 8.95 |
| 74LS373 - 1.29 | Intel 2716-1 (350 NS) - 12.95 |

## *NEW!* G.I. COMPUTER SOUND CHIP

AY3-8910. As featured in July, 1979 BYTE! A fantastically powerful Sound & Music Generator. Perfect for use with any 8 Bit Microprocessor. Contains: 3 Tone Channels, Noise Generator, 3 Channels of Amplitude Control, 16 bit Envelope Period Control, 2-8 Bit Parallel I/O, 3 D to A Converters, plus much more! All in one 40 Pin DIP. Super easy interface to the S-100 or other busses. $11.95 PRICE CUT!

SPECIAL OFFER: ~~$14.95~~ each Add $3 for 60 page Data Manual.

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(OF TEXAS)

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ALL SALES ARE MADE SUBJECT TO THE TERMS OF OUR 90 DAY LIMITED WARRANTY. A COPY OF THIS WARRANTY IS AVAILABLE FREE, ON REQUEST.

*TRADEMARK OF DIGITAL RESEARCH.

WE ARE NOT ASSOCIATED WITH DIGITAL RESEARCH OF CALIFORNIA, THE SUPPLIERS OF CPM SOFTWARE.

# What's New?

## SOFTWARE

### CP/M for Heath Microcomputers

Heath H-8 and H-89 All-In-One computers can now have the CP/M operating system. Three operating system modules (BIOS, BDOS, CCP) are included with Heath CP/M. Utilities included are a two-pass 8080 assembler; a text editor; an 8080 debugger with traced execution and disassembly; a file dump; system generation and relocation; programs to display file sizes and disk usage, set file class, assign physical and logical devices, display system parameters, copy files between devices, and convert internal HEX files into memory images. Full source code is provided. The Heath CP/M operating system comes on 5- and 8-inch floppy disks for $150. For details contact, Heath Company, Department 350-620, Benton Harbor MI 49022, (616) 982-3210.

Circle 449 on inquiry card

### Accountant's Software

DATAWRITE is a CP/M-based client-write-up program for accountants. It supports floppy- and hard-disk drives and incorporates expanded account-number structures, several journal options, and complete report-writing capabilities. For details on DATAWRITE, contact Dataword Inc, 1404 140th Pl NE, Bellevue WA 98007, (206) 643-2050.

Circle 450 on inquiry card

### Interface CBASIC With Assembly-Language Programs

CBASIC, Version 2, incorporates a function that allows assembly-language packages to be interfaced with CBASIC programs. It permits trace outputs to the console when a line-printer statement is in effect. It provides for 255 characters to be entered in response to an input statement. A backslash within a data statement is treated as a literal character rather than a continuation character. CBASIC features 14-digit accuracy for business applications, and is implemented as a compiler. It allows a text editor to be used. CBASIC, Version 2, was developed by Compiler Systems, POB 145, Sierra Madre CA 91024, (213) 355-1063.

Circle 451 on inquiry card

### Cribbage for the TRS-80

Cribbage Master plays a strong game, pegging its own points in play and never missing an opportunity to score—especially on points you miss. The program shows the order of the cards as played for in-play pegging. All entries are made by a single keystroke. Cribbage Master is designed for the TRS-80 16 K-byte Level II. It is available from Manhattan Software, POB 35, Pacific Palisades CA 90272, (213) 454-8290, for $12.95.

Circle 452 on inquiry card

### Software for Z80, 8080, and 8085 Systems

The ZAPS software system has assemblers and disassemblers for Z80, 8080, and 8085 systems. An editor, loader, and the use of Intel and Zilog-Mostek mnemonics are also featured. The system requires any Z80 processor with a North Star floppy-disk drive, and 48 K bytes of programmable memory. The price is $100 from Conentropy, POB 316, Yonkers NY 10704.

Circle 453 on inquiry card

### 6800 Diagnostics and Disk Repair

Technical Systems Consultants Inc has a memory-diagnostic and disk-repair package for the 6800 microprocessor. The programs run under the 6800 FLEX operating system. Included in the memory diagnostics are a 0s and 1s test, a random pattern test, walking bit tests, a dynamic programmable-memory dropout test, and a convergence test.

The disk-repair portion contains utilities that operate on a FLEX-formatted floppy disk. There are three diagnostic utilities that report unreadable sectors and structural inconsistencies among files, two utilities for recovering data, a utility to remove bad or intermittent sectors from the free space, a program to retrieve deleted files, a single-sector read/write/modify routine, and a copy utility which ignores CRC (cyclic redundancy check) errors. This package is available on 5- or 8-inch floppy disk for $75. Contact Technical Systems Consultants Inc, POB 2570, 1208 Kent Ave, West Lafayette IN 47906, (317) 463-2502.

Circle 454 on inquiry card

### Three Versions of FORTH for OSI

Starstruck Software has fig- (FORTH Interest Group) compatible FORTH for OSI (Ohio Scientific) C8P dual floppy-disk-drive systems. A line editor, commands for the OS65D operating system, and a record of unused dictionary space are featured. This version costs $79.95. Contact Back to Basic Computer Center, #43 Cross Keys Shopping Center, Florissant MO 63033, (314) 873-4495.

OSI-FORTH 2.0 runs under the OS-65D3 operating system, and has access to all commands and resources. A 6502 assembler and a text editor are included. OSI-FORTH 2.0 runs on C2, C3, C4, and C8 systems. It is supplied on 5- or 8-inch floppy disks, and has a suggested price of $79.95. For details, contact Technical Products Company, POB 12983, University Sta, Gainesville FL 32604.

TEK-AIDS' OS65U fig-FORTH uses the OS65U operating system and runs coresident with BASIC, allowing FORTH modules to be integrated into existing programs. OS65U will run on OSI 48 K-byte systems with dual disk drives or hard-disk and multi-user configurations. The price for this system is $250. Contact the Software Federation Inc, 44 University Dr, Arlington Hts IL 60004, (312) 259-1355.

Circle 455 on inquiry card

### New Games for the Apple II

The Apple now has three new high-resolution-graphics games written in machine language: Asteron, Star Avenger, and Shooting Gallery. They run on the Apple II under all versions of DOS (disk operating system) and on the Language System. Each game is supplied on a disk and requires 48 K bytes of memory. Shooting Gallery costs $22.50, and the others are priced at $27.50. Contact Western MicroData Enterprises Ltd, POB G33, Postal Station G, Calgary, Alberta, T3A 2G1, Canada.

Circle 456 on inquiry card

# VISTA. . . . . . . . Your Supermarket For Add-ons and Peripheral Products

## Vista V-300 Daisy Wheel Printer

Letter Quality

Immediate Shipment V-300 Printer

- Print Wheel — Industry standard 96-character Daisy Wheel (Including the extended-life dual plastic wheels)
- Printable columns (136)
- Proportional, bi-directional printing
- Interface — Industry standard parallel (RS232-C optional)
- Service - Prompt maintenance/service agreements available nationwide
- Warranty - 90 days parts and labor, one year parts only

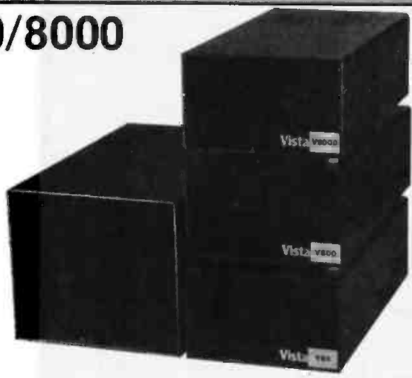
| | |
|---|---|
| V-300-25 | $1895.00 |
| V-300-45 | $2195.00 |
| Tractor Option | $ 300.00 |

## The Vista V80/800/8000

Family Disk Drive System

- Full compatible with TRS-80, Heath/Zenith
- 120 Day Warranty
- 40 Track Patch at NO CHARGE

| | |
|---|---|
| V-80 Single drive system (102K) | $ 395.00 |
| V-80 Two drive system (204K) | $ 770.00 |
| V-800 Single drive. B52 drive (204K) | $ 595.00 |
| V-800-2 Double dirve. B52 drives (408K) | $1175.00 |
| V-8000 Single drive. B92 drive (408K) | $ 775.00 |
| V-8000-2 Double drive B92 drives (816K) | $1450.00 |

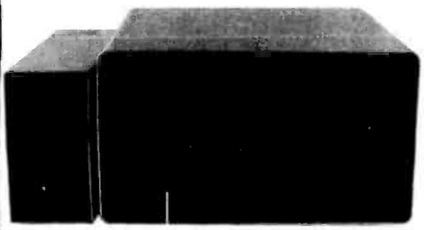


## Vista V-100 Printer . . . . .$745.00

- 9 x 7 dot matrix
- 125 cps bi-directional print speed
- 136 column
- Industrial quality

## The Vista Model II

Totally Compatible with the TRS-80* Model II



- Provides one, two or three drives
- Adds up to 1.5 million bytes of on-line storage
- 120 day warranty
- Does everthing Radio Shack's expansion system will do. . . for less!

| | |
|---|---|
| Single drive (non-expandable) | $ 900.00 |
| Single drive expansion system | $1000.00 |
| Two drive expansion system | $1550.00 |
| Three drive expansion system | $2100.00 |
| Additional drives alone | $ 525.00 |

### Vista Music Machine 9

- NEW! Uses latest State of the Art LSI Technology
- Requires only one slot for 9 voices!
- Uses three AY3-8910's to produce 9 voices
- Plays music generated by the ALF board
- APPLE II™ compatible
- ALF™ software required

Price: $129.95

### Add On Drives

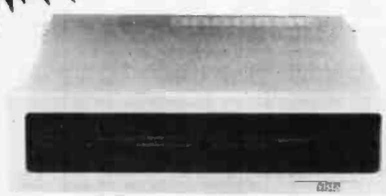
| | | |
|---|---|---|
| MPI B51 | 40 Track, Double Density 204K | $275.00 |
| MPI B52 | Dual Head, Double Density 408K | $375.00 |
| Siemens | FDD 100-5 40 Track Double Density 204K | $275.00 |
| Siemens | FDD 100-8 8" Single Sided Drive | $448.00 |
| Shugart | 801R Single Sided Drive | $448.00 |

### Other Products

| | |
|---|---|
| 1. 16K RAM upgrade kits | $ 49.95 |
| 2. NEW DOS 80 | $149.00 |
| 3. LNW 80 (computer board) | $ 86.95 |
| 4. LNW expansion board | $ 66.95 |
| 5. H.C. Pennington books: | |
| TRS-80 DISK AND OTHER MYSTERIES | $ 18.95 |
| MICROSOFT BASIC DECODER AND OTHER MYSTERIES | $ 27.95 |

NEW

## The Vista V-1000 Floppy Disk Drive Subsystem



- Deluxe chassis with internal slide allows easy access for drive positioning and mounting.
- Built to mechanically and electrically accomodate single sided drives, double sided drives — including, the most popular 8-inch Winchester and Shugart floppy disk drives, and 8-inch streaming tape cartridge units.

- Storage capacity from 0.5 to 40 megabytes
- Industrial quality cabinet with die cast front bezel
- Meets all UL and OSHA standards
- Additional Savings! Front and rear retma rail mounts provided at no extra charge (no external slides)
- Desk or rack mountable
- Features modular construction with removable sub-assembly that allows easy cabinet positioning and mounting
- Drives pull out for easy service and maintenance

| | |
|---|---|
| Cabinet | $ 395.00 |
| Cabinet with (2) single sided drives (Includes power supply and cable) | $1595.00 |
| Cabinet with (2) double sided drives (Includes power supply and cable) | $2295.00 |

## The Vista V-200 for Exidy

- Completely packaged system, tested and ready to plug in
- Includes: power supply, two 40 track drives, case, double density controllers, and all cabling and total CP/M™ documentation.
- Storage capacity from 400K to 1.2 meg.
- System software-VISTA CP/M Disk Operating System and BASIC-E Compiler recorded on 5¼" diskettes

Price: Starting as low as $1199.00

S-100 version as low as $699.00

Vista

**The Vista Computer Company**
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™ CP/M is a registered trademark of Digital Research

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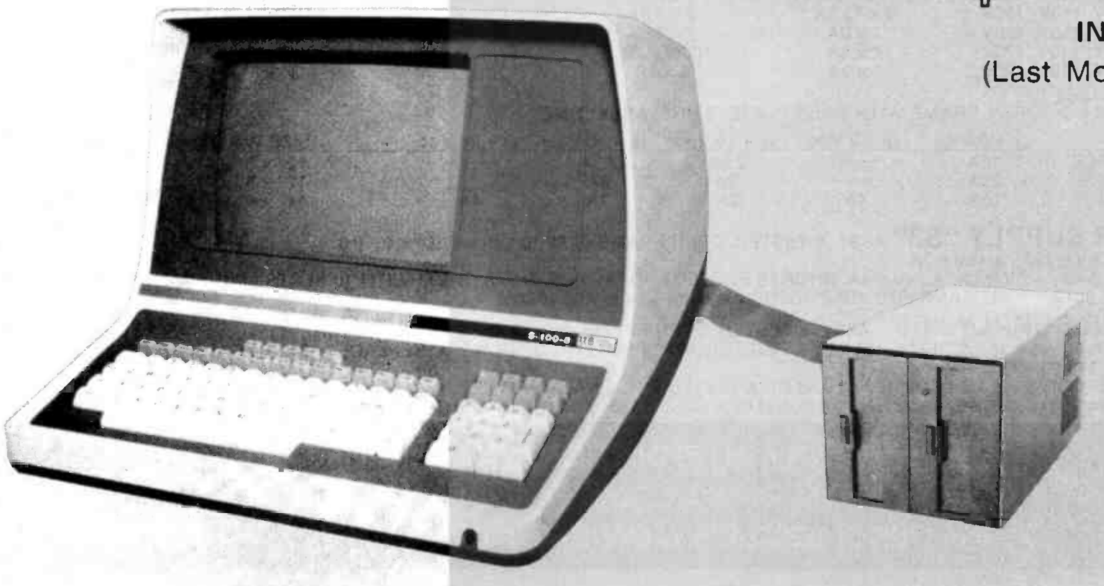
REGULAR $3250.00 LIST

INTRODUCTORY PRICE ONLY **$2450.00**

INCLUDING CP/M2.2®
(Last Month At This Price)



320K MINI DRIVES SHOWN, 8" and 5¼" 10MB HARD DISK OPTIONAL

*IMMEDIATE DELIVERY!*

**1 YEAR PARTS WARRANTY!**
*(90 DAYS ON DRIVE PACKAGE, KEYBOARD AND LABOR)*

**U.S. *MICRO* SALES S-100-8**

# CHECK THESE FEATURES!

## TERMINAL

- Feather Touch Capacitance Keyboard
- 60 Key Standard ASCII
  PLUS + Hex Keypad
  PLUS + 8 Special Function Keys
  PLUS + 20 Screen Editing Keys
- SOROC Type Screen Attribute Set
- Half Intensity

## COMPUTER

- 8 Slot S-100
- 64K Dynamic Ram
- 4MHZ Z-80
- Serial Printer Port (150 - 19.2K)
- Double Density Disk Controller
- Programmable Baud Rate
- Programmable Keyboard Set

## DISK STORAGE

- Dual Double Density
  5¼ Single Sided Drives
- DOUBLE SIDED Option
- Double Sided, 77
  Track, Option
- Color Matched Enclosure
- Self Contained Power Supply

OPTIONS:

- ♦ Dual 5¼" Double Sided MPI B51 (640K) add $225.00
- ♦ Dual 5¼" Double Sided MPI B91 (1.2MB) add $360.00
- ♦ Dual 8" SIEMANS FDD120-8 Drives (1MB) add $250.00
- ♦ Dual 8" QUME Double Sided Drives (2MB) add $625.00

U.S. MICRO SALES

11 EDISON DRIVE ★ NEW LENOX, ILLINOIS 60451 ★ (815) 485-4002

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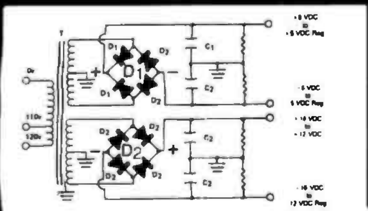
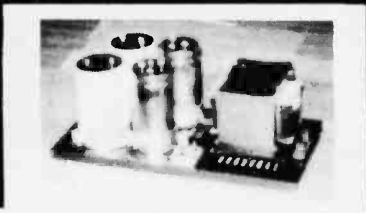


# BUILD YOUR OWN LOW COST MICRO-COMPUTER POWER SUPPLIES

## FOR S-100 BUS, FLOPPY DISKS, ETC.



## POWER TRANSFORMERS (WITH MOUNTING BRACKETS)

| ITEM NO. | USED IN KIT NO. | PRI. WINDING TAPS | SECONDARY WINDING OUTPUTS 2×8 Vac | 2×14 Vac | 2×24 Vac | SIZE W×D×H | UNIT PRICE |
|---|---|---|---|---|---|---|---|
| $T_1$ | 1 | 0V, 110V, 120V | 2×7.5A | 2×2.5A | —— | 3¾"×3⅝"×3⅛" | 21.95 |
| $T_2$ | 2 | 0V, 110V, 120V | 2×12.5A | 2×3.5A | —— | 3¾"×4⅜"×3⅛" | 27.95 |
| $T_3$ | 3 | 0V, 110V, 120V | 2×9A | 2×2.5A | 2×2.5A | 3¾"×4⅜"×3⅛" | 29.95 |
| $T_4$ | 4 | 0V, 110V, 120V | 2×4A | (28V, CT) | 48V, CT, @3A | 3¾"×3⅝"×3⅛" | 22.95 |
| $T_5$ | — | 0V, 110V, 120V | 2×3A | 2×2A | —— | 3"×3"X2½" | 14.95 |

## POWER SUPPLY KITS (OPEN FRAME WITH BASE PLATE, 3 HRS. ASSY. TIME)

| ITEM | USED FOR | @ +8 Vdc | @ −9 Vdc | @ +16 Vdc | @ −16 Vdc | @ +28 Vdc | SIZE W×D×H | UNIT PRICE |
|---|---|---|---|---|---|---|---|---|
| KIT 1 | 15 CARDS SOURCE | 15A | —— | 2.5A | 2.5A | —— | 12"×5"×4⅞" | 52.95 |
| KIT 2 | SYSTEM SOURCE | 25A | —— | 3A | 3A | —— | 12"×5"×4⅞" | 59.95 |
| KIT 3 | DISK SYSTEM | 15A | 1A | 2A | 2A | 4A | 14"×6"×4⅞" | 67.95 |

**DISK SYSTEM PWR SUPPLY "S3"** ASSY. & TESTED, OPEN FRAME, SIZE 10"(W)×6"(D)×4⅞"(H) ........ 92.95
UNREGULATED OUTPUTS: +8V@12A, ±16V@3A.
REGULATED OUTPUTS: +5V@4A, −5V@1A, +24V@4A, SHORTS PROTECT. IDEAL FOR THE SYSTEM WITH 10 SLOTS MAINFRAME & TWO 8" DISK DRIVES, SUCH AS SHUGART 801R OR SIEMANS FDD 100-8. (OPTION: OVP for +5V @ ADD $5.00)

**DISK DRIVE POWER SUPPLY "R3"** ASSY. & TESTED, OPEN FRAME, SIZE: 9"(W)×6¼"(D)×4⅞"(H) ........ 67.95
SPECS: +5V @ 5A REGUL, OVP, −5V @ 1A REG., +24 @ 5A REG., SHORTS PROTECT. OPTIONS: 1. REPLACE +24V BY +12V
2. ADD ± 12V @ 1A, $12.00 MORE.
IDEAL FOR 2 SHUGART 801/851 OR SIEMANS FDD 100-8/200-8 DISK DRIVES & ROCKWELL AIM-65.
SHIPPING FOR EACH TRANSFORMER: $4.75. FOR EACH POWER SUPPLY: $5.00 IN CALIF. $7.00 IN OTHER STATES. CALIF. RESIDENTS ADD 6% SALES TAX. OEM WELCOME.

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master charge

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WW component supply, inc.
1771 Junction Avenue
San Jose, California 95112
(408) 295-7247
(408) 295-7171

# Yes! We supply IMSAI® compatible products...

NOTE: "Original" IMSAI parts were purchased at the closing business sale of IMSAI Manufacturing Corp. WW Components also distributes S-100 buss IMSAI compatible parts and boards. As supplies of "original" parts are exhausted, WW reserves the right to supply equivalent compatible parts not made by IMSAI. All items listed as "Assembled & Tested" have been assembled by WW Components and carry a 1 year warranty.

**I-8080 S-100 ENCLOSURE Sheet Metal Kit** — THE ORIGINAL IMSAI: Mainframe with blue cover, cardguides and hardware spaced for PS-28D Power Supply, up to 22 slot motherboard.
*Kit of all metal parts and hardware w/docs* $115.00
*Thinker Toys WunderBuss20 for above w/o conn.* $79.00

**MPU-B SBC 8085 CPU** — Complete 8085 based CPU including: serial RS-232 port, parallel I/O port 3 MHz operation, 256 bytes memory, ROM monitor, 3 timers, and more.
*Assembled & Tested* $250.00

**PS-28D Power Supply Parts Kit:** — Mounts in the I-8080 enclosure, supplies +8V @ 28A, +/- 16V @ 3A, kit includes board, transformer, documentation, and all components.
KIT $95.50

**I-8015 Complete System w/MPU-B** — The complete 8085 system, includes MPU-B, RAM III, 10 slot terminated motherboard, PS-28D, and jump start front panel. A complete 64K system!
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**CP/M® 2.2 for IMSAI** — NOW AVAILABLE - CP/M for the IMSAI floppy disk system. Version 2.2 is available for the DIO-C 8" controller. Others on request. Docs. incl.
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TERMS: (1) PREPAID Send check or M.O. for merchandise amount only - we pay the shipping in USA only.
(2) UPS COD or bankcard orders by phone or mail - shipping charges added.
California Residents add 6.5% Sales Tax.

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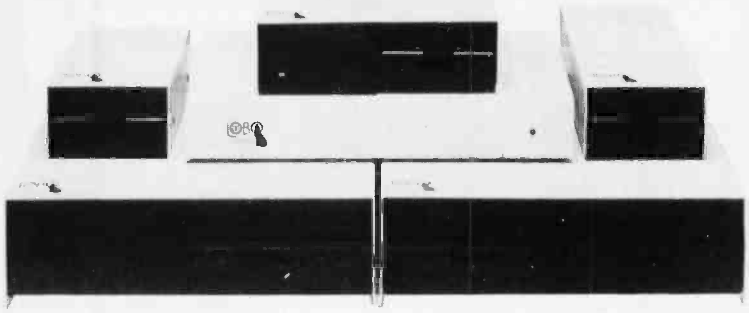
# Add-On Disk Drive Subsystems For Apple, TRS-80, S-100 Based Computers



**Expansion** and **enhanced capabilities** are key words in achieving full utilization of your computer system. Our complete line of LOBO disk drive subsystems are the ideal, cost-effective way to provide the expansion capabilities you need to meet your system growth requirements. All of our subsystems are complete, thoroughly-tested, 100% burned-in, and feature a 1 year 100% parts/labor warranty.

## APPLE

| | |
|---|---|
| 3101 | Minifloppy, 3101I Minifloppy w/interface card |
| 8101CA | One SA800 in cabinet w/power, DDC* Controller, cable and manual |
| 8202CA | Two SA800 in cabinet w/power, DDC* Controller, cable and manual |
| 5101CA | One SA850 in cabinet w/power, DDC* Controller, cable and manual |
| 5202CA | Two SA850 in cabinet w/power, DDC* Controller, cable and manual |

*Double Density Controller

## S-100 BASED COMPUTERS

| MODEL NO. | DESCRIPTION |
|---|---|
| 4101C | SA400 in cabinet w/power |
| 8212C | Two SA801 in cabinet w/power |
| 5212C | Two SA851 in cabinet w/power |

## GENERAL

| MODEL NO. | DESCRIPTION |
|---|---|
| 8212 | Two SA801 In cabinet |
| 8212C | Two SA801 In cabinet w/power |
| 5212 | Two SA851 In cabinet |
| 5212C | Two SA851 in cabinet w/power |

## TRS80

| MODEL NO. | DESCRIPTION |
|---|---|
| 4101C | SA400 in cabinet w/power |
| 8101C II | One SA800 in cabinet w/power for Mod. II |
| 8202C II | Two SA800 in cabinet w/power for Mod. II |
| C802 | Cable for Mod. II |
| C805 | Cable for TRS80 Minifloppy |
| C808 | Cable for TRS80 Eight-Inch Floppy |
| LX80 | Double-density expansion interface |
| RS232 | Dual Serial Port Option |
| 16K | 16K Byte RAM for LX80 (32KB max.) |
| VTOS | 4.0 Disk Operating System |

**JR INVENTORY CO.,**
P.O. Box 185, Santa Ynez, Ca., 93460
(805) 688-8781

---

## STANDARD RS232 CABLES

| PART NO. | DESCRIPTION | PRICE |
|---|---|---|
| RS232MM9 | Male to male 9 ft. cable | 24.00 |
| RS232MM18 | Male to male 18 ft. cable | 29.00 |
| RS232MF9 | Male to female 9 ft. cable | 29.00 |
| RS232MF18 | Male to female 18 ft. cable | 34.00 |
| RS232FF9 | Female to female 9 ft. cable | 34.00 |
| RS232FF18 | Female to female 18 ft. cable | 39.00 |
| RS232MO9 | Male to open 9 ft. cable | 18.00 |
| RS232MO18 | Male to open 18 ft. cable | 23.00 |
| RS232FO9 | Female to open 9 ft. cable | 24.00 |
| RS232FO18 | Female to open 18 ft. cable | 29.00 |

## DISK DRIVE POWER CABLES

| PART NO. | DESCRIPTION | PRICE |
|---|---|---|
| PDC-5 | 5¼" DC Power Connector 24" long | 6.00 |
| PAC-8 | 8" AC Power Connector 24" long | 6.00 |
| PDC-8 | 8" DC Power Connector 24" long | 7.00 |
| PAC-8D | 8" AC Power Connector for Double Density Disk Drives | 6.00 |
| ALL ASSEMBLED - NOT A KIT | | |

## DISK DRIVE SIGNAL CABLES

| | |
|---|---|
| Single 5¼" Drive Cable | **$24.00** |
| Dual 5¼" Drive Cable | **$29.00** |
| Quad 5¼" Drive Cable | **$34.00** |
| Single 8" Drive Cable | **$24.00** |
| Dual 8" Drive Cable | **$32.00** |
| Quad 8" Drive Cable | **$40.00** |

Please state type connector: card-edge or socket.

26 Pin Card-edge Connector to DB25S 2' long **$19.00**

| | |
|---|---|
| 4116 — (200 ns) | **8/$30.00** |
| 2708 — | **$6.00** |
| 2716 (5V) — | **$9.00** |
| 2732 — | **$25.00** |
| 2114L3 — | **8/$28.00** |

## CLOCK/CALENDAR FEATURES

- 12/24 Hr. Format
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- Day of Week
- Leap Year Bit
- 4 Interrupts
- +-30 Sec. Adjust
- Battery Backup
- Simple to Program

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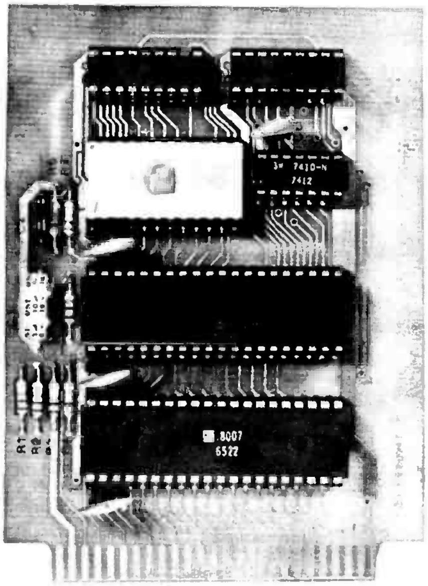
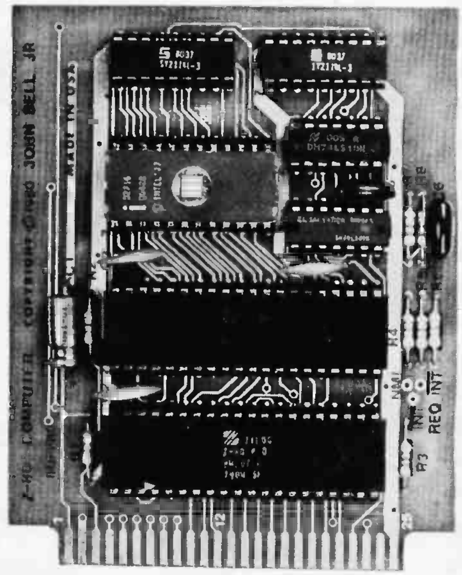
**TERMS:** Cash, checks, money orders, credit card. C.O.D. under $100.00 add $2.00 C.O.D. charge. Minimum shipping & handling charge $3.00. Prices subject to change without notice. All sales in American dollars only.

# 6502, Z80, 8080 AND 8085 USERS



**JOHN BELL ENGINEERING'S 6502 AND Z80 MICROCOMPUTERS** ARE DEDICATED COMPUTERS DESIGNED FOR **CONTROL FUNCTIONS.**

THESE BOARDS FEATURE:
- 2048 BYTES EPROM
- 1024 BYTES RAM
- ALL BOARDS INCLUDE COMPLETE DOCUMENTATION
- 50 PIN CONNECTOR INCLUDED IN KITS AND ASSEMBLED UNITS
- 2716 AVAILABLE SEPARATELY



**JOHN BELL ENGINEERING'S 6502 MICROCOMPUTER,** 2716 EPROM PROGRAMMER AND APPLE II PARALLEL INTERFACE PLUS THE APPLE II MICROCOMPUTER — **A COMPLETE DEVELOPMENT SYSTEM.**

6502 MICROCOMPUTER FEATURES:
- 1024 BYTES RAM
- 2048 BYTES EPROM
- USES ONE 6522 VIA (DOC. INCL.)
  - 2 8 BIT BIDIRECTIONAL I/O PORTS
  - 2 16-BIT PROGRAMMABLE TIMER/COUNTERS
  - SERIAL DATA PORT
  - LATCHED I/O WITH HANDSHAKING LOGIC
  - TTL AND CMOS COMPATIBLE

**80-153 ASSEMBLED $110.95**
**BARE BOARD $24.95 KIT $ 89.95**

**JOHN BELL ENGINEERING'S NEW Z80 MICROCOMPUTER FEATURES:**
- Z80 CPU SOFTWARE COMPATIBLE WITH Z80, 8080 AND 8085 MICROPROCESSORS
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- 1024 BYTES RAM
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- Z80 PIO (DOC. INCL.)
- 2 8 BIT BIDIRECTIONAL I/O PORTS
- LATCHED I/O WITH HANDSHAKING LOGIC
- TTL AND CMOS COMPATIBLE

**80-280 ASSEMBLED $129.95**
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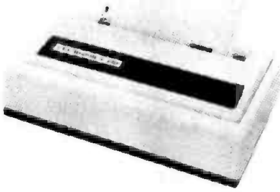

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| A.I. Cybernetics Speechboard | 260.00 | 380.00 |
| Anadex 40 Column Printer | 641.00 | 855.00 |
| Base 2 8K Memory Board Assembled | 211.00 | 282.00 |
| Commodore 2001-8 8K PET | 550.00 | 795.00 |
| Craig M-100 Translater | 122.00 | 199.95 |
| Dajen Cassette Interface | 88.00 | 120.00 |
| Dynabyte Naked Terminal | 245.00 | 350.00 |
| Digital Systems Dual 8" Single Density | 2293.00 | 2732.00 |
| Dutronics Poly Z-80 Upgrade Kit | 123.00 | 169.95 |
| Dutronics Imsai Z-80 Upgrade Kit | 116.00 | 159.95 |
| Eclectic Corp. Superchip for Apple II | 75.00 | 95.00 |
| Fidelity Electronics Ltd. | | |
| Level 1 Chess Challenger | 120.00 | 75.00 |
| Level 4 Checker Challenger | 100.00 | 115.00 |
| Level 2 Checker Challenger | 40.00 | 40.00 |
| George Risk Inc. Pet Keyboard | 176.00 | 250.00 |
| Imsai CPU Board | 125.00 | 175.00 |
| Icom Micro Peripherals 5" Disk Drive | 821.00 | 1095.00 |
| Intertec Data Intertube Terminal | 595.00 | 874.00 |
| Kent Moore 8K RAM 450NS | 148.00 | 197.50 |
| Kent Moore Alpha Display Module | 80.25 | 107.00 |
| Mountain Hardware | | |
| AC Control Apple | 132.00 | 189.00 |
| AC Remote | 95.00 | 149.00 |
| S-100 AC Control Kit | 104.00 | 149.00 |
| AC Remote Kit | 67.00 | 99.00 |
| AC Control- Apple Kit | 104.00 | 145.00 |
| Micromation Dual Memorex 8" disk drive | 1467.00 | 1990.00 |
| Micromation Dual Density disk controller Card | 310.00 | 500.00 |
| MS Corp. Apple PR-40 Interface | 87.00 | 87.00 |
| National Multiplex Digital Cassette Recorder | 150.00 | 200.00 |
| Novation 1200 Baud Modem (4202T) | 274.00 | 375.00 |
| Radio Shack TRS-80 Disk Drive | 399.00 | 499.00 |
| TRS-80 16K Computer | 479.00 | 599.00 |
| TRS-80 Expansion Interface | 239.00 | 299.00 |
| Polymorphic Systems | | |
| 8K Assembled | 289.00 | 385.00 |
| 8K Memory Board | 225.00 | 300.00 |
| Poly KBD | 169.00 | 225.00 |
| 8813 | 2880.00 | 3250.00 |
| System 0 | 378.00 | 525.00 |
| 88-System 2 | 529.00 | 735.00 |
| System 12 Kit | 846.00 | 1128.00 |
| System 6 | 1134.00 | 1575.00 |
| Video Card | 210.00 | 280.00 |
| Processor Tech | | |
| Cuts BD Assembled | 139.00 | 199.00 |
| 8K Dynamic Ram | 175.00 | 250.00 |
| 16K Dynamic Ram | 300.00 | 429.00 |
| 64K Dynamic Ram | 878.00 | 1350.00 |
| Extended Basic Cassette | 21.00 | 45.00 |
| SOL 20 W/O Memory | 1270.00 | 1895.00 |
| System II Kit | 1262.00 | 1905.00 |
| Panasonic Monitor | 143.00 | 210.00 |
| SD Sales 32K Dynamic Ram Board Kit | 332.00 | 475.00 |
| Solid State Music 16K Static Ram Board Kit | 300.00 | 325.00 |
| Southwest Technical (SWTPC) | | |
| MF-68 Dual 5" Floppy | 796.00 | 995.00 |
| Graphics Terminal | 79.00 | 98.50 |
| Technical Design Labs (TDL-Xitan) | | |
| I/O board - SMB-II | 257.00 | 395.00 |
| 32L Series K Memory Board | 559.00 | 799.00 |
| Fortran IV Ser.37 | 279.00 | 349.00 |
| Fortran IV Ser.41 | 279.00 | 349.00 |
| Xitan Alpha 1.5 | 823.00 | 1138.00 |
| Xitan Alpha 1 | 576.00 | 769.00 |
| Xitan Alpha 3 | 854.00 | 1181.00 |
| Xitan Alpha 1.5 | 571.00 | 868.00 |
| Video Board | 277.00 | 369.00 |
| Technico Super Starter Assembled | 293.00 | 300.00 |
| Technico Super Starter Kit | 199.00 | 299.00 |
| Trace Elec. 32K RAM Board Assem | 599.00 | 999.00 |

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# page DIGITAL INC.

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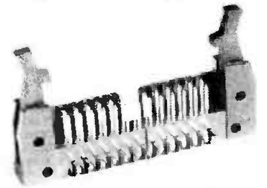
# INSULATION DISPLACEMENT SOCKETS

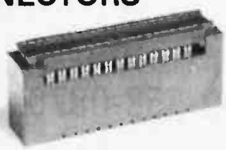
## RIGHT ANGLE HEADERS



| Pins | PC Mounting | | Wire Wrap | |
|---|---|---|---|---|
| 10 | IDH10SR | .80 | IDH10WR | 1.75 |
| 20 | IDH20SR | 1.25 | IDH20WR | 2.75 |
| 26 | IDH26SR | 1.85 | IDH26WR | 3.60 |
| 34 | IDS34SR | 2.15 | IDH34WR | 4.15 |
| 40 | IDH40SR | 2.50 | IDH40WR | 4.90 |
| 50 | IDH50SR | 3.15 | IDH50WR | 6.15 |

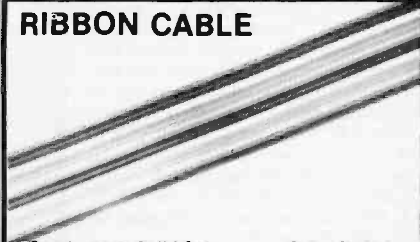
EJECTOR EARS .25 EACH

## CARD EDGE CONNECTORS



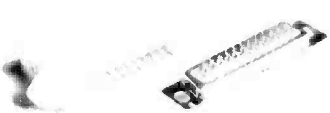
| Pins | Part No. | |
|---|---|---|
| 10 | IDE10 | 3.25 |
| 20 | IDE20 | 3.50 |
| 26 | IDE26 | 4.05 |
| 34 | IDE34 | 4.85 |
| 40 | IDE40 | 5.65 |
| 50 | IDE50 | 5.90 |

## RIBBON CABLE



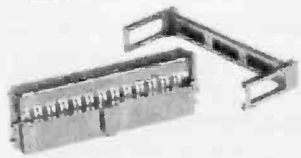
| Conductors: | Solid Color 10 ft. | Solid Color 100 ft. | Color Coded 10 ft. | Color Coded 100 ft. |
|---|---|---|---|---|
| 10 | 2.90 | 17.00 | 4.00 | 30.00 |
| 14 | 3.40 | 23.80 | 5.00 | 42.00 |
| 16 | 3.70 | 27.20 | 5.60 | 48.00 |
| 20 | 4.40 | 34.00 | 7.00 | 60.00 |
| 24 | 5.00 | 40.80 | 8.00 | 72.00 |
| 26 | 5.40 | 44.20 | 8.60 | 78.00 |
| 34 | 6.80 | 57.60 | 11.00 | 102.00 |
| 40 | 7.80 | 68.00 | 13.00 | 120.00 |
| 50 | 9.50 | 85.00 | 16.00 | 150.00 |

## 25 PIN "D" CONNECTORS



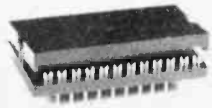
| Style | Part # | |
|---|---|---|
| **SOLDER STYLE** | | |
| Male | DB25P | 2.25 |
| Female | DB255 | 3.00 |
| Hood | DB25C | 1.10 |
| **INSULATION DISPLACEMENT** | | |
| Male | IDC25P | 4.95 |
| Female | IDC255 | 5.25 |
| Hood | IDC25C | 1.35 |

## SOCKETS



| Pins | Part No. | | Stain Relief |
|---|---|---|---|
| 10 | IDS10 | 1.25 | .25 |
| 20 | IDS20 | 2.02 | .25 |
| 26 | IDS26 | 2.65 | .25 |
| 34 | IDS34 | 3.50 | .25 |
| 40 | IDS40 | 4.05 | .25 |
| 50 | IDS50 | 5.06 | .25 |

## CABLE PLUGS



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

# WIRE WRAP WIRE

| Length | 100/Bag | 500/Bag | 1K/Bag | Length | 100/Bag | 500/Bag | 1K/Bag |
|---|---|---|---|---|---|---|---|
| 2.5" | $1.25 | $3.58 | $ 6.19 | 6.5" | $1.92 | $6.44 | $11.81 |
| 3.0" | 1.30 | 3.86 | 6.78 | 7.0" | 1.99 | 6.76 | 12.44 |
| 3.5" | 1.37 | 4.15 | 7.37 | 7.5" | 2.08 | 7.07 | 13.09 |
| 4.0" | 1.42 | 4.44 | 7.94 | 8.0" | 2.14 | 7.38 | 13.73 |
| 4.5" | 1.48 | 4.74 | 8.54 | 8.5" | 2.18 | 7.69 | 14.36 |
| 5.0" | 1.54 | 5.04 | 9.13 | 9.0" | 2.24 | 8.11 | 15.01 |
| 5.5" | 1.58 | 5.38 | 9.72 | 9.5" | 2.30 | 8.32 | 15.65 |
| 6.0" | 1.65 | 5.66 | 10.31 | 10.0" | 2.39 | 8.71 | 16.28 |

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

# WIRE KITS

| Kit No. 1 | $9.95 | | |
|---|---|---|---|
| 250 | 3" | 100 | 4½" |
| 250 | 3½" | 100 | 5" |
| 100 | 4" | 100 | 6" |

| Kit No. 2 | $24.95 | | |
|---|---|---|---|
| 250 | 2½" | 250 | 5" |
| 500 | 3" | 100 | 5½" |
| 500 | 3½" | 250 | 6" |
| 500 | 4" | 100 | 6½" |
| 250 | 4½" | 100 | 7" |

| Kit No. 3 | $32.95 | | |
|---|---|---|---|
| 500 | 2½" | 500 | 4½" |
| 500 | 3" | 500 | 5" |
| 500 | 3½" | 500 | 5½" |
| 500 | 4" | 500 | 6" |

| Kit No. 4 | $59.95 | | |
|---|---|---|---|
| 1000 | 2½" | 1000 | 4½" |
| 1000 | 3" | 1000 | 5" |
| 1000 | 3½" | 1000 | 5" |
| 1000 | 4" | 1000 | 6" |

## ORDERING INFORMATION:

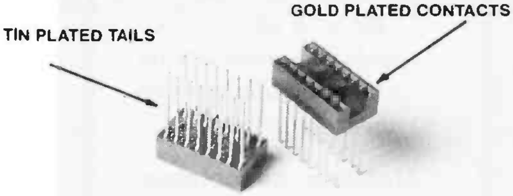
- Orders under $25 include $2 handling
- All prepaid orders shipped UPS Ppd.
- Visa, MC & COD's charged shipping.
- All prices good through cover date.
- Most orders shipped same day.
- Byte must be mentioned to get sale price.

**Write or call for 1981 catalog**

- IC Sockets
- Vector Board & Pins
- Bishop Drafting Aids
- OK Tools
- RN IDC Crimp Connectors

## "NEW" WIRE WRAP SOCKETS

**FEATURING A SELECTIVE PLATING METHOD THAT WILL SAVE YOU MONEY BY HAVING GOLD ONLY WHERE IT COUNTS.**




3 Level closed entry.

**RN Side Wipe contact design gives twice the contact area for high reliability.**

| Size | Quantity/Tube | Price ea.* | Price/Tube |
|---|---|---|---|
| 8 | 52 | .41 | 21.32 |
| 14 | 30 | .47 | 14.10 |
| 16 | 26 | .51 | 13.26 |
| 18 | 23 | .70 | 16.10 |
| 20 | 21 | .87 | 18.27 |
| 22 | 19 | .94 | 17.86 |
| 24 | 17 | .96 | 16.32 |
| 28 | 15 | 1.25 | 18.75 |
| 40 | 10 | 1.70 | 17.00 |

*FOR REFERENCE. MUST BE ORDERED IN TUBE QUANTITIES.

Circle 288 on inquiry card.

**TOLL FREE ORDERING NUMBER 1-(800)-423-7144**

Circle 341 on inquiry card.



Circle 342 on inquiry card.



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These are prime 4116's from one of the best MOS RAM manufacturers in the world.

| 4116 | 200ns |
|---|---|
| 8 for $25.00 | 32 for 96.00 |

Only prepaid orders on this special.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
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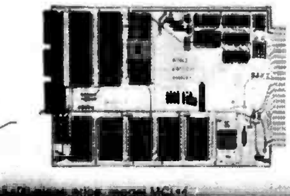

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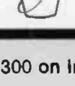

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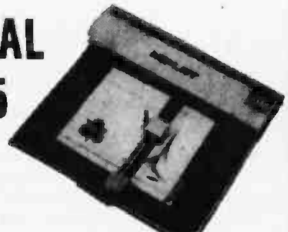

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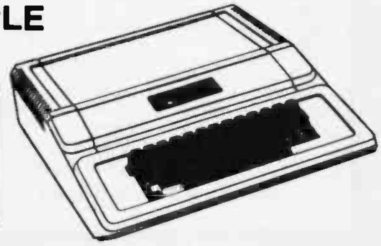

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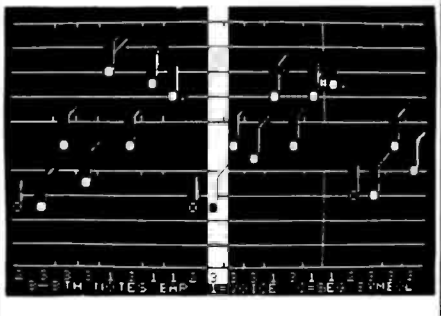

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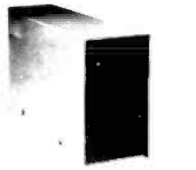

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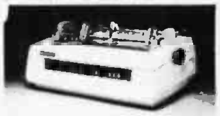

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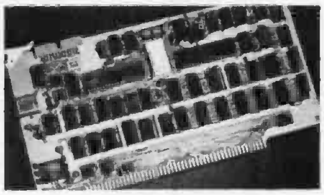

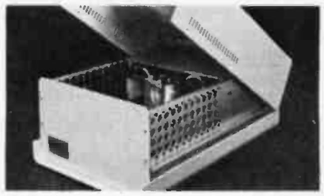

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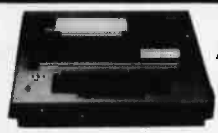
ASCII  ASCII

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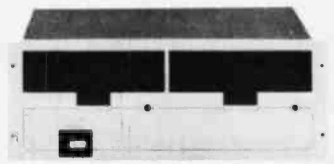

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**This is a partial listing of over 500 items available from 500 authorized Jim-pak Distributors:**

### TTL

| | | | |
|---|---|---|---|
| 7400 | 2/.85 | 7490 | .85 |
| 7402 | 2/.85 | 7493 | .85 |
| 7404 | 2/.85 | 74100 | 2.25 |
| 7406 | 2/1.19 | 74109 | 2/1.19 |
| 7407 | 2/1.19 | 74121 | .69 |
| 7408 | 2/.89 | 74123 | .99 |
| 7410 | 2/.85 | 74150 | 1.95 |
| 7414 | .99 | 74154 | 1.95 |
| 7417 | 2/1.10 | 74157 | .99 |
| 7420 | 2/.85 | 74161 | 1.19 |
| 7447 | 1.19 | 74164 | 1.59 |
| 7474 | .69 | 74174 | 1.59 |
| 7475 | .79 | 74175 | 1.49 |
| 7476 | .69 | 74192 | 1.19 |
| 7485 | 1.19 | 74193 | 1.19 |
| 7486 | 2/1.19 | 74367 | .99 |
| 7489 | 2.99 | 74393 | 1.95 |

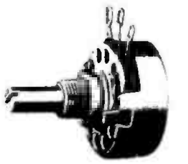
### GRAB BAGS

| | | | |
|---|---|---|---|
| GB100 Cer. Caps. (100) | 2.95 | GB123 Heat Sinks (30) | 3.95 |
| GB101 Mylar Caps. (60) | 4.95 | GB127 Transistors (100) | 3.95 |
| GB102 Electrolytics (60) | 4.95 | GB137 Chokes (50) | 3.95 |
| GB103 Tantalums (40) | 4.95 | GB139 Term. Strips (40) | 3.95 |
| GB108 TTL IC's (50) | 4.95 | GB140 Spcr/Stndff (150) | 2.95 |
| GB110 Asst. LEDs (100) | 5.95 | GB141 Washers (200) | 2.95 |
| GB113 Trimmers (30) | 4.95 | GB145 Lugs (100) | 2.95 |
| GB116 ¼w Resist. (200) | 2.95 | GB154 1&2w Resist. (100) | 2.95 |
| GB117 ½W Resist. (200) | 2.95 | GB162 7-Seg. Dsplys. (50) | 5.95 |
| GB120 Slide Switch (25) | 3.95 | GB173 3/8" Pots. (100) | 5.95 |

### LS Schottky

| | | | |
|---|---|---|---|
| 74LS00 | .55 | 74LS109 | .79 |
| 74LS02 | .55 | 74LS123 | 1.95 |
| 74LS04 | .69 | 74LS138 | 1.49 |
| 74LS08 | .55 | 74LS139 | 1.49 |
| 74LS10 | .55 | 74LS154 | 2.49 |
| 74LS14 | 1.09 | 74LS157 | 1.49 |
| 74LS30 | .55 | 74LS161 | 1.79 |
| 74LS32 | .69 | 74LS174 | 1.79 |
| 74LS38 | .69 | 74LS175 | 1.79 |
| 74LS42 | 1.49 | 74LS192 | 1.89 |
| 74LS47 | 1.49 | 74LS193 | 1.89 |
| 74LS48 | 1.79 | 74LS221 | 1.95 |
| 74LS73 | .79 | 74LS244 | 2.49 |
| 74LS74 | .79 | 74LS245 | 3.49 |
| 74LS75 | .99 | 74LS367 | 1.29 |
| 74LS85 | 1.95 | 74LS374 | 2.49 |
| 74LS90 | 1.09 | 81LS97 | 2.49 |

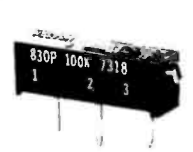
### POTENTIOMETERS



2 Watt @ 70°C
7/8" Slotted Shaft
Linear Taper

1K 5K 10K
25K 50K 100K
1 Meg

**CMU . . $2.95**




3/4 Watt @ 70°C
15 Turn Pot.
Linear Taper

100Ω 500Ω 1K
5K 10K 50K
100K 500K 1Meg

**830P . . $1.79**

### REGULATED POWER SUPPLY KIT

Uses LM309K. Heat Sink provided. PC board construction. Provides a solid 1 amp @ 5 volts. Can supply up to ±5V, ±9V and ±12V with JE205 Adapter. Includes components, hardware and instructions. 3½"x5"x2"H

**JE200 . . . . . . . . . . $14.95**

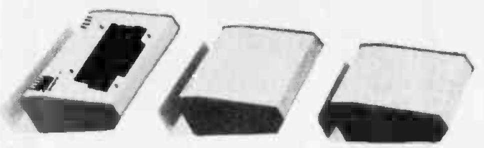
### SOCKETS

| Low Profile | | Wire Wrap | |
|---|---|---|---|
| 8 pin LP | 2/.59 | 14 pin WW tin | .75 |
| 14 pin LP | 2/.69 | 14 pin WW gold | 1.09 |
| 16 pin LP | 2/.79 | 16 pin WW tin | .79 |
| 18 pin LP | 2/.89 | 16 pin WW gold | 1.19 |
| 20 pin LP | 2/.99 | 24 pin WW gold | 1.69 |
| 22 pin LP | 2/1.09 | 40 pin WW gold | 2.75 |
| 24 pin LP | .79 | 14 p. plug/cover | 1.29 |
| 28 pin LP | .82 | 16 p. plug/cover | 1.39 |
| 36 pin LP | .99 | 24 p. plug/cover | 1.95 |
| 40 pin LP | 1.19 | Also, The Molex Line | |

### DIODES & TRANSISTORS

| | | | |
|---|---|---|---|
| IN751 | 2/.59 | 2N2219A | 2/1.19 |
| IN757 | 2/.59 | 2N2222A | 2/.89 |
| IN1188 | 2.69 | 2N2907A | 2/.89 |
| IN3600 | 5/.99 | 2N3055 | .99 |
| IN4001 | 4/.59 | 2N3772 | 2.25 |
| IN4004 | 4/.69 | 2N3904 | 2/.69 |
| IN4007 | 4/.79 | 2N3906 | 2/.69 |
| IN4148 | 10/.99 | 2N4401 | 2/.79 |
| IN4733 | 2/.69 | 2N4403 | 2/.79 |
| IN4734 | 2/.69 | 2N5129 | 2/.69 |
| IN4735 | 2/.69 | 2N5139 | 2/.69 |
| IN4742 | 2/.69 | 2N5210 | 2/.79 |
| IN4744 | 2/.69 | 2N5951 | 2/1.29 |

### DESK TOP ENCLOSURES



| | |
|---|---|
| DTE-8 (Pictured) | $31.95 |
| DTE-11 (Pictured) | 34.95 |
| DTE-14 | 36.95 |
| DTE-HK (Case for JE600) | 47.95 |
| DTE-AK (Case for JE610) (Pictured) | 52.95 |

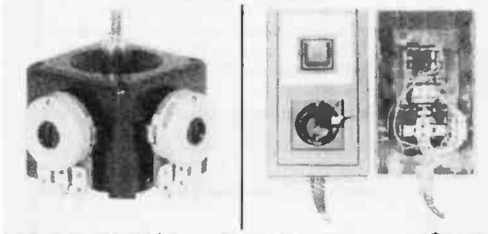
### CMOS

| | | | |
|---|---|---|---|
| 4000 | .69 | 4030 | .79 |
| 4001 | .69 | 4040 | 1.95 |
| 4002 | .69 | 4044 | 1.39 |
| 4006 | 1.95 | 4046 | 2.49 |
| 4009 | .89 | 4047 | 2.75 |
| 4010 | .85 | 4049 | .89 |
| 4011 | .69 | 4050 | .89 |
| 4013 | .85 | 4051 | 1.95 |
| 4016 | .85 | 4066 | 1.19 |
| 4017 | 1.49 | 4069 | .79 |
| 4018 | 1.49 | 4070 | .79 |
| 4020 | 2.19 | 4071 | .79 |
| 4023 | .49 | 4081 | .69 |
| 4024 | 1.29 | 4093 | 1.19 |
| 4027 | .89 | 4511 | 1.95 |

### CAPACITORS

| Dipped Tantalum | | ELECTROLYTIC | |
|---|---|---|---|
| .1mfd@35V | 2/.89 | 1mfd@50V | 3/.69 |
| .47mfd@35V | 2/.89 | 4.7mfd@50V | 2/.59 |
| 1mfd@35V | 2/.89 | 10mfd@50V | 2/.69 |
| 2.2mfd@25V | 2/1.09 | 22mfd@50V | 2/.79 |
| 3.3mfd@25V | 2/1.19 | 47mfd@50V | 2/.89 |
| 4.7mfd@25V | 2/1.39 | 100mfd@50V | .59 |
| 10mfd@25V | 1.19 | 220mfd@50V | .69 |
| 33mfd@25V | 3.95 | 1000mfd@25V | 1.19 |
| **100V MYLAR** | | 2200mfd@16V | 1.39 |
| .001-.01mfd | 4/.79 | **50V CERAMIC** | |
| .022mfd | 4/.89 | 10pf-.022mfd | 4/.59 |
| .047mfd | 4/.99 | .047mfd | 4/.69 |
| .1mfd | 4/1.19 | .1mfd | 4/.79 |
| .22mfd | 4/1.29 | | |

### JOYSTICKS



| | | |
|---|---|---|
| JS-100K | 100K Linear Taper Pots | $5.49 |
| JVC-40 | 40K (2) Video Controller | 5.95 |

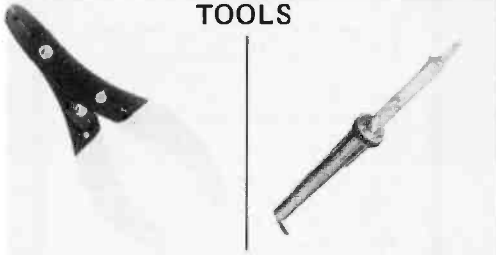
### CONNECTORS

| | | |
|---|---|---|
| DB25P | D-Subminiature Plug | 3.95 |
| DB25S | D-Subminiature Socket | 4.95 |
| DB51226 | Cover for DB25P/S | 2.25 |
| 22/44SE | P.C. Edge | 2.95 |
| UG88/U | BNC Plug | 2.19 |
| UG89/U | BNC Jack | 3.95 |
| UG175/U | UHF Adapter | .59 |
| SO239 | UHF Panel Recp. | 1.49 |
| PL258 | UHF Adapter | 1.95 |
| PL259 | UHF Plug | 1.95 |
| UG260/U | BNC Plug | 2.39 |
| UG1094/U | BNC Bulkhead Recp. | 1.49 |

### MICROPROCESSORS

| | | |
|---|---|---|
| Z80A | CPU (4MHz) | 14.95 |
| MC6800 | 8 Bit MPU | 14.95 |
| 8080A | CPU | 7.95 |
| 8212 | 8 Bit I/O Port | 3.95 |
| 8216 | Bi-Directional Bus Driver | 4.49 |
| 2513/2140 | Character Generator | 12.95 |
| 8T97 | Tri-State Hex Buffer | 2.25 |
| AY-5-1013 | 30K Baud UART | 6.95 |
| AY-5-2376 | 88-Key Keyboard Encoder | 13.95 |
| 2114-3 | 4K Static RAM (300ns) | 9.49 |
| MK4116 | 16K Dynamic RAM (250ns) | 9.95 |
| 2708 | 8K EPROM | 10.95 |
| 2716 | 16K EPROM (+5V) | 19.95 |

### TOOLS



| | | |
|---|---|---|
| PCB-3 | P.C. Board Vise | $12.49 |
| WS-150 | 5" Wire Strip./Cut. (12-24AWG) | 3.99 |
| SG-30 | 10" 110-120V 30W Solder Iron | 7.50 |
| SG-TIP | Replacement Tip for SG-30 S. Iron | 1.25 |

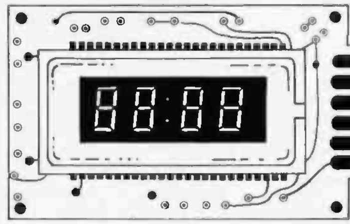
### LINEAR

| | | | |
|---|---|---|---|
| LM301N | .59 | LM7805T | 1.75 |
| LM305H | 1.39 | LM7812T | 1.75 |
| LM307N | .75 | LM7815T | 1.75 |
| LM308N | 1.19 | LM380N | 1.49 |
| LM309K | 2.25 | LM384N | 2.49 |
| LM310N | 2.69 | LM555N | .69 |
| LM311N | 1.49 | LM556N | 1.49 |
| LM317T | 2.29 | LM565N | 1.95 |
| LM318N | 2.95 | LM566N | 1.95 |
| LM319N | 2.95 | LM567N | 1.79 |
| LM320K-5 | 2.25 | LM723N | .79 |
| LM7905T | 1.75 | LM741N | .65 |
| LM7912T | 1.75 | LM1310N | 2.95 |
| LM7915T | 1.75 | LM1458N | .99 |
| LM323K | 5.95 | LM1488N | 1.59 |
| LM324N | 1.29 | LM1489N | 1.59 |
| LM337T | 2.29 | LM1800N | 4.49 |
| LM339N | 1.29 | 76477N | 3.95 |

### WALL TRANSFORMERS

| | | |
|---|---|---|
| AC250 | 250mA 12VAC (117V/60Hz) | $3.95 |
| DV9200 | 200mA 9VAC (117V/60Hz) | 3.95 |

### 12VDC AUTOMOTIVE/ INSTRUMENT CLOCK MODULE



.300 GREEN DISPLAY

**MA1003 . . . . . . . . . $19.95**

Circle 331 on inquiry card.

## !! REAL TIME !!

The TIME MACHINE from ALPHA OMEGA COMPUTER SYSTEMS isn't just another digital clock chip surrounded by interlace circuitry. It's an intelligent microcomputer based peripheral device.

The TIME MACHINE communicates with your computer via a serial I/O port at a user selectable data rate between 300 and 2400 baud. RS-232, RS-422, or current loop communication may be used.

Battery protection against power loss is included. The TIME MACHINE automatically computes day of the week and leap year. Buffered output pulses at one second, one minute, and one hour intervals are provided.

Dimensions are 2.5 x 4.75 x 7.5 inches. Batteries, power supply, and communication cable are included.

Price is only $450 single lot and quantity discounts are available. Dealer inquiries invited. Off the shelf delivery.

**ALPHA OMEGA COMPUTER SYSTEMS, INC.**
P.O. Box 727 / Corvallis, Oregon 97330
(503) 754-1919

Circle 332 on inquiry card.

# ZAS Z-8000

## SOFTWARE DEVELOPMENT PACKAGE

A professional Z-8000 assembly language package now available for 8080 & Z-80 based microcomputers which use the CP/M® or ISIS-II® operating system.

The package includes:

**ZAS** Full featured relocatable cross assembler. Uses Zilog syntax, supports segmented and non-segmented code, symbol names to 64 characters. 26 directives, including nested conditional assembly, "include" files, and named program, data and absolute sections. Outputs: object and listing files.

**ZLK** Task Builder. The most powerful linker you've ever used! Sections can be combined in any order and optionally "located" at fixed address. ZLK can also handle complicated overlay arrangements.

**ZLD** Object Loader. Loads an absolute object file for execution by a Z-8000 CPU on the bus. Includes host OS interface.

ZAS, ZLK, ZLD CP/M® .. $395
ISIS-II® .. $495
Manual Only .......... $25
Supplied on Single Density 8" Disk
CP/M® Digital Research, Inc. ISIS-II® Intel Corp.

WESTERN WARES
Box 48 Placerville, CO 81430

Circle 333 on inquiry card.

# North Star

## BASIC UTILITY SET

- EDITOR — Create & edit a Basic program using 26 commands, including GLOBAL locate & change.
- BPRT — Print & cross reference a Basic program.
- BPAK — Pack a Basic program.
- RE — Rename a disk file.

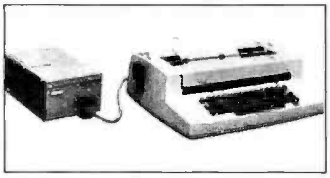
$69 plus $1.50 shipping, Calif. Res. add 6%.
Check, VISA, M/C

**SZ Software Systems**
1269 Rubio Vista Road, Altadena, Calif. 91001
(213) 791-3202

Circle 334 on inquiry card.

# IPEX NEW!

## Interface Converts Your Typewriter Into Printer



- Finest print quality
- Low cost
- Easy installation
- Quick delivery
- Fits IBM SELECTRIC® typewriter with no modification.
- For TRS-80®, Apple®, or any parallel or RS232 port.
- Write or phone for more information, today!

— U.S. and worldwide sales —

IPEX INTERNATIONAL INC.
16140 Valerio St.
Van Nuys, CA 91406 USA
TEL: 213/781-0020 TLX/TWX: 910-495-1767

Circle 335 on inquiry card.

**New Sensibly-Priced Paper Tape Reader**

A new, smaller, less expensive Stand-Alone Paper Tape Reader Model 605 reads at 150 CPS, has a parallel TTL output and is bidirectional. It stops on character, is completely self-contained and has automatic taut-tape sensing.

The new reader has 5 volt DC and 24 volt DC output power available and an optional internal clock. The desk-top model is priced at $495 for one unit, a saving of about 25% of the price of the larger Model 612.

**Contact Louis Doshay, Addmaster Corporation, 416 Junipero Serra Drive, San Gabriel 91776; telephone (213) 285-1121**

Circle 336 on inquiry card.

**A NEW WIRELESS AC REMOTE CONTROL INTERFACE** for the Sears and BSR X-10 home control system. Use your present TRS-80 Level II, Apple II or S100 computer to provide complete home security through control of lights, appliances and motors with a few simple BASIC commands.

As featured in:
"COMPUTERIZE A HOME" BYTE, January 1980

Busy Box - Assembled & tested
For TRS-80 .. $109.95
For S100 .... 119.95
For Apple II ... 114.95
Realtime control software – TRS-80 19.95
To order call (516) 374-6793
or write: The MicroMint Inc.
917 Midway,
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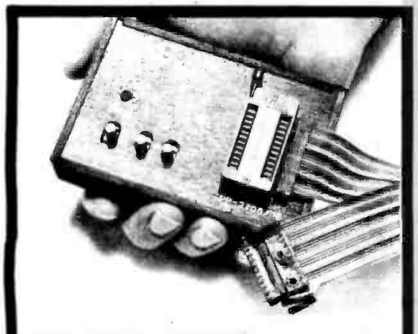
**BUSY BOX™**

DEALER INQUIRIES INVITED

MICRO MINT

Circle 337 on inquiry card.



OAE's PP-Series EPROM Programmers plug directly into any vacant EPROM socket and allow you to transfer data directly from RAM to EPROMs. No additional power supplies are required. All timing & control sequences are handled by the programmer. Each unit includes internal DC to DC switching regulator, ZIF socket and 4 ft. ribbon cable terminated with a 24 pin plug. Programmers are available for all EPROMs from 2708's thru 2532's.

**Oliver Advanced Engineering, Inc.**
676 W. Wilson Ave., Glendale, CA 91203
(213) 240-0080 or Telex 194773.
PP SERIES PROGRAMMERS
See us at NCC, booth 770

Circle 338 on inquiry card.

# DISK DRIVES

## REMEX

Compatible with IBM and Shugart.
Double sided, Double Density
............ 1600 K Bytes.
RFD 4000 ................ $595
Double Sided, Double Density
.............. 800 K Bytes
RFD 2000 ................ $395

For fast delivery, send certified checks, money orders or call to arrange direct bank wire transfers. Personal or company checks require two weeks to clear. California Res. add 6% sales tax. Minimum shipping charge $10.00. No C.O.D.

**Electronic Equipment Unlimited**
**3845 Birch Street**
**Newport Beach, CA 92660**
**PH: (714) 540-5231**

Pricing and availability subject to change without notice.

Circle 339 on inquiry card.

# *MEDICAL BILLING*

*for*

## *APPLE II*

- *7000 ACCOUNTS*
- *2000 TRANSACTIONS*

*$995*

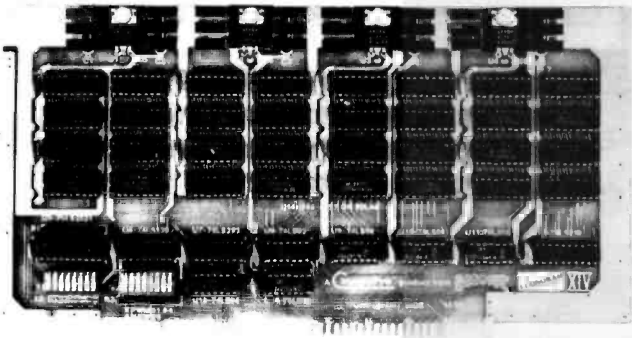
**PROSOFT**

*3604 Foothill, LaCrescenta, CA*
*(213) 248-2884*

Circle 340 on inquiry card.

# ANOTHER FAMOUS PRIORITY 1 ELECTRONICS TRUCK LOAD PURCHASE 10 MHZ 16K A&T STATIC S-100 RAM FROM

**CompuPro**™ division of **GODBOUT ELECTRONICS**



LIST $349^{00}

SAVE $150^{00}

The **RAM 14** provides 16K X 8 of reliable, totally static RAM storage. Conforming fully to the IEEE 696/S-100 bus standard, **RAM 14** not only provides 24 address lines for 16 megabyte extended addressing capability, but also includes a number of features you would only expect to find in memory boards costing considerably more. Here's a partial listing of what makes **RAM 14** your best choice!

- Operates up to 10 MHZ (70 ns Ram Chips)
- Assembled & Tested
- Meets or exceeds all IEEE 696/S-100 specifications (including timing).
- Fully static design eliminates the timing problems associated with dynamic memories.
- Switch selectable choice of 24 address lines conforming to the IEEE 696/S-100 extended addressing specifications, or 16 address lines as used in older S-100 systems.
- Ideal for multi-user installations.
- Board is addressable as one 16K x 8 block on any 4K boundary.
- Switch selectable PHANTOM disable and write protect.
- +5 Volt operation (requires no other supply voltages).
- Low power operation (900 mA typical, 1200 mA maximum).
- 1 year Factory Warranty

**GBT-143A $199.00**

**Quantities are limited so hurry!**


**ORDER TOLL FREE 1-800-423-5633 except CA., AK., HI., CALL (213) 894-8171**

***PRIORITY ONE ELECTRONICS***

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Terms: Visa, MC, BAC, Check, Money Order, U.S. Funds Only. CA residents add 6% sales tax.
*Sales Prices are for prepaid orders only. Credit card orders will be charged appropriate freight.

Circle 290 on inquiry card.

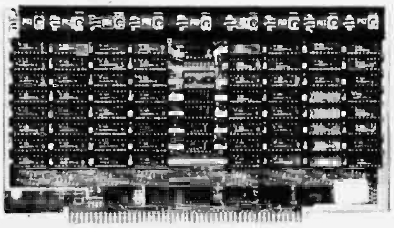
# U.S. MICRO SALES

## DEALS ☐ DEALS ☐ DEALS

SHOP HERE AND

**SAVE!**

(MINIMUM ORDER $10.00)



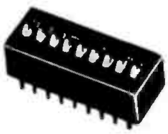
*This is ABSOLUTELY the LOWEST PRICE EVER for a Hi Speed (300 NS) LO-LO Power 32K RAM. 4K by 1 Chips are organized in Selectable Banks.*

- *Extended Address Lines A16 - A17*
- *Phantom Line*
- *9 Regulators*

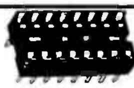
**$299** (KIT)

## SCHOOLS

### DIP SWITCHES



| POS. | PRC. |
|---|---|
| 4 | .88 |
| 5 | .92 |
| 6 | .95 |
| 7 | .99 |
| 8 | 1.05 |
| 9 | 1.15 |
| 10 | 1.19 |



| PINS | PC | WW |
|---|---|---|
| 8 | .10 | .26 |
| 14 | .13 | .29 |
| 16 | .16 | .32 |
| 18 | .18 | .34 |
| 20 | .22 | .38 |
| 24 | .32 | .48 |
| 28 | .34 | .50 |
| 40 | .45 | .61 |

AMP - Need we say more? There is a difference in sockets! These aren't the lowest prices you can find. But, if you've been "burned" before by bad connections in your computer, a few pennies for the best is worth it!

### RESISTORS .02 ea!

(100 PACK) ¼W

| | | | | |
|---|---|---|---|---|
| 1.0 | 75 | 2.7K | 22K | 220K |
| 4.7 | 100 | 3.3K | 24K | 330K |
| 6.8 | 150 | 3.9K | 27K | 470K |
| 10 | 220 | 4.7K | 33K | 680K |
| 15 | 330 | 6.8K | 39K | 1M |
| 22 | 470 | 10K | 47K | 1.5M |
| 27 | 680 | 12K | 68K | 2.2M |
| 33 | 1K | 15K | 100K | 4.7M |
| 47 | 1.5K | 18K | 150K | 10M |
| 68 | 2.2K | 20K | | |

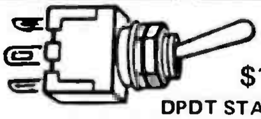
### WIRE WRAP WIRE

Packed in 500 Lot Bundles
(Length includes 2" x 1" Strip)
Color — R, Bu, G, Y, Bk, W

**50 ft. $1.65 - 100 ft. $3.00 - 500 ft. $9.50**

| | | |
|---|---|---|
| 2.5—3.25 | 4.0—3.75 | 6.0—4.75 |
| 3.0—3.35 | 4.5—4.00 | 7.0—5.00 |
| 3.5—3.50 | 5.0—4.50 | 8.0—5.50 |
| | | 10.0—6.50 |

### OK WIRE WRAP TOOL $5.95



6 Amps 125 VAC
7 Amps 30 VDC

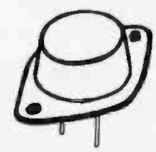
**$1.25 ea.**

**DPDT STANDARD TOGGLE**

- ST21 (ON-NONE-ON)
- ST22 (ON-OFF-ON)
- ST23 (MOM ON-OFF-MOM ON)
- ST24 (ON-OFF-MOM ON)
- ST25 (ON-NONE-MOM-ON)
- ST26 (ON-ON-ON)

## HOBBIEST

### LM323K 5V. 3A.



REGULATOR

**$5.50**

### TAB MOUNT

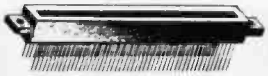
| | | |
|---|---|---|
| 7805 | +5V | 1A |
| 7905 | –5V | 1A |
| 7812 | +12V | 1A |
| 7912 | –12V | 1A |

HEAT SINKS 49¢

**$1.25**

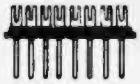
### ♦ GOLD ♦ S-100-CONNECTOR

TI or Better



SOLDER TAIL **$2.50** WIRE WRAP **$3.25**

### DIP PLUGS



| PART# | PINS | PRICE |
|---|---|---|
| 08DP | 8 | .40 |
| 14DP | 14 | .55 |
| 16DP | 16 | .58 |
| 24DP | 24 | .95 |
| 40DP | 40 | 1.50 |

Socket and Dip Plug priced based on gold not exceeding $700 per ounce.

### CONNECTORS

| DUAL ROW .100 PINS | PRICE | CARD EDGE PINS | PRICE |
|---|---|---|---|
| 20 | 2.35 | 20 | 3.35 |
| 26 | 3.00 | 26 | 3.80 |
| 34 | 3.85 | 34 | 4.65 |
| 40 | 4.50 | 40 | 5.50 |
| 50 | 5.50 | 50 | 5.90 |

RIBBON — 20 to 34 @ 1.00 ft.
40 & 50 @ 1.30 ft.

CRIMPING 2.00 / CONNECTOR

## OEM'S

### Z-80-A

**$6.95**

*4MHZ Beastie with extra instructions!*

### Z-80 SUPPORT

CTC — $6.55
SIO — $25.50
PIO — $6.50
DMA — $18.75

*All 4MHZ (who wants 2MHZ?)*

### 74LSXX

| | | | | | |
|---|---|---|---|---|---|
| 74LS00 | .33 | 74LS107 | .59 | 74LS221 | 2.95 |
| 74LS01 | .33 | 74LS109 | .59 | 74LS240 | 2.95 |
| 74LS02 | .33 | 74LS112 | .59 | 74LS241 | 2.49 |
| 74LS03 | .33 | 74LS113 | .59 | 74LS242 | 1.95 |
| 74LS04 | .59 | 74LS114 | .49 | 74LS243 | 1.95 |
| 74LS05 | .39 | 74LS122 | .59 | 74LS244 | 2.95 |
| 74LS06 | .39 | 74LS123 | 1.19 | 74LS245 | 8.95 |
| 74LS07 | .39 | 74LS124 | 1.49 | 74LS247 | 1.19 |
| 74LS08 | .59 | 74LS125 | .89 | 74LS248 | 1.19 |
| 74LS09 | .39 | 74LS126 | .89 | 74LS249 | 1.69 |
| 74LS10 | .29 | 74LS132 | .79 | 74LS251 | 1.79 |
| 74LS11 | .39 | 74LS133 | 1.19 | 74LS253 | .95 |
| 74LS12 | .39 | 74LS136 | .69 | 74LS257 | 1.95 |
| 74LS13 | .69 | 74LS138 | .99 | 74LS258 | 1.95 |
| 74LS14 | 1.25 | 74LS139 | .99 | 74LS259 | 2.95 |
| 74LS15 | .49 | 74LS145 | 1.25 | 74LS260 | .75 |
| 74LS20 | 1.95 | 74LS148 | 1.49 | 74LS266 | 1.15 |
| 74LS21 | 3.7 | 74LS151 | .79 | 74LS273 | 1.75 |
| 74LS22 | .29 | 74LS154 | 2.49 | 74LS275 | 4.39 |
| 74LS26 | .39 | 74LS155 | 1.49 | 74LS279 | .79 |
| 74LS27 | .49 | 74LS156 | 1.49 | 74LS283 | 1.49 |
| 74LS28 | .39 | 74LS157 | 1.49 | 74LS289 | 5.75 |
| 74LS30 | .49 | 74LS158 | 1.49 | 74LS290 | 1.29 |
| 74LS32 | .95 | 74LS160 | .75 | 74LS293 | 1.95 |
| 74LS33 | 1.95 | 74LS161 | 1.99 | 74LS295 | 1.95 |
| 74LS37 | .75 | 74LS162 | 1.25 | 74LS298 | 1.29 |
| 74LS38 | .39 | 74LS163 | 1.25 | 74LS324 | 1.75 |
| 74LS40 | .25 | 74LS164 | 2.15 | 74LS352 | 1.65 |
| 74LS42 | 1.39 | 74LS165 | 1.49 | 74LS353 | 1.65 |
| 74LS47 | .79 | 74LS166 | 2.49 | 74LS365 | .95 |
| 74LS48 | .79 | 74LS168 | 2.95 | 74LS366 | .79 |
| 74LS35 | .25 | 74LS169 | 1.95 | 74LS367 | .99 |
| 74LS54 | .25 | 74LS170 | 1.95 | 74LS368 | .99 |
| 74LS55 | .70 | 74LS173 | 1.25 | 74LS373 | 2.95 |
| 74LS73 | .79 | 74LS174 | 1.49 | 74LS374 | 3.95 |
| 74LS74 | .59 | 74LS175 | 1.49 | 74LS377 | 1.95 |
| 74LS75 | .79 | 74LS181 | 2.15 | 74LS378 | 1.95 |
| 74LS76 | .79 | 74LS189 | 6.95 | 74LS379 | 1.95 |
| 74LS78 | .49 | 74LS190 | .99 | 74LS386 | .59 |
| 74LS83 | .95 | 74LS191 | 1.95 | 74LS390 | 1.95 |
| 74LS85 | 1.49 | 74LS192 | 1.95 | 74LS393 | 1.95 |
| 74LS86 | .95 | 74LS193 | 1.95 | 74LS395 | 1.95 |
| 74LS90 | .75 | 74LS194 | 1.49 | 74LS490 | 4.95 |
| 74LS92 | .75 | 74LS195 | .95 | 74LS668 | 1.69 |
| 74LS93 | .95 | 74LS196 | .95 | 74LS669 | 1.89 |
| 74LS95 | 1.29 | 74LS197 | 1.95 | 74LS670 | 3.55 |
| 74LS96 | 1.29 | | | | |

# SALE SALE SALE

## Disk Drives

*JADE's new dual disk sub-assemblies include: Handsome metal cabinet with proportionally balanced air flow system, rugged dual drive power supply, cooling fan, cable kit, lighted power switch, approved fuse assembly, line cord, Never-Mar rubber feet, and all necessary hardware to mount 2-8" disk drives - it's all American made, guaranteed for six months, and it's in stock!*

Dual 8" Sub-Assembly Cabinet

**END-000421** *Cabinet kit* .......... **$225.00**
**END-000420** *Bare cabinet* .......... **$59.95**

Single sided, double density disk drive sub-system

**END-000423** *Kit w/2 8" drives* .... **$975.00**
**END-000424** *A & T w/2 8" drives* **$1195.00**

Double sided, double density disk drive sub-system

**END-000426** *kit w/2 8" drives* .... **$1495.00**
**END-000427** *A & T w/2 8" drives* **$1695.00**

### JADE DISK PACKAGE

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

**Special package price** .......... **$1395.00**

## *8" Disk Drive Sale*

*Highly reliable double density floppy disk drives*

Shugart 801R single sided, double density

**MSF-10801R** *SA-801R* .......... **$425.00**
***Special Sale Price*** .......... ***2 for $790.00***

Siemens FDD100-8D2 single sided, double density

**MSF-201120** *6 mo warranty* ....... **$385.00**
***Special sale price*** .......... ***2 for $750.00***

## *Real Double-Sided Drives*

### 8" Double-Sided Double-Density Sale

***Shugart SA-851R double-sided, double-density***
***only $625.00 ea*** ........ ***2 for $1190.00***

*MFE M701 8" double-sided, double-density drives*
***only $525 ea*** .......... ***2 for $1040.00***

*Qume Data Track 8 double-sided, double-density drives*
***only $575.00*** .......... ***2 for $1100.00***

## Printers

### CENTRONICS 737-1

*9 x N dot matrix, letter quality, proportional spacing*

**PRM-15737** *Parallel* .......... **$795.00**
***With interface for Apple*** .......... **$895.00**

### MX-80 - Epson

*132 column, 9 x 9 dot matrix, multiple fonts*

**PRM-27080** *Save $100.00* .......... **$545.00**
***Interface for Apple*** .......... **$110.00**

### SPINWRITER - NEC

*65 cps, bi-directional, letter quality printer with deluxe tractor mechanism, both parallel and serial interfaces on-board, 16K buffer, ribbon, print thimble, graphics, micro space justification, data cable, and self test/diagnostic ROM.*

**PRD-55511** *without 16K buffer* ... **$2795.00**
**PRD-55512** *with 16K buffer* ...... **$2895.00**

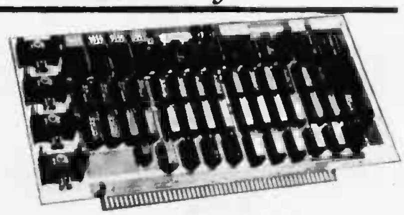
## S-100 Systems

### S-100 SYSTEM - Calif Computer Sys

*Complete S-100 system including 12 slot mainframe, 4 MHz Z-80 CPU, 64K RAM memory, double density disk controller, RS-232 cable, 8" & 5¼" disk drive cables, CP/M 2.2, manuals, auto boot ROM, completely assembled & tested.*

**2210A** *Integrated & tested* .......... **$1995.00**
**2210B** *Not integrated* .......... **$1795.00**

## S-100 Memory



### 64K RAM - Calif Computer Sys

*4 MHz bank port / bank byte selectable, extended addressing, 16K bank selectable, PHANTOM line allows memory overlay, 8080 / Z-80 / front panel compatible.*

**MEM-64565A** *A & T* .......... **$449.95**

### MEMORY BANK - Jade

*4 MHz, IEEE S-100, bank selectable, 8 or 16 bit*

**MEM-99730B** *Bare board* .......... **$55.00**
**MEM-99730K** *Kit, no RAM* .......... **$219.95**
**MEM-16730K** *16K kit* .......... **$249.95**
**MEM-32731K** *32K kit* .......... **$289.95**
**MEM-48732K** *48K kit* .......... **$324.95**
**MEM-64733K** *64K kit* .......... **$359.95**
*Assembled & tested* .......... add **$50.00**

### EXPANDORAM II - S D Systems

*4 MHz RAM board expandable from 16K to 256K*

**MEM-16630K** *16K kit* .......... **$275.95**
**MEM-32631K** *32K kit* .......... **$295.95**
**MEM-48632K** *48K kit* .......... **$315.95**
**MEM-64633K** *64K kit* .......... **$335.95**
*Assembled & tested* .......... add **$50.00**

### 32K STATIC RAM - Jade

*2 or 4 MHz expandable static RAM board uses 2114L's*

**MEM-16151K** *16K 4 MHz kit* ...... **$169.95**
**MEM-32151K** *32K 4 MHz kit* ...... **$299.95**
*Assembled & tested* .......... add **$50.00**

### 16K STATIC RAM - Cal Comp Sys

*2 or 4 MHz 16K static RAM board, IEEE S-100, bank selectable, Phantom capability, addressable in 4K blocks*

**MEM-16160A** *16K 2 MHz A & T* ... **$286.95**
**MEM-16162A** *16K 4 MHz A & T* ... **$289.95**
**MEM-16160B** *Bare board* .......... **$50.00**

### PB-1 - S.S.M.

*2708, 2716 EPROM board with built-in programmer*

**MEM-99510K** *Kit* .......... **$154.95**
**MEM-99510A** *A & T* .......... **$229.95**

### PROM-100 - SD Systems

*2708, 2716, 2732, 2758, & 2516 EPROM programmer*

**MEM-99520K** *Kit* .......... **$219.95**
**MEM-99520A** *Jade A & T* .......... **$269.95**

## S-100 Video

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

*80 characters x 24 lines expandable to 80 x 48 for a full page of text, upper & lower case, 256 user defined symbols, 160 x 192 graphics matrix, memory mapped, has key board input.*

**IOV-1095K** *4 MHz kit* .......... **$375.00**
**IOV-1095A** *4 MHz A & T* .......... **$450.00**
**IOV-1096K** *80 x 48 upgrade* .......... **$39.95**

### VIDEO BOARD - Jade

*64 characters x 16 lines, 7 x 9 dot matrix, full upper/lower case ASCII character set, numbers, symbols, and greek letters, normal/reverse/blinking video, S-100.*

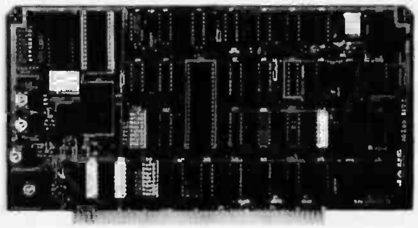
**IOV-1050K** *Kit* .......... **$99.95**
**IOV-1050A** *A & T* .......... **$125.00**
**IOV-1050B** *Bare board* .......... **$19.95**

## S-100 CPU

### 2810 Z-80* CPU - Cal Comp Sys

*2/4 MHz Z-80A* CPU with RS-232C serial I/O port and on-board MOSS 2.2 monitor PROM, front panel compatible.*

**CPU-30400A** *A & T* .......... **$269.95**



### THE BIG Z* - Jade

*2 or 4 MHz switchable Z-80* CPU with serial I/O, accomodates 2708, 2716, or 2732 EPROM, baud rates from 75 to 9600*

**CPU-30201K** *Kit* .......... **$145.00**
**CPU-30201A** *A & T* .......... **$199.00**
**CPU-30200B** *Bare board* .......... **$35.00**

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

*2 or 4 MHz Z-80 CPU board with provision for up to 8K of ROM or 4K of RAM on board, extended addressing, IEEE S-100, front panel compatible.*

**CPU-30300A** *A & T* .......... **$229.95**

### SBC-200 - SD Systems

*4 MHz Z-80* CPU with serial & parallel I/O ports, up to 8K of on-board PROM, software programmable baud rate generator, 1K of on-board RAM, Z-80 CTC.*

**CPC-30200K** *Kit* .......... **$339.95**
**CPC-30200A** *Jade A & T* .......... **$399.95**

## S-100 Disk Controller

### DOUBLE DENSITY - Cal Comp Sys

*5¼" and 8" disk controller, single or double density, with on-board boot loader ROM, and free CP/M 2.2* and manual set.*

**IOD-1300A** *A & T* .......... **$369.95**

### DOUBLE-D - Jade

*Double density controller with the inside track, on-board Z-80A*, printer port, IEEE S-100, can function on an interrupt driven buss*

**IOD-1200K** *Kit* .......... **$299.95**
**IOD-1200A** *8" A & T* .......... **$389.95**
**IOD-1205A** *5¼" A & T* .......... **$389.95**
**IOD-1200B** *Bare board* .......... **$65.00**

### VERSAFLOPPY II - SD Systems

*New double density controller for both 8" & 5¼"*

**IOD-1160K** *Kit* .......... **$379.95**
**IOD-1160A** *Jade A & T* .......... **$439.95**

## Motherboards

### ISO-BUS - Jade

*Silent, simple, and on sale - a better motherboard*

6 Slot (5¼" x 8⅝")

**MBS-061B** *Bare board* .......... **$19.95**
**MBS-061K** *Kit* .......... **$39.95**
**MBS-061A** *A & T* .......... **$49.95**

12 Slot (9¾" x 8⅝")

**MBS-121B** *Bare board* .......... **$29.95**
**MBS-121K** *Kit* .......... **$69.95**
**MBS-121A** *A & T* .......... **$89.95**

18 Slot (14½" x 8⅝")

**MBS-181B** *Bare board* .......... **$49.95**
**MBS-181K** *Kit* .......... **$99.95**
**MBS-181A** *A & T* .......... **$139.95**

## Card Cages

### S-100 CARD CAGE - Jade

*Metal cage with card guides & fan mounting*

**ENX-106001** *Six slot* .......... **$29.95**

### S-100 CARD CAGE - Vector

*19" rack mountable, adjustable, holds 21 cards*

**VCT-CCK100** *Anodized Al* .......... **$49.95**

# SALE SALE SALE

## S-100 I/O

### S.P.I.C. - Jade
*Our new I/O card with 2 SIO's, 4 CTC's, and 1 PIO*

IOI-1045K *2 CTC's, 1 SIO, 1 PIO* .. $199.00
IOI-1045A *A & T* .......... $259.00
IOI-1046K *4 CTC's, 2 SIO's, 1 PIO* $259.00
IOI-1046A *A & T* .......... $319.00
IOI-1045B *Bare board w/ manual* ... $59.95
IOI-1045D *Manual only* .......... $20.00

### I/O-4 - S.S.M.
*2 serial I/O ports plus 2 parallel I/O ports*

IOI-1010K *Kit* .......... $179.95
IOI-1010A *A & T* .......... $249.95
IOI-1010B *Bare board* .......... $35.00

### TERMINATOR - S.S.M.
*Active terminator for S-100 bus*

TSX-195K *Kit* .......... $29.95
TSX-195A *A & T* .......... $54.95
TSX-195B *Bare board* .......... $22.95

### S-100 EXTENDER - Cal Comp Sys
*Put those problem boards (the ones you probably bought from one of our competitors) within easy reach.*

TSX-160A *A & T* .......... $37.95

### S-100 PROTO BOARD - Jade
*Universal design, plated thru holes, gold fingers*

TSX-140B *Bare board* .......... $24.95

### TERMINATOR & EXTENDER - C.C.S.
*Can be used as both an S-100 extender and terminator*

TSX-150K *Kit* .......... $43.95

## Diskettes

### DISKETTES - Jade
*Bargain prices on magnificent magnetic media*

5¼" single sided, single density, box of 10

MMD-5110103 *Soft sector* .......... $27.95
MMD-5111003 *10 sector* .......... $27.95
MMD-5111603 *16 sector* .......... $27.95

5¼" double sided, double density, box of 10

MMD-5220103 *Soft sector* .......... $39.95

8" single sided, single density, box of 10

MMD-8110103 *Soft sector* .......... $33.95

8" single sided, double density, box of 10

MMD-8120103 *Soft sector* .......... $39.95

8" double sided, double density, box of 10

MMD-8220103 *Soft sector* .......... $49.95

## Video Monitors

### 9" B & W MONITOR - A.P.F.
*High quality, high resolution video monitor*

VDM-750900 *9" monitor* .......... $159.95

### 13" COLOR MONITOR - Zenith
*The hi res color you've been promising yourself*

VDC-201301 .......... $449.00

### 12" GREEN SCREEN - NEC
*20 MHz, P31 phosphor video monitor with audio, exceptionally high resolution - A fantastic monitor at a very reasonable price*

VDM-651200 *12" monitor* .......... $259.95

## Mainframes

### MAINFRAME - Cal Comp Sys
*12 slot S-100 mainframe with 20 amp power supply*

ENC-112105 *Kit* .......... $359.95
ENC-112106 *A & T* .......... $419.95

### DISK MAINFRAME - NNC
*Holds 2 8" drives and an 8 slot S-100 system. Attractive metal cabinet with 8 slot motherboard, power supply, fan, key switch, and other professional features*

ENS-112320 *with 30 amp p.s.* .......... $699.95

## Accessories-Apple/TRS-80


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

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

### DISK DRIVE for APPLE
*5¼" disk drive with controller for your Apple*

MSM-12310C *with controller* .......... $499.95
MSM-123101 *w/out controller* .......... $375.00

### DISK DRIVES for TRS-80
*23% more storage, 8 times faster, 40 track with free patch, 120 day warranty, includes case, power supply, and cable*

MSM-12410C *Save $125.00 !!!* .......... $299.95

### DOS 3.3 UPGRADE - Apple
*Upgrade your old DOS to the improved 3.3*

IOD-2233A *Complete kit* .......... $64.95

### APPLE STICK - Micromate
*Joy stick with pots for Apple II*

SYA-1510A *A & T* .......... $35.95

### Z-80* CARD for APPLE
*Z-80* CPU card with CP/M 2.2 for your Apple*

CPX-30800A *A & T* .......... $279.95

### AIO - S.S.M.
*Parallel & serial interface for your Apple*

IOI-2050K *Kit* .......... $155.95
IOI-2050A *A & T* .......... $194.95

### PRINTER INTERFACE - C.C.S.
*Centronics type I/O card w/ firmware*

IOI-2041A *A & T* .......... $99.95

### APPLE CLOCK - Cal Comp Sys
*Real time clock w/battery back-up*

IOK-2100A *A & T* .......... $109.95

## Modems

******************************

### LEX-11 MODEM - Lexicon
*A real star! 300 baud, answer/originate, RS 232C*

IOM-5511A *Best buy !!!* .......... $128.00

******************************

### NOVATION CAT
*300 baud, answer/originate acoustic modem*

IOM-5200A *1 year warranty* .......... $179.00

*D-CAT 300 baud, direct connect modem*

IOM-5201A *Special sale price* .......... $189.00

*AUTO-CAT Auto answer/origiate, direct connect*

IOM-5230A *Special sale price* .......... $239.95

### MICROMODEM - D.C. Hayes
*Auto answer/dial modem card for Apple or S-100*

IOM-2010A *Apple modem* .......... $349.95
IOM-1100A *S-100 modem* .......... $375.00

### MICRONET MODEM - Micromate
*Direct connect with extra features - a best buy*

IOM-2020A *Best Apple modem* .......... $275.00

* Z-80, Z-80A, and the letter Z are recognized trademarks of Zilog, Inc. *CP/M is a registered trademark of Digital Research Corp. *CBASIC is a trademark of Compiler Systems, Inc.

## Single Board Computers

### AIM-65 - Rockwell
*6502 computer with alphanumeric display, printer, & keyboard, and complete instructional manuals*

CPK-50165 *1K AIM* .......... $374.95
CPK-50465 *4K AIM* .......... $449.95
SFK-74600008E *8K BASIC ROM* .......... $99.95
SFK-64600004E *4K assembler ROM* .......... $84.95
PSX-030A *Power supply* .......... $64.95
ENX-000002 *Enclosure* .......... $49.95

*4K AIM, 8K BASIC, power supply, & enclosure*

**Special package price** .......... $625.00

### Z-80* STARTER KIT - SD Systems
*Complete Z-80* computer with RAM, ROM, I/O, display, keyboard, manual, and kluge area.*

CPS-30010K *Kit* .......... $369.95
CPS-30010A *Jade A & T* .......... $459.95

**MICROPROCESSORS**

| | |
|---|---|
| Z-80 | 10.95 |
| Z-80A | 12.95 |
| 6502 | 11.50 |
| 6800 | 11.95 |
| 6802 | 17.95 |
| 6809 | 39.95 |
| 8035 | 24.00 |
| 8080A | 6.59 |
| 8085 | 15.95 |
| 8748 | 59.95 |

**Z-80 SUPPORT**

| | |
|---|---|
| 3881 *PIO* | 9.50 |
| 3881-4 *PIO-4 MHz* | 14.50 |
| 3882 *CTC* | 9.50 |
| 3882-4 *CTC-4 MHz* | 14.95 |
| 3883 *SIO* | 29.50 |
| 3884 *SIO* | 49.50 |

**BAUD RATE GENERATORS**

| | |
|---|---|
| MC14411 | 10.00 |
| 1.843 MHz xtal | 4.95 |

**UARTS**

| | |
|---|---|
| AY5-1013A | 5.25 |
| AY3-1014A | 8.25 |
| TR1602B | 5.25 |
| TMS6011 | 5.95 |
| IM6402 | 9.00 |

**6800 SUPPORT**

| | |
|---|---|
| 6821P | 5.95 |
| 6828P | 11.95 |
| 6834P | 22.50 |
| 6840P | 18.75 |
| 6850P | 4.80 |
| 6852P | 5.79 |
| 6875L | 7.40 |
| 68488P | 25.00 |

**PROMS**

| | |
|---|---|
| 2708 *450ns* | 6.25 |
| *10 for $4.90 ea* | |
| 2716 *12.5v* | 11.95 |
| 2716 *5v* | 11.95 |
| *10 for $8.90 ea* | |
| 2532 *5v* | 39.95 |
| 2732 *5v* | 39.95 |
| 2758 *5v* | 9.95 |

**RAMS**

| | |
|---|---|
| 21L02 *2 MHz* | 1.25 |
| 21L02A *4 MHz* | 1.50 |
| 2114L *2 MHz* | 3.75 |
| 2114LA *4 MHz* | 3.95 |
| 4116 | 4.25 |
| 4164 *64K x1* | 59.95 |
| 5257 *2 MHz* | 6.75 |
| 5257A *4 MHz* | 7.25 |
| MK4118 | 18.95 |

**SUPPORT DEVICES**

| | |
|---|---|
| 8212 | 3.25 |
| 8214 | 4.65 |
| 8216 | 2.95 |
| 8224 | 3.25 |
| 8224-4 | 5.75 |
| 8226 | 3.85 |
| 8228 | 4.95 |
| 8238 | 4.95 |
| 8243 | 8.00 |
| 8250 | 14.95 |
| 8251 | 6.50 |
| 8253 | 17.95 |
| 8255 | 6.50 |
| 8257 | 19.95 |
| 8259 | 17.95 |
| 8275 | 49.95 |
| 8279 | 15.95 |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## 7400

| | | | | | |
|---|---|---|---|---|---|
| SN7400N | .25 | SN7472N | .29 | SN74156N | .79 |
| SN7401N | .20 | SN7473N | .35 | SN74157N | .69 |
| SN7402N | .25 | SN7474N | .35 | SN74160N | .89 |
| SN7403N | .25 | SN7475N | .49 | SN74161N | .89 |
| SN7404N | .25 | SN7476N | .35 | SN74162N | .89 |
| SN7405N | .29 | SN7479N | 5.00 | SN74163N | .89 |
| SN7406N | .35 | SN7480N | .50 | SN74164N | .89 |
| SN7407N | .35 | SN7482N | .99 | SN74165N | .89 |
| SN7408N | .29 | SN7483N | .69 | SN74166N | 1.25 |
| SN7409N | .29 | SN7485N | .89 | SN74167N | 2.79 |
| SN7410N | .25 | SN7486N | .35 | SN74170N | 1.95 |
| SN7411N | .29 | SN7489N | 1.75 | SN74172N | 4.95 |
| SN7412N | .35 | SN7490N | .49 | SN74173N | 1.39 |
| SN7413N | .40 | SN7491N | .59 | SN74174N | .99 |
| SN7414N | .69 | SN7492N | .45 | SN74175N | .89 |
| SN7416N | .29 | SN7493N | .45 | SN74176N | .79 |
| SN7417N | .29 | SN7494N | .69 | SN74177N | .79 |
| SN7420N | .25 | SN7495N | .69 | SN74179N | 1.49 |
| SN7421N | .29 | SN7496N | .69 | SN74180N | .79 |
| SN7422N | .45 | SN7497N | 3.00 | SN74181N | 2.25 |
| SN7423N | .29 | SN74100N | 1.49 | SN74182N | .79 |
| SN7425N | .29 | SN74107N | .35 | SN74184N | 2.49 |
| SN7426N | .29 | SN74109N | .39 | SN74185N | 2.49 |
| SN7427N | .25 | SN74116N | 1.95 | SN74190N | 1.25 |
| SN7428N | .49 | SN74121N | .39 | SN74191N | 1.25 |
| SN7430N | .25 | SN74122N | .55 | SN74192N | .89 |
| SN7432N | .29 | SN74123N | .59 | SN74193N | .89 |
| SN7437N | .25 | SN74125N | .49 | SN74194N | .89 |
| SN7438N | .40 | SN74126N | .49 | SN74195N | .69 |
| SN7439N | .25 | SN74132N | .75 | SN74196N | .89 |
| SN7440N | .20 | SN74136N | .75 | SN74197N | .89 |
| SN7441N | .89 | SN74141N | .99 | SN74198N | 1.49 |
| SN7442N | .59 | SN74142N | 3.25 | SN74199N | 1.49 |
| SN7443N | 1.10 | SN74143N | 3.49 | SN74221N | 1.25 |
| SN7444N | 1.10 | SN74144N | 3.49 | SN74251N | .99 |
| SN7445N | .89 | SN74145N | .79 | SN74276N | 1.95 |
| SN7446N | .79 | SN74147N | 1.95 | SN74279N | .79 |
| SN7447N | .69 | SN74148N | 1.29 | SN74283N | 1.49 |
| SN7448N | .79 | SN74150N | 1.25 | SN74284N | 3.95 |
| SN7450N | .20 | SN74151N | .69 | SN74285N | 3.95 |
| SN7451N | .20 | SN74152N | .69 | SN74365N | .69 |
| SN7453N | .20 | SN74153N | .79 | SN74366N | .69 |
| SN7454N | .20 | SN74154N | 1.25 | SN74367N | .69 |
| SN7459A | .25 | SN74155N | .79 | SN74368N | .69 |
| SN7460N | .20 | | | SN74390N | 1.49 |
| SN7470N | .29 | | | SN74393N | 1.49 |

## 74LS

| | | | | | |
|---|---|---|---|---|---|
| 74LS00 | .29 | 74LS92 | .75 | 74LS192 | 1.15 |
| 74LS01 | .29 | 74LS93 | .75 | 74LS193 | 1.15 |
| 74LS02 | .29 | 74LS95 | .99 | 74LS194 | 1.15 |
| 74LS03 | .29 | 74LS96 | 1.15 | 74LS195 | 1.15 |
| 74LS04 | .35 | 74LS107 | .45 | 74LS197 | 1.19 |
| 74LS05 | .35 | 74LS109 | .45 | 74LS221 | 1.19 |
| 74LS08 | .29 | 74LS112 | .45 | 74LS240 | 1.95 |
| 74LS09 | .35 | 74LS113 | .49 | 74LS241 | 1.95 |
| 74LS10 | .29 | 74LS114 | .49 | 74LS242 | 1.95 |
| 74LS11 | .75 | 74LS122 | .89 | 74LS243 | 1.95 |
| 74LS12 | .35 | 74LS123 | 1.25 | 74LS244 | 1.95 |
| 74LS13 | .59 | 74LS125 | .89 | 74LS245 | 2.95 |
| 74LS14 | .99 | 74LS126 | .89 | 74LS247 | 1.19 |
| 74LS15 | .35 | 74LS132 | .99 | 74LS248 | 1.19 |
| 74LS20 | .29 | 74LS133 | .89 | 74LS249 | 1.19 |
| 74LS21 | .35 | 74LS136 | .49 | 74LS251 | 1.49 |
| 74LS22 | .35 | 74LS138 | .89 | 74LS253 | .99 |
| 74LS26 | .35 | 74LS139 | .89 | 74LS257 | .89 |
| 74LS27 | .35 | 74LS151 | .89 | 74LS258 | .99 |
| 74LS28 | .35 | 74LS153 | .89 | 74LS260 | .69 |
| 74LS30 | .29 | 74LS154 | 1.75 | 74LS266 | .69 |
| 74LS32 | .35 | 74LS155 | 1.19 | 74LS273 | 1.95 |
| 74LS33 | .59 | 74LS156 | 1.19 | 74LS279 | .75 |
| 74LS37 | .45 | 74LS157 | .89 | 74LS283 | 1.09 |
| 74LS38 | .49 | 74LS158 | .99 | 74LS290 | .99 |
| 74LS40 | .35 | 74LS160 | 1.15 | 74LS293 | .99 |
| 74LS42 | .89 | 74LS161 | 1.15 | 74LS298 | 1.25 |
| 74LS47 | .89 | 74LS162 | 1.15 | 74LS352 | 1.29 |
| 74LS48 | 1.15 | 74LS163 | 1.15 | 74LS353 | 1.29 |
| 74LS49 | 1.15 | 74LS164 | 1.25 | 74LS365 | .75 |
| 74LS51 | .29 | 74LS165 | 1.25 | 74LS366 | .75 |
| 74LS54 | .29 | 74LS168 | 1.19 | 74LS367 | .75 |
| 74LS55 | .29 | 74LS169 | 1.19 | 74LS368 | .75 |
| 74LS73 | .45 | 74LS170 | 2.49 | 74LS373 | 1.95 |
| 74LS74 | .45 | 74LS173 | 1.39 | 74LS374 | 1.95 |
| 74LS75 | .59 | 74LS174 | .99 | 74LS375 | 1.89 |
| 74LS76 | .45 | 74LS175 | .99 | 74LS386 | .69 |
| 74LS78 | .59 | 74LS181 | 2.95 | 74LS393 | 2.49 |
| 74LS83 | .89 | 74LS190 | 1.25 | 74LS399 | 2.49 |
| 74LS85 | 1.25 | 74LS191 | 1.25 | 74LS670 | 2.49 |
| 74LS86 | .45 | | | 81LS95 | 1.95 |
| 74LS90 | .59 | | | 81LS97 | 1.95 |

## 74S

| | | | | | |
|---|---|---|---|---|---|
| 74S00 | .50 | 74S133 | .55 | 74S244 | 3.25 |
| 74S02 | .50 | 74S134 | .69 | 74S251 | 1.45 |
| 74S03 | .50 | 74S135 | 1.19 | 74S253 | 1.45 |
| 74S04 | .55 | 74S136 | 1.75 | 74S257 | 1.35 |
| 74S05 | .55 | 74S138 | 1.35 | 74S258 | 1.35 |
| 74S08 | .50 | 74S139 | 1.35 | 74S260 | .79 |
| 74S09 | .50 | 74S140 | 1.35 | 74S280 | 2.95 |
| 74S10 | .50 | 74S151 | 1.35 | 74S287* | 4.95 |
| 74S11 | .50 | 74S153 | 1.35 | 74S288* | 4.95 |
| 74S15 | .50 | 74S157 | 1.35 | 74S373 | 3.49 |
| 74S20 | .50 | 74S158 | 1.35 | 74S374 | 3.49 |
| 74S22 | .55 | 74S174 | 1.59 | 74S387* | 5.95 |
| 74S30 | .50 | 74S175 | 1.59 | 74S471* | 19.95 |
| 74S32 | .55 | 74S188 | 4.95 | 74S472* | 19.95 |
| 74S40 | .55 | 74S194 | 1.95 | 74S473* | 19.95 |
| 74S51 | .50 | 74S195 | 1.95 | 74S474* | 21.95 |
| 74S64 | .50 | 74S196 | 3.95 | 74S475* | 21.95 |
| 74S65 | .50 | 74S240 | 2.95 | 74S570* | 7.95 |
| 74S74 | .79 | 74S241 | 2.95 | 74S571* | 7.95 |
| 74S86 | .79 | 74S242 | 3.25 | 74S572* | 19.95 |
| 74S112 | .79 | 74S243 | 3.25 | 74S573* | 19.95 |
| 74S113 | .79 | | | 74S940 | 3.15 |
| 74S114 | .79 | | | 74S941 | 3.15 |

* LIMITED AVAILABILITY ON THESE PROMS

## CA–LINEAR

| | | | | | |
|---|---|---|---|---|---|
| CA3013H | 2.15 | CA3081N | 2.00 | CA3089N | 3.75 |
| CA3023H | 3.25 | CA3082N | 2.00 | CA3096N | 3.95 |
| CA3039H | 1.35 | CA3083N | 1.60 | CA3130H | 1.39 |
| CA3046N | 1.30 | CA3086N | .85 | CA3140H | 1.25 |
| CA3059N | 3.25 | | | CA3160H | 1.25 |
| CA3060N | 3.25 | | | CA3401N | .59 |
| CA3080H | 1.25 | | | CA3600N | 3.50 |

## CD–CMOS

| | | | | | |
|---|---|---|---|---|---|
| CD4000 | .39 | CD4041 | 1.49 | CD4082 | .39 |
| CD4001 | .39 | CD4042 | .99 | CD4093 | .99 |
| CD4002 | .39 | CD4043 | .89 | CD4098 | 2.49 |
| CD4006 | 1.19 | CD4044 | .89 | CD4506 | .75 |
| CD4007 | .25 | CD4046 | 1.79 | CD4507 | .99 |
| CD4009 | .49 | CD4047 | 2.50 | CD4508 | 3.95 |
| CD4010 | .49 | CD4048 | 1.35 | CD4510 | 1.39 |
| CD4011 | .39 | CD4049 | .49 | CD4511 | 1.29 |
| CD4012 | .25 | CD4050 | .69 | CD4514 | 3.95 |
| CD4013 | .49 | CD4051 | 1.19 | CD4515 | 2.95 |
| CD4014 | 1.39 | CD4052 | 1.19 | CD4516 | 1.49 |
| CD4015 | 1.19 | CD4053 | 1.19 | CD4518 | 1.79 |
| CD4016 | .59 | CD4056 | 2.95 | CD4519 | .89 |
| CD4017 | 1.19 | CD4059 | 9.95 | CD4520 | 1.29 |
| CD4018 | .99 | CD4060 | 1.49 | CD4526 | 1.79 |
| CD4019 | .49 | CD4066 | .79 | CD4528 | 1.79 |
| CD4020 | 1.19 | CD4068 | .39 | CD4529 | 1.95 |
| CD4021 | 1.39 | CD4069 | .45 | CD4543 | 2.79 |
| CD4022 | 1.19 | CD4070 | .55 | CD4562 | 11.95 |
| CD4023 | .29 | CD4071 | .49 | CD4566 | 2.79 |
| CD4024 | .79 | CD4072 | .49 | CD4583 | 2.49 |
| CD4025 | .23 | CD4073 | .39 | CD4723 | 1.95 |
| CD4026 | 2.95 | CD4075 | .39 | CD4724 | 1.95 |
| CD4027 | .69 | CD4076 | 1.39 | MC14409 | 14.95 |
| CD4028 | .89 | CD4078 | .55 | MC14410 | 14.95 |
| CD4029 | 1.49 | CD4081 | .39 | MC14411 | 14.95 |
| CD4030 | .49 | | | MC14412 | 11.95 |
| CD4035 | .99 | | | MC14419 | 4.95 |
| CD4040 | 1.49 | | | MC14433 | 13.95 |

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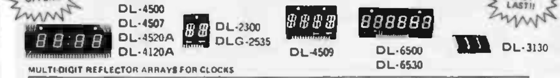


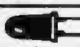

MULTI-DIGIT REFLECTOR ARRAYS FOR CLOCKS

| PART NUMBER | CHAR HT. (IN.) | POLARITY | DESCRIPTION | LIGHT OUTPUT (MCD) TYP | MIN | @mA | FORWARD VOLTAGE SEGMENT (V) $I_F$ = 20mA TYP | MAX | CONTINUOUS FORWARD CURRENT PER SEGMENT (mA) MAX | PRICE |
|---|---|---|---|---|---|---|---|---|---|---|
| DL-4500 (Red) DL-4507 (Red) | | C.C. MPX | | .5 | .5 / 1.0 | | | | | 2.49 / 2.49 |
| DLG-4507 (orng) DLG-4507 (grn) DL-4520A (red) | .50 | C.C. nonMPX | 4 Digit 7 Segment With Colon And Auxiliary Indicators | .5 | .5 | 10 | 1.7 | 2.0 | 30 | 4.99 / 4.99 / 2.49 |
| DL-4120A (red) | 1.0 | C.C. nonMPX | | 1.5 | .8 | | 3.4 | 4.0 | | 4.99 |

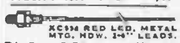
MULTI-DIGIT REFLECTOR ARRAYS

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| DL-2300 (Red) | .30 | C.C. MPX | 7 Seg. 2 Digit D.P. Right | 2.5 | 1.1 | 20 | 1.7 | 2.0 | 30 | .99 |
| DLG-2535 (green) | .50 | C.A. MPX | 8 Seg. 2 Digit | | 2.8 | 20 | | 3.5 | 25 | 1.49 |
| DL-4509 (Red) | .50 | C.C. MPX | 8 Seg. 4 Digit D.P. Right | .8 | .5 | 10 | 1.7 | 2.0 | 30 | 2.49 |
| DL-6500 (Red) | .50 | C.C. MPX | 7 Seg. 6 Digit D.P. Right | .8 | .5 | 10 | 1.7 | 2.0 | 30 | 2.99 |
| DL-6530 (Red) | .50 | C.A. MPX | 7 Seg. 6 Digit D.P. Right | .8 | .5 | 10 | 1.7 | 2.0 | 30 | 2.99 |
| DL-3130 (Red) | 1.0 | C.A. MPX | 7 Seg. 3 Digit D.P. Right | 1.5 | 1.0 | 10 | 3.4 | 4.0 | 30 | 3.99 |

## DISCRETE LEDS

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| XC556R | .200" | red | 5/$1 | MV50 | .085" | red | 6/$1 | XC111R | .190" | red | 5/$1 |
| XC556G | .200" | green | 4/$1 | XC209R | .125" | red | 5/$1 | XC111G | .190" | green | 4/$1 |
| XC556Y | .200" | yellow | 4/$1 | XC209G | .125" | green | 4/$1 | XC111Y | .190" | yellow | 4/$1 |
| XC556C | .200" | clear | 4/$1 | XC209Y | .125" | yellow | 4/$1 | XC111C | .190" | clear | 4/$1 |
| XC22R | .200" | red | 5/$1 | XC526R | .185" | red | 5/$1 | | | | |
| XC22G | .200" | green | 4/$1 | XC526G | .185" | green | 4/$1 | | | | |
| XC22Y | .200" | yellow | 4/$1 | XC526Y | .185" | yellow | 4/$1 | | | | |
| MV10B | .170" | red | 4/$1 | XC526C | .185" | clear | 4/$1 | | | | |



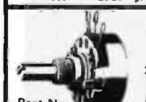
XC556 RED LED, METAL MTG. HDW. 24" LEADS.
RL-2 . . $.39 ea. or 3/$1.00

## DISPLAY LEDS

C.A. — Common Anode    C.C. — Common Cathode

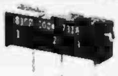
| Type | Polarity | Ht | Price | Type | Polarity | Ht | Price |
|---|---|---|---|---|---|---|---|
| MAN 1 | C.A.—red | .270 | 2.95 | DLG507 | C.A.—green | .500 | 1.25 |
| MAN 2 | 5x7 D.M.—red | .300 | 4.95 | DL704 | C.C.—red | .300 | 1.25 |
| MAN 3 | C.C.—red | .125 | .25 | DL707 | C.A.—red | .300 | 1.25 |
| MAN 52 | C.A.—green | .300 | 1.25 | DL728 | C.C.—red | .500 | 1.49 |
| MAN 54 | C.C.—green | .300 | 1.25 | DL741 | C.A.—red | .600 | 1.25 |
| MAN 71 | C.A.—red | .300 | .75 | DL746 | C.A.—red ± 1 | .630 | 1.49 |
| MAN 72 | C.A.—red | .300 | .75 | DL747 | C.A.—red | .600 | 1.49 |
| MAN 74 | C.C.—red | .300 | 1.25 | DL750 | C.C.—red | .600 | 1.49 |
| MAN 82 | C.A.—yellow | .300 | .49 | DL0847 | C.A.—orange | .800 | 1.49 |
| MAN 84 | C.C.—yellow | .300 | .99 | DL0850 | C.C.—orange | .800 | 1.40 |
| MAN 3620 | C.A.—orange | .300 | .49 | DL33B | C.C.—red | .110 | .35 |
| MAN 3630 | C.A.—orange ± 1 | .300 | .99 | FND358 | C.C. ± 1 | .357 | .99 |
| MAN 3640 | C.C.—orange | .300 | .99 | FND359 | C.C. | .357 | .75 |
| MAN 4610 | C.A.—orange | .400 | .99 | FND503 | C.C. (FND500) | .500 | .99 |
| MAN 6610 | C.A.—orange—DD | .560 | .99 | FND507 | C.A. (FND510) | .500 | .99 |
| MAN 6630 | C.A.—orange ± 1 | .560 | .99 | HDSP-3401 | C.A.—red | .800 | 1.50 |
| MAN 6640 | C.C.—orange—DD | .560 | .99 | HDSP-3403 | C.C.—red | .800 | 1.50 |
| MAN 6650 | C.C.—orange ± 1 | .560 | .99 | 5082-7751 | C.A., R.H.D.—red | .430 | 1.25 |
| MAN 6660 | C.A.—orange | .560 | .99 | 5082-7760 | C.C., R.H.D.—red | .430 | 1.75 |
| MAN 6710 | C.A.—red—DD | .560 | .99 | 5082-7300 | 4x7 sgl. dig. RHD | .600 | 22.00 |
| MAN 6750 | C.C.—red ± 1 | .560 | .99 | 5082-7302 | 4x7 sgl. dig. LHD | .600 | 22.00 |
| MAN 6780 | C.C.—red | .560 | .99 | 5082-7304 | Overnge. char. (±1) | .600 | 19.95 |
| DL0304 | C.C.—orange | .300 | 1.25 | 4N28 | Photo Xsistor Opto-Isol. | | .99 |
| DL0307 | C.A.—orange | .300 | 1.25 | LIT-1 | Photo Xsistor Opto-Isol. | | .69 |
| DLG500 | C.C.—green | .500 | 1.25 | MOC3010 | Optically Isol. Triac Driver | | 1.25 |

## POTENTIOMETERS



**$2.95 each**
2 Watt @ 70°C ± 10%
7/8" Slotted Shaft
Linear Taper
Meets Mil-R-94

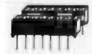
| Part No. | | |
|---|---|---|
| CMU 1021 | RV4NAY SD - 102A | 1K |
| CMU 5021 | RV4NAY SD - 502A | 5K |
| CMU 1031 | RV4NAY SD - 103A | 10K |
| CMU 2531 | RV4NAY SD - 253A | 25K |
| CMU 5031 | RV4NAY SD - 503A | 50K |
| CMU 1041 | RV4NAY SD - 104A | 100K |
| CMU 1052 | RV4NAY SD - 105A | 1Meg |



**$1.35 each**
3/4 Watt @ 70°C
15 turn pot. Linear taper. Printed circuit mount.

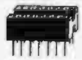
| Part No. | Part No. | Part No. |
|---|---|---|
| 830P-50ohm | 830P-5K | 830P-100K |
| 830P-100ohm | 830P-10K | 830P-200K |
| 830P-500ohm | 830P-20K | 830P-500K |
| 830P-1K | 830P-50K | 830P-1Meg |
| 830P-2K | | |

## LOW PROFILE (TIN) SOCKETS



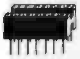
| | 1-24 | 25-49 | 50-100 |
|---|---|---|---|
| 8 pin LP | .17 | .16 | .15 |
| 14 pin LP | .20 | .19 | .18 |
| 16 pin LP | .22 | .21 | .20 |
| 18 pin LP | .29 | .28 | .27 |
| 20 pin LP | .34 | .32 | .30 |
| 22 pin LP | .37 | .36 | .35 |
| 24 pin LP | .38 | .37 | .36 |
| 28 pin LP | .45 | .44 | .43 |
| 36 pin LP | .60 | .59 | .58 |
| 40 pin LP | .63 | .62 | .61 |

## SOLDERTAIL STANDARD (TIN)



| | 1-24 | 25-49 | 50-100 |
|---|---|---|---|
| 14 pin ST | .27 | .25 | .24 |
| 16 pin ST | .30 | .27 | .25 |
| 18 pin ST | .35 | .32 | .30 |
| 24 pin ST | .49 | .45 | .42 |
| 28 pin ST | .99 | .90 | .81 |
| 36 pin ST | 1.39 | 1.26 | 1.15 |
| 40 pin ST | 1.59 | 1.45 | 1.30 |

## SOLDERTAIL (GOLD) STANDARD



| | 1-24 | 25-49 | 50-100 |
|---|---|---|---|
| 8 pin SG | .39 | .35 | .31 |
| 14 pin SG | .49 | .45 | .41 |
| 16 pin SG | .54 | .49 | .44 |
| 18 pin SG | .59 | .53 | .48 |
| 24 pin SG | .79 | .75 | .69 |
| 28 pin SG | 1.10 | 1.00 | .90 |
| 36 pin SG | 1.65 | 1.40 | 1.26 |
| 40 pin SG | 1.75 | 1.59 | 1.45 |

## WIRE WRAP SOCKETS (GOLD) LEVEL #3

| | 1-24 | 25-49 | 50-100 |
|---|---|---|---|
| 8 pin WW | .59 | .54 | .49 |
| 10 pin WW | .69 | .63 | .58 |
| 14 pin WW | .79 | .73 | .67 |
| 16 pin WW | .85 | .77 | .70 |
| 18 pin WW | .99 | .90 | .81 |
| 20 pin WW | 1.19 | 1.08 | .99 |
| 22 pin WW | 1.49 | 1.35 | 1.23 |
| 24 pin WW | 1.39 | 1.26 | 1.14 |
| 28 pin WW | 1.69 | 1.53 | 1.38 |
| 36 pin WW | 2.19 | 1.99 | 1.79 |
| 40 pin WW | 2.29 | 2.09 | 1.89 |

## 1/4 WATT RESISTOR ASSORTMENTS – 5%

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| ASST. 1 | 5ea. | 10 Ohm 27 Ohm | 12 Ohm 33 Ohm | 15 Ohm 39 Ohm | 18 Ohm 47 Ohm | 22 Ohm 56 Ohm | 50pcs. | $1.95 |
| ASST. 2 | 5ea. | 68 Ohm 180 Ohm | 82 Ohm 220 Ohm | 100 Ohm 270 Ohm | 120 Ohm 330 Ohm | 150 Ohm 390 Ohm | 50pcs. | $1.95 |
| ASST. 3 | 5ea. | 470 Ohm 1.2K | 560 Ohm 1.5K | 680 Ohm 1.8K | 820 Ohm 2.2K | 1K 2.7K | 50pcs. | $1.95 |
| ASST. 4 | 5ea. | 3.3K 8.2K | 3.9K 10K | 4.7K 12K | 5.6K 15K | 6.8K 18K | 50pcs. | $1.95 |
| ASST. 5 | 5ea. | 22K 56K | 27K 68K | 33K 82K | 39K 100K | 47K 120K | 50pcs. | $1.95 |
| ASST. 6 | 5ea. | 150K 390K | 180K 470K | 220K 560K | 270K 680K | 330K 820K | 50pcs. | $1.95 |
| ASST. 7 | 5ea. | 1M 2.7M | 1.2M 3.3M | 1.5M 3.9M | 1.8M 4.7M | 2.2M 5.6M | 50pcs. | $1.95 |

ASST. 8R Includes Resistor Assts. 1-7 (350 pcs.) $10.95 ea.

$10.00 Min. Order — U.S. Funds Only
Calif. Residents Add 6% Sales Tax
Postage — Add 5% plus $1 Insurance

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1355 SHOREWAY ROAD, BELMONT, CA 94002
PRICES SUBJECT TO CHANGE

4/81

## INTERSIL

| Part No. | Function | Price |
|---|---|---|
| 7045IPI | CMOS Precision Timer | 14.95 |
| 7045EV/Kit* | Stopwatch Chip, XTL | 22.95 |
| 7106CPL | 3½ Digit A/D (LCD Drive) | 16.95 |
| 7106EV/Kit* | IC, Circuit Board, Display | 34.95 |
| 7107CPL | 3½ Digit A/D (LED Drive) | 15.95 |
| 7107EV/Kit* | IC, Circuit Board, Display | 28.95 |
| 7116CPL | 3½ Digit A/D LCD Dis. HLD. | 18.95 |
| 7117CPL | 3½ Digit A/D LED Dis. HLD. | 17.95 |
| 72011DR | Low Battery Volt Indicator | 2.25 |
| 72051PG | CMOS LED Stopwatch/Timer | 12.95 |
| 7205EV/Kit* | Stopwatch Chip, XTL | 19.95 |
| 7206CJPE | Tone Generator | 5.15 |
| 7206CEV/Kit* | Tone Generator Chip, XTL | 9.95 |
| 7207AIPD | Oscillator Controller | 6.50 |
| 7207AEV/Kit* | Freq. Counter Chip, XTL | 11.10 |
| 7208IPI | Seven Decade Counter | 17.95 |
| 7209IPA | Clock Generator | 3.95 |
| 7215IPG | 4 Func. CMOS Stopwatch CKT | 13.95 |
| 7215EV/Kit* | 4 Func. Stopwatch Chip, XTL | 19.95 |
| 7216AIJI | 8-Digit Univ. Counter C.A. | 32.00 |
| 7216CIJI | 8-Digit Freq. Counter C.A. | 26.95 |
| 7216DIPI | 8-Digit Freq. Counter C.C. | 21.95 |
| 7217IJI | 4-Digit LED Up/Down Counter | 12.95 |
| 7218CIJI | 8-Digit Univ. LED Drive | 10.95 |
| 7224IPL | LCD 4½ Digit Up Counter DRI | 11.25 |
| 7226AIJL | 8-Digit Univ. Counter | 31.95 |
| 7226AEV/Kit* | 5 Function Counter Chip, XTL | 74.95 |
| 72401JE | CMOS Bin Prog. Timer/Counter | 4.95 |
| 7242IJA | CMOS Divide-by-256 RC Timer | 2.05 |
| 72501JE | CMOS BCD Prog. Timer/Counter | 6.00 |
| 72601JE | CMOS BCD Prog. Timer/Counter | 5.25 |
| 75551PA | CMOS 555 Timer (8 pin) | 1.45 |
| 75561PD | CMOS 556 Timer (14 pin) | 2.20 |
| 7611BCPA | CMOS Op Amp Comparator 5MV | 2.25 |
| 7612BCPA | CMOS Op Amp Ext. Cmvr. 5MV | 2.95 |
| 7621BCPA | CMOS Dual Op Amp Comp. 5MV | 3.95 |
| 7631CCPE | CMOS Tri Op Amp Comp. 10MV | 5.35 |
| 7641CCPD | CMOS Quad Op Amp Comp. 10MV | 7.50 |
| 7642CCPD | CMOS Quad Op Amp Comp. 10MV | 7.50 |
| 7660CPA | Voltage Converter | 2.95 |
| 8069CCQ | 50ppm Band—GAP Volt Ref. Diode | 2.50 |
| 8211CPA | Volt Ref/Indicator | 2.50 |
| 8212CPA | Volt Ref/Indicator | 2.50 |

* INTERSIL'S EVALUATION KITS

## 74C

| | | | | | |
|---|---|---|---|---|---|
| 74C00 | .39 | 74C106 | .75 | 74C195 | 1.59 |
| 74C02 | .39 | 74C107 | 1.89 | 74C221 | 1.95 |
| 74C04 | .39 | 74C151 | 2.95 | 74C240 | 2.25 |
| 74C08 | .39 | 74C154 | 3.95 | 74C244 | 2.25 |
| 74C10 | .39 | 74C157 | 2.25 | 74C373 | 2.49 |
| 74C14 | .75 | 74C160 | 1.69 | 74C374 | 2.59 |
| 74C20 | .39 | 74C161 | 1.60 | 74C901 | .89 |
| 74C30 | .39 | 74C162 | 1.49 | 74C903 | 1.15 |
| 74C42 | 1.39 | 74C163 | 1.69 | 74C911 | 10.95 |
| 74C48 | 1.95 | 74C164 | 1.59 | 74C912 | 10.95 |
| 74C73 | .79 | 74C173 | 1.39 | 74C915 | 1.69 |
| 74C74 | .79 | 74C174 | 1.39 | 74C917 | 10.95 |
| 74C85 | 1.95 | 74C175 | 1.39 | 74C922 | 5.49 |
| 74C86 | .99 | 74C192 | 1.69 | 74C923 | 5.75 |
| 74C89 | 6.95 | 74C193 | 1.69 | 74C925 | 7.50 |
| 74C90 | 1.29 | | | 74C926 | 7.50 |
| 74C93 | 1.29 | | | 80C95 | .79 |
| 74C95 | 1.59 | | | 80C97 | .79 |

## LINEAR

| | | | | | |
|---|---|---|---|---|---|
| LH0002CN | 6.85 | LM340T-5 | 1.25 | NE570N | 4.95 |
| LM10CLH | 4.50 | LM340T-12 | 1.25 | LM702H | .79 |
| LM11CLH | 4.75 | LM340T-15 | 1.25 | LM703CN | .89 |
| LH0070-0H | 6.05 | LM341P-5 | .75 | LM709N | .29 |
| TL071CP | .79 | LM341P-12 | .75 | LM710N | .79 |
| TL072CP | 1.39 | LM341P-15 | .75 | LM711N | .79 |
| TL074CN | 2.49 | LM342P-5 | .69 | LM723N | .69 |
| LH0082CD | 35.80 | LM342P-12 | .69 | LM733N | 1.00 |
| TL082CP | 1.19 | LM342P-15 | .69 | LM739N | 1.19 |
| TL084CN | 2.19 | LM348N | 1.25 | LM741CN | .35 |
| LH0094CD | 36.80 | LM350K | 5.75 | MC1741SCG | 3.00 |
| LM300H | .99 | LF351N | .60 | LM747N | .79 |
| LM301CN | .35 | LF353N | 1.00 | LM748N | .59 |
| LM302H | 1.95 | LF355N | 1.10 | LM1014N | 2.75 |
| LM304H | 1.95 | LF356N | 1.10 | LM1310N | 1.95 |
| LM305H | .99 | LM358N | 1.00 | LM1458CN | .59 |
| LM307CN | .45 | LM359N | 1.79 | LM1488N | 1.25 |
| LM308CN | 1.00 | LM370N | 4.49 | LM1489N | 1.25 |
| LM309H | 1.95 | LM373N | 3.25 | LM1496N | 1.95 |
| LM309K | 1.25 | LM377N | 2.95 | LM1556V | 1.75 |
| LM310CN | 1.75 | LM380N | 1.25 | LM1800N | 2.95 |
| LM311H | .90 | LM381N | 1.95 | LM1877N-9 | 3.25 |
| LM312H | 2.49 | LM382N | 1.79 | LM1889N | 3.20 |
| LM317MP | 1.15 | LM384N | 1.95 | LM1896N | 1.75 |
| LM317T | 1.75 | LM386N-3 | 1.29 | LM2002T | 1.49 |
| LM317K | 3.95 | LM387N | 1.45 | LM2877P | 2.05 |
| LM318CN | 1.95 | LM389N | 1.35 | LM2878P | 2.25 |
| LM319N | 1.95 | LM392N | .69 | LM2896P-1 | 2.25 |
| LM320K-5 | 1.35 | LF398N | 4.00 | LM3189N | 2.95 |
| LM320K-12 | 1.35 | LM399H | 5.00 | LM3900N | .69 |
| LM320K-15 | 1.35 | TL494CN | 4.49 | LM3905CN | 1.25 |
| LM320T-5 | 1.25 | TL496CP | 1.75 | LM3909N | 1.15 |
| LM320T-12 | 1.25 | NE510A | 6.00 | LM3914N | 3.95 |
| LM320T-15 | 1.25 | NE529A | 4.95 | LM3915N | 3.95 |
| LM323K-5 | 5.95 | NE531H | 3.95 | LM3916N | 3.95 |
| LM324N | .99 | NE536H | 6.00 | RC4136N | 1.25 |
| LM329DZ | .65 | NE540H | 6.00 | RC4151NB | 3.95 |
| LM331N | 3.95 | NE544N | 4.95 | RC4194TK | 5.95 |
| LM334Z | 1.30 | NE550A | 1.30 | RC4195TK | 5.49 |
| LM335Z | 1.40 | NE555V | .39 | KB4428 | 4.25 |
| LM336Z | 1.75 | LM556N | .99 | KB4429 | 5.95 |
| LM337T | 1.95 | NE564N | 3.95 | LM4500A | 3.25 |
| LM337MP | 1.15 | LM565N | 1.25 | ICL8038B | 4.95 |
| LM338K | 6.95 | LM566CN | 1.95 | LM13080N | 1.29 |
| LM339N | .99 | LM567V | 1.25 | LM13600N | 1.49 |
| LM340K-5 | 1.35 | | | 75138N | 1.95 |
| LM340K-12 | 1.35 | | | 75450N | .89 |
| LM340K-15 | 1.35 | | | 75451CN | .39 |

## CAPACITOR CORNER

### 50 VOLT CERAMIC DISC CAPACITORS

| Value | 1-9 | 10-99 | 100+ | Value | 1-9 | 10-99 | 100+ |
|---|---|---|---|---|---|---|---|
| 10 pf | .08 | .06 | .05 | .001µF | .08 | .06 | .05 |
| 22 pf | .08 | .06 | .05 | .0047µF | .08 | .06 | .05 |
| 47 pf | .08 | .06 | .05 | .01µF | .08 | .06 | .05 |
| 100 pf | .08 | .06 | .05 | .022µF | .09 | .07 | .06 |
| 220 pf | .08 | .06 | .05 | .047µF | .09 | .07 | .06 |
| 470 pf | .08 | .06 | .05 | .1µF | .15 | .12 | .10 |

### 100 VOLT MYLAR FILM CAPACITORS

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| .001mf | .12 | .10 | .07 | .022mf | .13 | .11 | .08 |
| .0022mf | .12 | .10 | .07 | .047mf | .21 | .17 | .13 |
| .0047mf | .12 | .10 | .07 | .1mf | .27 | .23 | .17 |
| .01mf | .12 | .10 | .07 | .22mf | .33 | .27 | .22 |

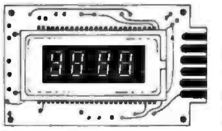
### +20% DIPPED TANTALUMS (Solid) CAPACITORS

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| .1/35V | .39 | .34 | .29 | 1.5/35V | .41 | .37 | .29 |
| .15/35V | .39 | .34 | .29 | 2.2/35V | .51 | .45 | .34 |
| .22/35V | .39 | .34 | .29 | 3.3/25V | .53 | .47 | .37 |
| .33/35V | .39 | .34 | .29 | 4.7/25V | .63 | .56 | .45 |
| .47/35V | .39 | .34 | .29 | 6.8/25V | .79 | .69 | .55 |
| .68/35V | .39 | .34 | .29 | 15/25V | 1.39 | 1.25 | .95 |
| 1.0/35V | .39 | .34 | .29 | 22/6V | .79 | .69 | .55 |

### MINI. ALUMINUM ELECTROLYTIC CAPACITORS

| Axial Lead | | | | Radial Lead | | | |
|---|---|---|---|---|---|---|---|
| .47/50V | .16 | .14 | .10 | .47/25V | .15 | .13 | .12 |
| 1.0/50V | .19 | .16 | .12 | .47/50V | .16 | .14 | .13 |
| 3.3/50V | .17 | .15 | .11 | 1.0/16V | .15 | .13 | .12 |
| 4.7/25V | .18 | .15 | .11 | 1.0/25V | .16 | .14 | .13 |
| 10/25V | .18 | .15 | .11 | 1.0/50V | .17 | .15 | .14 |
| 10/50V | .19 | .16 | .12 | 4.7/16V | .15 | .13 | .12 |
| 22/25V | .19 | .16 | .12 | 4.7/25V | .16 | .14 | .13 |
| 22/50V | .24 | .20 | .18 | 4.7/50V | .17 | .15 | .14 |
| 47/25V | .25 | .21 | .19 | 10/16V | .15 | .13 | .12 |
| 47/50V | .29 | .25 | .23 | 10/25V | .16 | .14 | .13 |
| 100/25V | .28 | .24 | .22 | 10/50V | .17 | .15 | .14 |
| 100/50V | .41 | .37 | .34 | 47/50V | .25 | .21 | .19 |
| 220/25V | .39 | .34 | .33 | 100/16V | .21 | .17 | .14 |
| 220/50V | .49 | .45 | .41 | 100/25V | .25 | .23 | .21 |
| 470/25V | .54 | .49 | .45 | 100/50V | .37 | .34 | .31 |
| 1000/16V | .79 | .69 | .61 | 220/16V | .25 | .21 | .19 |
| 2200/16V | .89 | .79 | .69 | 470/25V | .35 | .31 | .27 |

## National Semiconductor Clock Modules



12VDC AUTOMOTIVE/ INSTRUMENT CLOCK

APPLICATIONS:
- In-dash autoclocks
- After-market auto/ RV clocks
- Aircraft-marine clks.
- 12VDC oper. instru.
- Portable/battery powered instrumnts.

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

**MA1003 Module .............. $16.95**

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

National Semiconductor

## RAM SALE

**MM5290N-4** (MK4116/UPD416) . . **$4.95 each**
16K DYNAMIC RAM (250NS)
(8 EACH $39.95) (100 EACH $450.00/lot)

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16K DYNAMIC RAM (150NS)
(8 EACH $49.95) (100 EACH $550.00/lot)

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

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

**MM2114L-3** .............. **$6.25 each**
4K STATIC RAM (LOW POWER 300NS)
(8 EACH $44.95) (100 EACH $475.00/lot)

## EPROM Erasing Lamp

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

**UVS-11E ........... $79.95**

## Jumbo 6-Digit Clock Kit

- Four .630" ht. and two .300" ht. common anode displays
- Uses MM5314 clock chip
- Switches for hours, minutes and hold functions
- Hours easily viewable to 30 feet
- Simulated walnut case
- 115VAC operation
- 12 or 24 hour operation
- Includes all components, case and wall transformer
- Size: 6¾" x 3-1/8" x 1¾"

**JE747 ............. $29.95**

## 6-Digit Clock Kit

- Bright .300 ht. comm. cathode display
- Uses MM5314 clock chip
- Switches for hours, minutes and hold modes
- Hrs. easily viewable to 20 ft.
- Simulated walnut case
- 115 VAC operation
- 12 or 24 hr. operation
- Incl. all components, case & wall transformer
- Size: 6¾" x 3-1/8" x 1¾"

**JE701 ............... $19.95**

## NEW! JE215 Adjustable Dual Power Supply

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

FEATURES:
- Adjustable regulated power supplies, pos. and neg. 1.2VDC to 15VDC.
- Power Output (each supply): 5VDC @ 500mA, 10VDC @ 750mA, 12VDC @ 600mA, and 15VDC @ 175mA.
- Two, 3-terminal adj. IC regulators with thermal overload protection.
- Heat sink regulator cooling
- LED "on" indicator
- Printed Board Construction
- 120VAC input
- Size: 3-1/2" w x 5-1/16" L x 2" H

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

(Picture not shown but similar in construction to above)

| | | |
|---|---|---|
| JE200 | Reg. Power Supply Kit (5VDC, 1 amp) | $14.95 |
| JE205 | Adapter Brd. (to JE200) ±5, ±9 & ±12V. | $12.95 |
| JE210 | Var. Pwr. Sply. Kit, 5-15VDC, to 1.5amp. | $19.95 |

# MICROPROCESSOR COMPONENTS

### 8080A/8080A SUPPORT DEVICES

| | | |
|---|---|---|
| INS8080A | CPU | 6.50 |
| DP8212 | 8-Bit Input/Output | 3.25 |
| DP8214 | Priority Interrupt Control | 5.95 |
| DP8216 | Bi-Directional Bus Driver | 3.49 |
| DP8224 | Clock Generator/Driver | 3.95 |
| DP8226 | Bus Driver | 3.49 |
| DP8228 | System Controller/Bus Driver | 4.95 |
| DP8238 | System Controller | 5.95 |
| INS8243 | I/O Expander for 48 Series | 9.95 |
| INS8250 | Asynchronous Comm. Element | 16.95 |
| DP8251 | Prog. Comm. I/O (USART) | 7.95 |
| DP8253 | Prog. Interval Timer | 14.95 |
| DP8255 | Prog. Peripheral I/O (PPI) | 9.95 |
| DP8257 | Prog. DMA Control | 19.95 |
| DP8259 | Prog. Interrupt Control | 16.95 |
| DP8275 | Prog. CRT Controller | 49.95 |
| DP8279 | Prog. Keyboard/Display Interface | 19.95 |
| DP8300 | Octal Bus Receiver | 6.95 |
| DP8303 | System Timing Element | 6.95 |
| DP8304 | 8-Bit Bi-Directional Receiver | 3.95 |
| DP8307 | 8-Bit Bi-Directional Receiver | 3.95 |
| DP8308 | 8-Bit Bi-Directional Receiver | 3.95 |

### 6800/6800 SUPPORT DEVICES

| | | |
|---|---|---|
| MC6800 | MPU | 14.95 |
| MC6802CP | MPU with Clock and RAM | 19.95 |
| MC6810API | 128x8 Static RAM | 4.95 |
| MC6821 | Peripheral Inter. Adapt (MC6820) | 7.49 |
| MC6828 | Priority Interrupt Controller | 10.95 |
| MC6830L8 | 1024x8-Bit ROM (MC68A30-8) | 14.95 |
| MC6850 | Asynchronous Comm. Adapter | 6.95 |
| MC6852 | Synchronous Serial Data Adapter | 6.95 |
| MC6860 | 0-600bps Digital MODEM | 10.95 |
| MC6862 | 2400bps Modulator | 12.95 |
| MC6880A | Quad 3-State Bus. Trans. (MC8T26) | 2.25 |

### MICROPROCESSOR CHIPS

| | | |
|---|---|---|
| Z80 (780C) | CPU (MK3880N) (2MHz) | 13.95 |
| Z80A (780-1) | CPU (MK3880N-4) (4MHz) | 15.95 |
| CDP1802 | CPU | 19.95 |
| 2650 | MPU | 16.95 |
| IDM2901ADC | CPU—4-Bit Slice (Com. Temp. Grade) | 19.95 |
| MC56502 | MPU w/Clock (65K Bytes Memory) | 11.95 |
| INS8035N-6 | MPU—8-Bit (6MHz) | 16.95 |
| INS8039N-6 | CPU—Sgl. Chip 8-Bit (128bytes RAM) | 19.95 |
| INS8040N-6 | CPU (256 Bytes RAM) | 24.95 |
| INS8070N | CPU—64 Bytes RAM | 24.95 |
| INS8073N | CPU w/Basic Micro Interpreter | 29.95 |
| P8085 | CPU | 19.95 |
| INS8900 | CPU—16-Bit | 29.95 |
| TMS9900JL | MPU—16-Bit | 49.95 |

### SHIFT REGISTERS

| | | |
|---|---|---|
| MM500H | Dual 25-Bit Dynamic | .50 |
| MM503H | Dual 50-Bit Dynamic | .50 |
| MM506H | Dual 100-Bit Static | .50 |
| MM510H | Dual 64-Bit Accumulator | .50 |
| MM1402 | 256-Bit Dynamic | 1.95 |
| MM5013 | 1024-Bit Dynamic/Accumulator | 1.95 |
| MM5016H | 500/512-Bit Dynamic | .89 |
| MM5034N | Octal 80-Bit | 9.95 |
| MM5035N | Octal 80-Bit | 9.95 |
| 2504V(1404A) | 1024-Bit Dynamic | 3.95 |
| 2518N | Hex 32-Bit Static | 4.95 |
| 2522V | Dual 132-Bit Static | 2.95 |
| 2524V | 512-Bit Dynamic | .99 |
| 2525V | 1024-Bit Dynamic | 2.95 |
| 2527V | Dual 256-Bit Static | 2.95 |
| 2528V | Dual 250-Bit Static | 4.00 |
| 2529V | Dual 240-Bit Static | 4.00 |
| 2532N | Quad 80-Bit Static | 2.95 |
| 3341PC | Fifo (Dual 80) | 6.95 |

### DATA ACQUISITION

| | | |
|---|---|---|
| AF100-ICN | Universal Active Filter 2.5% | 5.95 |
| AF121-ICJ | Touch Tone Low Pass Filter | 19.95 |
| AF122-ICJ | Touch Tone Low Pass Filter | 19.95 |
| LM308AH | Super Gain Op Amp | 1.00 |
| LM334Z | Constant Current Source | 1.30 |
| LM335Z | Temperature Transducer | 1.40 |
| LF356N | JFET Input Op Amp | 1.10 |
| LF398N | Sample & Hold Amplifiers | 3.95 |
| LM399H | Temp. Comp. Prec. Ref. (.5ppm/C°) | 4.95 |
| ADC0804LCN | 8-Bit A/D Converter (1 LSB) | 4.95 |
| DAC0806LCN | 8-Bit D/A Converter (0.78% Lin.) | 2.25 |

### DATA ACQUISITION (CONTINUED)

| | | |
|---|---|---|
| ADC0809CCN | 8-Bit A/D Converter (8-Ch. Multi.) | 5.25 |
| ADC0817CCN | 8-Bit A/D Converter (16-Ch. Multi.) | 10.95 |
| DAC1000LCN | 10-Bit D/A Conv. Micro. Comp. (0.05%) | 13.95 |
| DAC1006LCN | 10-Bit D/A Conv. Micro. Comp. (0.20%) | 8.95 |
| DAC1020LCN | 10-Bit D/A Converter (0.05% Lin.) | 8.49 |
| DAC1022LCN | 10-Bit D/A Converter (0.20% Lin.) | 5.95 |
| DAC1222LCN | 12-Bit D/A Converter (0.20% Lin.) | 9.95 |
| CD4051N | 8-Channel Multiplexer | 1.19 |
| AY-5-1013 | 30K BAUD UART | 5.95 |

### RAM'S

| | | |
|---|---|---|
| 1101 | 256x1 Static | 1.49 |
| 1103 | 1024x1 Dynamic | .99 |
| 2101 (8101) | 256x4 Static | 3.95 |
| 2102 | 1024x1 Static | 1.75 |
| 21L02 | 1024x1 Static | 1.95 |
| 2111 (8111) | 256x4 Static | 3.95 |
| 2112 | 256x4 Static MOS | 4.95 |
| 2114 | 1024x4 Static 450ns | 5.95 |
| 2114L | 1024x4 Static 450ns Low Power | 6.95 |
| 2114-3 | 1024x4 Static 300ns | 7.49 |
| 2114L-3 | 1024x4 Static 300ns Low Power | 7.95 |
| 2117 | 16,384x1 Dynamic 550ns (housemarked) | 4.95 |
| 4116 (UPD416) | 16K Dynamic 250ns | 4.95 |
| MM2147J | 4096x1 Fast 70ns | 19.95 |
| 5101 | 256x4 Static | 7.95 |
| MM5261 | 1024x1 Dynamic Fully Decoded | .99 |
| MM5262 | 2Kx1 Dynamic | .25 |
| MM5280/2107 | 4096x1 Dynamic | 4.95 |
| MM5290J-2(4116) | 16K Dynamic 150ns (UPD416) | 6.95 |
| MM5298J-3A | 8K Dyn. 200ns (lower ½ of MM5290J) | 4.95 |
| 7489 | 16x4 Static | 1.75 |
| UPD414/MK4027 | 4K Dynamic 16-pin | 4.95 |
| TMS4044-45NL | 4K Static | 14.95 |
| TMS4045 | 1024x4 Static | 14.95 |

### PROMS/EPROMS

| | | |
|---|---|---|
| 1702A | 2K UV Erasable PROM | 5.95 |
| 2708 | 8K EPROM | 9.95 |
| TMS2716 | 16K EPROM (-5V, +5V, +12V) | 19.95 |
| 2716Intel(2516)TI | 16K EPROM (Single +5V) | 17.95 |
| 2732Intel(2532)TI | 32K EPROM | 49.95 |
| 2758 | 8K EPROM (450ns) (Single +5V) | 7.95 |
| 5203 | 2048 PROM | 14.95 |
| 82S23(74S188) | 32x8 PROM (Open Collector) | 4.95 |
| 82S115 | 4096 Bipolar PROM | 19.95 |
| 82S123(74S288) | 32x8 Tri-State Bipolar PROM | 4.95 |
| 82S185 | 8K PROM | 29.95 |

### ROM'S

| | | |
|---|---|---|
| 2513(2140) | Character Generator (Upper Case) | 9.95 |
| 2513(3021) | Character Generator (Lower Case) | 9.95 |
| 2516N | Character Generator | 10.95 |
| MM5230N | 2048-Bit Read Only Memory | 1.95 |

### NMOS READ ONLY MEMORIES

| | | |
|---|---|---|
| MCM66710P | 128x9x7 ASCII Shifted w/Greek | 13.50 |
| MCM66740P | 128x9x7 Main Symbol & Pictures | 13.50 |
| MCM66750P | 128x9x7 Alpha. Control Char. Gen. | 13.50 |

### MICROPROCESSOR MANUALS

| | | |
|---|---|---|
| M-Z80 | User Manual | 7.50 |
| M-COP1802 | User Manual | 7.50 |
| M-2650 | User Manual | 5.00 |

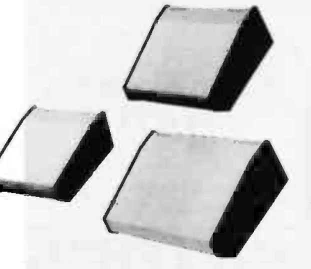
### SPECIAL FUNCTION

| | | |
|---|---|---|
| DS0025CN | Dual MOS Clock Driver (5MZ) | 3.50 |
| DS0026CN | Dual MOS Clock Driver (5MZ) | 1.95 |
| INS1771N-1 | Floppy Disc Controller | 24.95 |
| INS2651N | Communication Chip | 19.95 |
| MM58167N | Microprocessor Real Time Clock | 8.95 |
| MM58174N | Microprocessor Compatible Clock | 11.95 |
| COP402N | Microcontroller with 64-Digit RAM and Direct LED Drive | 6.95 |
| COP402MN | Microcontroller with 64-Digit RAM & Direct LED Drive w/N Buss Int. | 7.49 |
| COP470N | 32-Seg. VAC Fluor. Driver (20-pin pkg.) | 3.25 |

### TELEPHONE/KEYBOARD CHIPS

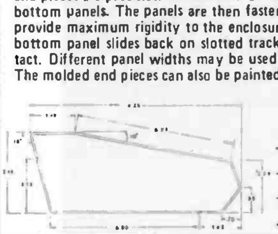
| | | |
|---|---|---|
| AY-5-9100 | Push Button Telephone Dialer | 14.95 |
| AY-5-9200 | Repertory Dialer | 14.95 |
| AY-5-9500 | CMOS Clock Generator | 4.95 |
| AY-5-2376 | Keyboard Encoder (88 keys) | 11.95 |
| HD0165-5 | Keyboard Encoder (16 keys) | 7.95 |
| 74C922 | Keyboard Encoder (16 keys) | 5.49 |
| 74C923 | Keyboard Encoder (20 keys) | 5.75 |
| MM53190N | Push Button Pulse Dialer | 7.95 |
| MM57499N | 96/144-Key Serial Keyboard Encoder | 8.95 |

## DESIGNERS' SERIES
## Blank Desk-Top Electronic Enclosures



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

CONSTRUCTION:
The "DTE" Blank Desk Top Electronic Enclosures are designed to blend and complement today's modern computer equipment and can be used in both industrial and home. The end pieces are precision molded with an internal slot (all around) to accept both top and bottom panels. The panels are then fastened to ¼" thick tabs inside the end pieces to provide maximum rigidity to the enclosure. For ease of equipment servicing, the rear/bottom panel slides back on slotted tracks while the rest of the enclosure remains intact. Different panel widths may be used while maintaining a common profile outline. The molded end pieces can also be painted to match any panel color scheme.



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

$10.00 Min. Order — U.S. Funds Only
Calif. Residents Add 6% Sales Tax
Postage — Add 5% plus $1 Insurance

Spec Sheets — 25¢
Send 41¢ Postage for your FREE 1981 JAMECO CATALOG

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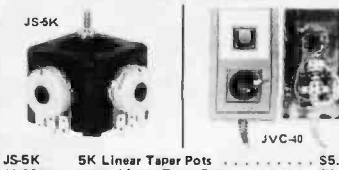
4/81

## JOYSTICKS




| | | |
|---|---|---|
| JS-5K | 5K Linear Taper Pots | $5.25 |
| JS-100K | 100K Linear Taper Pots | $4.95 |
| JVC-40 | 40K (2) Video Controller in case | $5.95 |

## AC and DC Wall Transformers

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

| Part No. | Input | Output | Price |
|---|---|---|---|
| AC 250 | 117V/60Hz | 12 VAC 250mA | $3.95 |
| AC 500 | 117V/60Hz | 12 VAC 500mA | $4.95 |
| AC1000 | 117V/60Hz | 12 VAC 1 amp | $5.95 |
| AC1700 | 117V/60Hz | 9 VAC 1.7 amp | $6.95 |
| DV 9200 | 117V/60Hz | 9 VDC 200mA | $3.25 |
| DC 900 | 120V/60Hz | 9 VDC 500mA | $3.95 |

## CONNECTORS

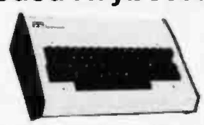
| | | |
|---|---|---|
| DB25P | D-Subminiature Plug | $2.95 |
| DB25S | D-Subminiature Socket | $3.50 |
| DB51226 | Cover for DB25P/S | $1.75 |
| 22/44SE | P.C. Edge (22/44 Pin) | $2.95 |
| UG88/U | BNC Plug | $1.79 |
| UG89/U | BNC Jack | $3.79 |
| UG175/U | UHF Adapter | $ .49 |
| SO239 | UHF Panel Recp. | $1.29 |
| PL258 | UHF Adapter | $1.60 |
| PL259 | UHF Plug | $1.60 |
| UG260/U | BNC Plug | $1.79 |
| UG1094/U | BNC Bulkhead Recp. | $1.29 |

## TRS-80 16K Conversion Kit

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

**TRS-16K2** *150NS ............ **$49.95**
**TRS-16K4** *250NS ............ **$39.95**

## JE610 ASCII Encoded Keyboard Kit



The JE610 ASCII Keyboard Kit can be interfaced into most any computer system. The kit comes complete with an industrial grade keyboard switch assembly (62-keys), IC's, sockets, connector, electronic components and a double-sided printed wiring board. The keyboard assembly requires +5V @ 150mA and −12V @ 10 mA for operation. Features: 60 keys generate the 126 characters, upper and lower case ASCII set. Fully buffered. Two user-define keys provided for custom applications. Caps lock for upper-case-only alpha characters. Utilizes a 2376 (40-pin) encoder read-only memory chip. Outputs directly compatible with TTL/DTL or MOS logic arrays. Easy interfacing with a 16-pin dip or 18-pin edge connector. Size: 3½"H x 14¾"W x 8¾"D

**JE610/DTE-AK** (as pictured above) . . . **$124.95**
**JE610 Kit** 62-Key Keyboard, PC Board, & Components (no case) . . . . **$ 79.95**
**K62** 62-Key Keyboard (Keyboard only) . . . **$ 34.95**
**DTE-AK** (case only — 3¼"Hx11"Wx8¾"D) **$ 49.95**

## JE600 Hexadecimal Encoder Kit

FULL 8-BIT LATCHED OUTPUT 19-KEY KEYBOARD

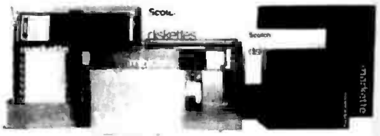
The JE600 Encoder Keyboard Kit provides two separate hexadecimal digits produced from sequential key entries to allow direct programming for 8-bit microprocessor or 8-bit memory circuits. Three additional keys are provided for user operations with one having a bistable output available. The outputs are latched and monitored with 9 LED readouts. Also included is a key entry strobe. Features: Full 8-bit latched output for microprocessor use. Three user-define keys with one being bistable operation. Debounce circuit provided for all 19 keys. 9 LED readouts to verify entries. Easy interfacing with standard 16-pin IC connector. Only +5VDC required for operation. Size: 3½"H x 8¾"W x 8¾"D

**JE600/DTE-HK** (as pictured above) . . . . **$99.95**
**JE600 Kit** 19-Key Hexadec. Keyboard, PC Board & Cmpnts. (no case) . . **$59.95**
**K19** 19-Key Keyboard (Keyboard only) . . . . **$14.95**
**DTE-HK** (case only — 3½"Hx8¼"Wx8¾"D) **$44.95**

Circle 352 on Inquiry card.

# California Digital

Post Office Box 3097 B • Torrance, California 90503




## DISKETTES

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

Private labeled for California Digital by one of the most respected producers of magnetic media. Each diskette is certified double density at 40 tracks. To insure extended media life each diskette is manufactured with a reinforced hub-hole. And of course, a plastic library case is included with every box of diskettes. MMD-CD5(01K10) Please specify computer or required sectors.

**$24.95 BOX**

Ten boxes $22.75 One hundred boxes $21.50

| MINIDISKETTES | Box | 10 boxes | | Box | 10 boxes |
|---|---|---|---|---|---|
| Memorex 3401 | $27.00 | $25.00 | Scotch 744(0K10K16) | $31.00 | $29.00 |
| Verbatim 525(01K10) | 29.00 | 27.00 | Dysan | 45.00 | 43.00 |

| EIGHT INCH | Scotch | box | 10 bx. | Dysan | box | 10 bx. | MRX | box | 10 bx. |
|---|---|---|---|---|---|---|---|---|---|
| Single side/single den. | 740-0 | $35. | $33. | 3740/1 | $49. | $47. | 3060 | $45. | $43. |
| Single side/double den. | 741-0 | 45. | 43. | 3740/1d | 75. | 73. | 3090 | 37. | 35. |
| Single side/32 sector | 740-32 | 35. | 33. | | na. | | | na. | |
| Double side/double D. | 743-0 | 65. | 59. | | na. | | 3115 | 49. | 45. |

SCOTCH brand head cleaning kit. $24.95 MMA-CK(5X8) please specify 5 1/4 8"
Prices available on request for: tape, cartridges, diskpacks, volume diskettes.

## MEMORY


**TRS-80 APPLE II $29**

**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.

| STATIC | 1-31 | 32-99 | 100-5C | -999 | 1K+ |
|---|---|---|---|---|---|
| 21L02 450nS. | 1.19 | .99 | | | |
| 21L02 250nS. | 1.49 | 1.39 | | * | * |
| 2114 1Kx4 450 | 5.95 | 5.50 | 5.25 | 4.75 | 4.50 |
| 2114 1Kx4 300 | 8.95 | 8.50 | 8.00 | * | * |
| 4044 4Kx1 450 | 5.95 | 5.50 | 5.25 | * | * |
| 4044 4Kx1 250 | 9.95 | 9.50 | 9.00 | * | * |
| 4045 1Kx4 450 | 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 |

## 2716 EPROM SALE $9.95

We have slashed price in an effort to reduce our over stocked inventory. These are single five volt EPROMs manufactured by one of the Worlds largest producers of semiconductors. All are first quality prime devices. Ceramic 450 nS.

## FREE

**Ultra-Violet Products UVS 11-E**

**UV EPROM ERASER**

With purchase of FORTY 2716 EPROM's

$79 value

## NEW from Shugart Technology 5 Megabyte Hard Disk Drive

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

The ST506 is factory sealed to protect the media from environmental contaminates. Requires only DC voltage.

Dual California Digital 5 1/4" enclosure. ST506 drive and power supply. **$1500**

Shugart Associates SA400 removable media disk drive for above package. add: **$300**
S-100 & Apple controller scheduled for spring release.

## Shugart Associates

**$395**

**801/ R Disk Drive 15 lbs.**

Shugart 801/R with CP 206 power supply. muffin exhaust fan. complete in dual enclosure with all the necessary harnessing cables. Documentation included. 36 pounds. MSD-1801 **$795**

Same as above but with two Shugart 801R disk drives. 50 pounds. MSD-2801 **$1195**

Disk drive cable. 6 feet 50 conductor with edge card connector at both ends. WCA-650S $25.00

Export Disk drives. 220V. 50MHz add $50.00 per disk drive.

## BSR SYSTEM X-10

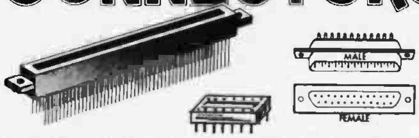
The new BSR timer runs your home just like clockwork. Turns on lamps and appliances while your away from home. Completely compatible with your existing System X-10 devices.

| | | | |
|---|---|---|---|
| BSR Timer eight channel | $65.00 | Appliance Module 500 W. | $13.95 |
| Master control console | 34.95 | Lamp Module 300 Watts | 13.95 |
| Ultrasonic Controller | 19.95 | NEW full control wall switch | 14.50 |

## Rotron Wisper Fan $14.77

115 VAC. 7 Watts WR2A1
Factory fresh Muffin fans
NOT pull-outs. EMF-4M

## CONNECTORS



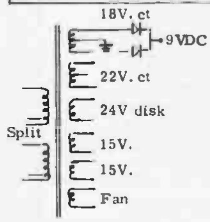

| GOLD EDGE CONNECTORS | each | 10+ |
|---|---|---|
| S-100 .125" centers | | |
| Imsai solder .250" row | $2.95 | $2.50 |
| Imsai wire wrap (TI) | 3.95 | 3.50 |
| Sullins III-Rel. .250" | 4.50 | 4.00 |
| Sullins III-Rel. W/W | 5.35 | 4.90 |
| Sullins / Altair .140" | 4.95 | 4.50 |
| .156" Centers (standard) | | |
| 22/44 Kim Eyelet | 2.50 | 2.15 |
| 36/72 Digital Group S/T | 5.95 | 5.50 |
| 36/72 Digital Group W/W | 6.50 | 6.15 |
| 43/86 Motorola 6800 S/T | 6.60 | 6.15 |
| 43/86 Moto. 6800 W/W | 7.00 | 6.85 |

INTEGRATED CIRCUIT SOCKETS

| | Low Profile each | Low Profile 100+ | Wire Wrap each | Wire Wrap 100+ |
|---|---|---|---|---|
| 8 pin | $.10 | $.09 | $.46 | $.41 |
| 14 pin | .10 | .09 | .45 | .41 |
| 16 pin | .12 | .11 | .50 | .45 |
| 18 pin | .15 | .13 | .68 | .61 |
| 24 pin | .26 | .24 | .94 | .87 |
| 40 pin | .42 | .40 | 1.60 | 1.47 |

| "D" Type | each | 10-24 | 25+ |
|---|---|---|---|
| DE9P male | $1.60 | $1.40 | $1.30 |
| DE9S female | 2.25 | 2.00 | 1.90 |
| DE hood | 1.50 | 1.35 | 1.20 |
| DA15P male | 2.35 | 2.15 | 2.00 |
| DA15S female | 3.25 | 3.10 | 2.90 |
| DA hood 2/P | 1.60 | 1.35 | 1.30 |
| DB25P male | 2.50 | 2.35 | 2.25 |
| DB25S female | 3.35 | 3.15 | 3.05 |
| DB hood 2/P | 1.35 | 1.15 | 1.05 |
| DC37P male | 4.20 | 4.00 | 3.70 |
| DC37S female | 6.00 | 5.75 | 5.50 |
| DC hood 2/P | 2.25 | 2.00 | 1.75 |
| DD50P male | 5.50 | 5.10 | 4.75 |
| DD50S female | 9.40 | 8.60 | 8.00 |
| DD50 hood 2/P | 2.60 | 2.40 | 2.10 |
| CENTRONICS | | | |
| 57-30360 | 7.95 | 6.75 | 5.75 |
| RIBBON CABLE CONNECTORS | | | |
| 17/34 5" disk | 4.85 | 4.15 | 3.95 |
| 20/40 TRS-80 | 5.65 | 5.05 | 4.70 |
| 25/50 8" disk | 5.90 | 5.15 | 4.90 |

## SURPLUS




## S-100 POWER SUPPLY KIT $59

Kit contains five high current bridge rectifiers, five computer grade electrolytic capacitors and a 700+ watt split primary transformer (110/220V.) The supply is capable of supporting a full 30 Amp S-100 system along with (2) eight inch disk drives.
Electrolytic capacitors consist of: one each 83,000 uF/15V; 34,000 uF/40V; 26,000 uF/30V; and Two 12,000/30V.
All components are new surplus acquired from excess inventory of the National Cash Register Company.
Please place your order early, at this low price we expect this kit to be a quick sell out. SPC-PW100. . . . Shipping: East of Mississippi add $15.00 California add $8.00 all other states please add $11.00 Foreign $21.00


## DATA INPUT TERMINAL

This Keystation terminal was recently acquired from the CMC division of the Pertec Corporation. The unit was originally designed for inputing data directly onto magnetic tape.

The system is comprised of a premium cast aluminium and fiberglass enclosure, along with a Honeywell / Microswitch hall effect keyboard. Thirty display lamps advise the operator of the systems status. Four inch loud speaker acknowledges acceptance of data and alerts the operator of pending problems.
But most of all this "USED" terminal, with a little imagination, can be engineered to make the perfect home for an S-100 computer and video display; or with slight modification will accept the Rockwell AIM-65 micro/computer.
Five volt regulated power supply is available for an additional $20. (see June Byte) All units are in excellent condition. Original acquisition over $700. 22 lbs.

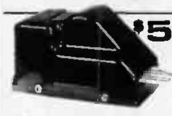
**$139.50**

PORTABLE DATA ENTRY SYSTEM

These used data terminals were originally designed for retail store order entry systems. The operator enters the inventory control number, merchandise on hand and the unit price. After all pertinent data has been entered, the main warehouse is telephoned, the handset is placed in the acoustic coupler an all the recorded information is transmitted back the master computer.
Each system includes: Cassette drive unit; Removable hex keyboard with LED display; Five Gould "D" NiCads with charger; Acoustical coupler and DB25 cable.
All units removed from service in working condition. Original cost over $2,500.

## Regulated Power Supply 5 VOLT 5 AMP $11.95

This USED surplus power supply was removed from working equipment. Pass transistor regulation outputs five volts at a conservative five amps. Suitable for TTL hobby applications. SPC-PS1 8 pounds.



## $59 Sankyo Magnetic Card Transport

This Sankyo card transport is capable of storing and retrieving over 400 characters of data from a single 2 x 4" HP style magnetic data card.
Motorized mechanism pulls the magnetic card across the four channel read/write head in under two seconds. Ideal for any data processing application where small amounts of information must be randomly retrieved. Original cost over $200.00 Documentation and sample card inclpded. New surplus. SPC-SCR

## WESTERN UNION ENCLOSURE

These enclosures were manufactured for Western Union by Universal Technology. The exact purpose of the product is still a mystery but the enclosure is ideally suited for an S-100 motherboard with shielded power supply. Removable hood and plexiglas front make this enclosure an attractive home for any hobby product.
New surplus in factory boxes supplied with three 22/44 edge connectors; DB 25S communications connector; six foot grounded power cord and more. Inside dimensions: 19" x 10 1/2" x 6 7/8". Shipping weight 8 lbs.

**$24.95**

VISA
master charge

All merchandise sold by California Digital is premium grade.
Shipping: First five pounds $2.00; each additional add $.40
Foreign orders 10% shipping. Excess will be refunded.
California residents add 6% sales tax. COD's discouraged.
Open accounts extended to state supported educational institutions and companies with a "Strong Dun & Bradstreet."
Warehouse: 15608 Inglewood Blvd. Visitors by appointment.

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**(213) 679-9001**

# ADVANCED COMPUTER PRODUCTS

16K UPGRADE ONLY $39.95 SPECIFY COMPUTER

## 7400

| | | | |
|---|---|---|---|
| SN7400N | 19 | SN74123N | 59 |
| SN7401N | 22 | SN74125N | 39 |
| SN7402N | .22 | SN74126N | 44 |
| SN7403N | 22 | SN74128N | 59 |
| SN7404N | 22 | SN74132N | 69 |
| SN7405N | 23 | SN74136N | 95 |
| SN7406N | .23 | SN74139N | 95 |
| SN7407N | 23 | SN74141N | 69 |
| SN7408N | 26 | SN74142N | 2.95 |
| SN7409N | .23 | SN74143N | 2.95 |
| SN7410N | .22 | SN74144N | 2.95 |
| SN7411N | 29 | SN74145N | 62 |
| SN7412N | 29 | SN74147N | 1.95 |
| SN7413N | 39 | SN74148N | 1.20 |
| SN7414N | 59 | SN74150N | 99 |
| SN7416N | 29 | SN74151N | 67 |
| SN7417N | .29 | SN74152N | 67 |
| SN7420N | 22 | SN74153N | 67 |
| SN7421N | 35 | SN74154N | 1.19 |
| SN7422N | .29 | SN74155N | 82 |
| SN7423N | 29 | SN74156N | 89 |
| SN7425N | 29 | SN74157N | 69 |
| SN7426N | .29 | SN74158N | 1.65 |
| SN7427N | 29 | SN74160N | 95 |
| SN7429N | 45 | SN74161N | .95 |
| SN7430N | 23 | SN74162N | 89 |
| SN7432N | .29 | SN74163N | 87 |
| SN7437N | 29 | SN74164N | 97 |
| SN7438N | 29 | SN74165N | 97 |
| SN7439N | .29 | SN74166N | 1.20 |
| SN7440N | .24 | SN74167N | 1.95 |
| SN7441N | 79 | SN74170N | 1.69 |
| SN7442N | 57 | SN74172N | 5.95 |
| SN7443N | 79 | SN74173N | 79 |
| SN7444N | 79 | SN74174N | 89 |
| SN7445N | 79 | SN74175N | 89 |
| SN7446N | 79 | SN74176N | 85 |
| SN7447N | 59 | SN74177N | 85 |
| SN7448N | 79 | SN74179N | 1.80 |
| SN7450N | 23 | SN74180N | 75 |
| SN7451N | .23 | SN74181N | 1.75 |
| SN7453N | .23 | SN74182N | 75 |
| SN7454N | 23 | SN74184N | 1.95 |
| SN7459N | 29 | SN74185N | 1.95 |
| SN7460N | .23 | SN74186N | 9.95 |
| SN7470N | .39 | SN74188N | 3.90 |
| SN7472N | 34 | SN74190N | 1.15 |
| SN7473N | 38 | SN74191N | 1.15 |
| SN7474N | 36 | SN74192N | 85 |
| SN7475N | 38 | SN74193N | 85 |
| SN7476N | 36 | SN74194N | .85 |
| SN7479N | 4.60 | SN74195N | 85 |
| SN7480N | 59 | SN74196N | 85 |
| SN7481N | 1.10 | SN74197N | 85 |
| SN7482N | 1.10 | SN74198N | 1.39 |
| SN7483N | .55 | SN74199N | 1.39 |
| SN7485N | .65 | SN74221N | 1.39 |
| SN7486N | 39 | SN74251N | .95 |
| SN7489N | 1.75 | SN74273N | 1.05 |
| SN7490N | 39 | SN74279N | 89 |
| SN7491N | 65 | SN74283N | 2.15 |
| SN7492N | .52 | SN74284N | 3.90 |
| SN7493N | .49 | SN74285N | 3.90 |
| SN7494N | .72 | SN74290N | 1.25 |
| SN7495N | .65 | SN74298N | 95 |
| SN7496N | .72 | SN74365N | 68 |
| SN7497N | 3.10 | SN74366N | 68 |
| SN74100N | 99 | SN74367N | .79 |
| SN74107N | 32 | SN74368N | .79 |
| SN74109N | 53 | SN74390N | 1.90 |
| SN74116N | 1.95 | SN74393N | 1.90 |
| SN74121N | .29 | SN74490N | 1.90 |
| SN74122N | .39 | | |

## CMOS

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|---|---|---|---|
| CD4000 | .35 | CD4093 | .99 |
| CD4001 | .35 | CD4094 | 2.95 |
| CD4002 | .35 | CD4098 | 2.49 |
| CD4006 | 1.39 | CD4099 | 2.25 |
| CD4007 | 29 | MC14408 | 12.95 |
| CD4008 | 1.39 | MC14409 | 12.95 |
| CD4009 | .49 | MC14410 | 12.95 |
| CD4010 | .49 | MC14412 | 12.95 |
| CD4011 | .35 | MC14415 | 8.95 |
| CD4012 | .29 | MC14419 | 4.95 |
| CD4013 | 49 | CD4501 | 39 |
| CD4014 | 1.39 | CD4502 | 1.65 |
| CD4015 | 1.15 | CD4503 | .69 |
| CD4016 | .59 | CD4505 | 8.95 |
| CD4017 | 1.19 | CD4506 | 75 |
| CD4018 | 99 | CD4507 | .95 |
| CD4019 | .49 | CD4508 | 3.95 |
| CD4020 | 1.19 | CD4510 | 1.39 |
| CD4021 | 1.19 | CD4511 | 1.39 |
| CD4022 | 1.15 | CD4512 | 1.39 |
| CD4023 | .38 | CD4515 | 3.95 |
| CD4024 | .79 | CD4516 | 1.69 |
| CD4025 | 38 | CD4518 | 1.39 |
| CD4027 | .65 | CD4520 | 1.39 |
| CD4028 | 85 | CD4555 | 4.95 |
| CD4029 | 1.29 | CD4556 | .99 |
| CD4030 | .45 | CD4566 | 2.25 |
| CD4031 | 3.25 | 74C00 | 39 |
| CD4032 | 2.15 | 74C02 | 39 |
| CD4034 | 3.25 | 74C04 | .39 |
| CD4035 | 95 | 74C08 | .49 |
| CD4037 | 1.95 | 74C10 | .49 |
| CD4040 | 1.29 | 74C14 | 1.65 |
| CD4041 | 1.25 | 74C20 | .39 |
| CD4042 | 95 | 74C30 | 39 |
| CD4043 | 85 | 74C32 | .99 |
| CD4044 | 85 | 74C42 | 1.85 |
| CD4046 | 1.75 | 74C48 | 2.39 |
| CD4047 | 1.25 | 74C73 | 85 |
| CD4048 | 99 | 74C74 | 85 |
| CD4049 | .69 | 74C85 | 2.49 |
| CD4050 | 69 | 74C89 | 4.95 |
| CD4051 | 1.10 | 74C90 | 1.85 |
| CD4052 | 1.10 | 74C93 | 1.85 |
| CD4053 | 1.10 | 74C95 | 1.85 |
| CD4055 | 3.95 | 74C107 | 1.19 |
| CD4056 | 2.95 | 74C151 | 2.49 |
| CD4059 | 9.95 | 74C154 | 3.50 |
| CD4060 | 1.39 | 74C157 | 2.10 |
| CD4066 | .75 | 74C160 | 2.39 |
| CD4069 | .35 | 74C161 | 2.30 |
| CD4070 | 49 | 74C163 | 2.39 |
| CD4071 | .35 | 74C164 | 2.39 |
| CD4072 | .35 | 74C173 | 2.59 |
| CD4073 | .35 | 74C174 | 2.75 |
| CD4075 | .35 | 74C175 | 2.75 |
| CD4076 | 1.29 | 74C192 | 2.39 |
| CD4077 | .35 | 74C193 | 2.39 |
| CD4078 | .35 | 74C195 | 2.39 |
| CD4081 | .35 | 74C922 | 7.95 |
| CD4082 | .35 | 74C923 | 6.95 |
| CD4085 | 1.95 | MM80C95 | 1.50 |
| CD4089 | 2.95 | MM80C97 | 1.25 |

## 74LS00

| | | | |
|---|---|---|---|
| 74LS00N | 35 | 74LS164N | 1.19 |
| 74LS01N | 28 | 74LS165N | 89 |
| 74LS02N | 28 | 74LS166N | 2.48 |
| 74LS03N | 28 | 74LS168N | 1.89 |
| 74LS04N | 39 | 74LS169N | 1.89 |
| 74LS05N | 28 | 74LS170N | 1.99 |
| 74LS08N | 39 | 74LS173N | .89 |
| 74LS09N | 39 | 74LS174N | .99 |
| 74LS10N | 28 | 74LS175N | 99 |
| 74LS11N | 39 | 74LS181N | 2.20 |
| 74LS12N | 39 | 74LS190N | 1.15 |
| 74LS13N | 47 | 74LS191N | 1.15 |
| 74LS14N | 1.25 | 74LS192N | .98 |
| 74LS15N | 39 | 74LS193N | .98 |
| 74LS20N | 26 | 74LS194N | 1.15 |
| 74LS21N | 38 | 74LS195N | 95 |
| 74LS22N | 38 | 74LS196N | 89 |
| 74LS26N | 39 | 74LS197N | 89 |
| 74LS27N | 39 | 74LS221N | 1.49 |
| 74LS28N | 39 | 74LS240N | 1.95 |
| 74LS30N | 26 | 74LS241N | 1.90 |
| 74LS32N | 39 | 74LS242N | 1.95 |
| 74LS37N | 79 | 74LS243N | 1.95 |
| 74LS38N | 39 | 74LS244N | 1.95 |
| 74LS40N | 26 | 74LS245N | 4.95 |
| 74LS42N | 79 | 74LS247N | 1.10 |
| 74LS47N | 79 | 74LS248N | 1.10 |
| 74LS48N | 79 | 74LS249N | 1.69 |
| 74LS51N | 26 | 74LS251N | 1.79 |
| 74LS54N | 35 | 74LS253N | .98 |
| 74LS55N | 35 | 74LS257N | .98 |
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| 74LS75N | .68 | 74LS260N | .69 |
| 74LS76N | 45 | 74LS261N | 2.49 |
| 74LS78N | 65 | 74LS266N | 59 |
| 74LS83AN | 99 | 74LS273N | 1.75 |
| 74LS85N | 1.19 | 74LS275N | 4.40 |
| 74LS86N | 45 | 74LS279N | .59 |
| 74LS90N | 75 | 74LS283N | 1.10 |
| 74LS92N | 75 | 74LS290N | 1.29 |
| 74LS93N | 75 | 74LS293N | 1.95 |
| 74LS95N | 88 | 74LS295N | 1.10 |
| 74LS96N | 98 | 74LS298N | 1.29 |
| 74LS107N | 45 | 74LS324N | 1.75 |
| 74LS109N | 45 | 74LS347N | 1.95 |
| 74LS112N | 49 | 74LS348N | 1.95 |
| 74LS113N | 49 | 74LS352N | 1.65 |
| 74LS114N | 55 | 74LS353N | 1.65 |
| 74LS122N | 55 | 74LS363N | 1.49 |
| 74LS123N | 1.19 | 74LS365N | .99 |
| 74LS124N | 1.35 | 74LS366N | 99 |
| 74LS125N | 89 | 74LS367N | .73 |
| 74LS126N | 89 | 74LS368N | .73 |
| 74LS132N | 79 | 74LS373N | 2.75 |
| 74LS136N | 59 | 74LS374N | 2.75 |
| 74LS138N | 89 | 74LS375N | .69 |
| 74LS139N | 89 | 74LS377N | 1.95 |
| 74LS145N | 1.25 | 74LS385N | 1.95 |
| 74LS148N | 1.49 | 74LS386N | .65 |
| 74LS151N | 79 | 74LS390N | 1.95 |
| 74LS153N | .79 | 74LS393N | 1.95 |
| 74LS154N | 2.49 | 74LS395N | 1.70 |
| 74LS155N | 1.19 | 74LS399N | 2.95 |
| 74LS156N | 99 | 74LS424N | 2.95 |
| 74LS157N | 99 | 74LS668N | 1.75 |
| 74LS158N | 75 | 74LS670N | 2.29 |
| 74LS160N | 98 | 81LS95N | 1.99 |
| 74LS161N | 1.15 | 81LS96N | 1.99 |
| 74LS162N | .98 | 81LS97N | 1.99 |
| 74LS163N | 98 | 81LS98N | 1.99 |

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| | | | |
|---|---|---|---|
| 78H05 | 5.95 | LM1414N | 1.90 |
| 78M06 | 1.49 | LM1458CN/N | .49 |
| 78M.G | 1.49 | MC1488N | 1.49 |
| LM105H | .99 | MC1489N | 1.49 |
| LM108AH | 2.95 | LM1496N | .89 |
| LM300H | .79 | LM1556N | 1.50 |
| LM301CN/H | .35 | LM1800N | .79 |
| LM304H | .98 | LM1820N | .95 |
| LM305H | .89 | LM1850N | .95 |
| LM306H | 3.25 | LM1889N | 3.95 |
| LM307CN/H | .29 | LM2111N | 1.75 |
| LM308CN/H | .98 | LM2900N | 99 |
| LM309K | 1.49 | LM2901N | 2.50 |
| LM310CN | 1.25 | LM2917N | 2.95 |
| LM311D/CN/H | 98 | CA3013T | 2.29 |
| LM312H | 1.75 | CA3018T | 1.99 |
| LM317T | 2.75 | CA3021T | 3.49 |
| LM318CN/H | 1.49 | CA3023T | 2.99 |
| LM319N/H | 1.25 | CA3035T | 2.75 |
| LM320K-XX* | 1.49 | CA3039T | 1.49 |
| LM320T-XX* | 1.25 | CA3046T | 1.29 |
| LM320H-XX* | 1.25 | LM3053N | 1.49 |
| LM323K | 4.95 | CA3059N | 3.25 |
| LM324N | 1.25 | CA3060N | 3.25 |
| LM339N | 95 | CA3062N | 4.95 |
| LM340K-XX* | 1.49 | LM3065N | 1.49 |
| LM340T-XX* | 1.25 | CA3080N | 1.29 |
| LM340H-XX* | 1.25 | CA3081N | 1.69 |
| LM344H | 1.95 | CA3082N | 1.69 |
| LM348N | 1.85 | CA3083N | 1.99 |
| LM358CN | .98 | CA3086N | 1.29 |
| LM360N | 1.49 | CA3089N | 2.75 |
| LM372N | 1.95 | CA3096N | 2.49 |
| LM376N | 3.75 | CA3097N | 1.99 |
| LM377N | 3.75 | CA3130T | 2.49 |
| LM380CN/N | 1.25 | CA3140T | 2.49 |
| LM381N | 1.79 | CA3146N | 2.49 |
| LM383T | 1.95 | CA3160T | 1.49 |
| LM386N | 1.49 | CA3190N | 1.95 |
| LM387N | 1.49 | CA3401N | .69 |
| LM390N | 1.95 | MC3423N | 1.49 |
| NE531V/T | 3.75 | MC3460N | 3.95 |
| NE555V | .39 | SG3524N | 3.95 |
| NE556N | .98 | CA3600N | 3.50 |
| NE561T | 19.95 | LM3900N | .59 |
| NE562B | 7.95 | LM3905N | 1.49 |
| NE565N/H | 1.25 | LM3909N | .98 |
| NE566H/V | 1.75 | RC4131N | 2.95 |
| NE567V/H | 1.50 | RC4136N | 1.10 |
| NE592N | 2.75 | RC4151N | 4.50 |
| LM702H | 2.99 | RC4194 | 4.95 |
| LM709N/H | .29 | RC4195 | 4.40 |
| LM710N/H | .98 | ULN2001 | 1.25 |
| LM711N/H | .39 | ULN2003 | 1.50 |
| LM715N | 1.95 | SN75450N | .59 |
| LM723N/H | .75 | SN75451N | .49 |
| LM733N/H | .98 | SN75452N | .49 |
| LM739N | 1.15 | SN75453N | .49 |
| LM741CN/H | .33 | SN75454N | .49 |
| LM741CN-14 | .19 | SN75491N | .89 |
| LM747N/H | .79 | SN75492N | .89 |
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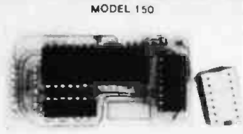
**APPLE™ 40 CHARACTER TYPE-AHEAD BUFFER**

MODEL 150



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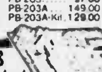

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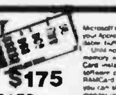

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| Super Breakout™ | 42.00 | Business Communications | 35.00 | Blank Diskettes | |
| Music Composer | 55.00 | Basic Psychology | 35.00 | Disk File Manager | 5.00 |
| Super Bug™ | 42.00 | Effective Writing | 35.00 | **Accessory Controllers** | |
| Computer Chess | 55.00 | Auto Mechanics | 35.00 | Driving Controller Pair | 18.00 |
| Home Finance | 55.00 | Principles of Economics | 35.00 | Paddle Controller Pair | 18.00 |
| | | | | Joystick Controller Pair | 18.00 |

## SINGLE BOARD COMPUTER SELECTION GUIDE

| BOARD | PROCESSOR | ACP PRICE | ENCLOSURE | BOARD | PROCESSOR | ACP PRICE | ENCLOSURE |
|---|---|---|---|---|---|---|---|
| KIM-1 | 6502 | 169.00 | Add 29.95 | SC-SBC100 | Z80 | 239.00 | N/A |
| SYM-1 | 6502 | 239.00 | Add 39.95 | AIM 65 | 6502 | 375.00 | Add 49.95 |
| Cromemco | Z80 | 409.00 | N/A | Cosmac Vip | 1802 | 199.00 | Inc |

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Superior Color, Music, Sound & Graphics - & a Powerful Extended Basic - All Built-In.

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**INTELLIVISION**

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GAME CARTRIDGES $26.95

| | | |
|---|---|---|
| BASEBALL | HOCKEY | POKER/BLACKJACK |
| FOOTBALL | BASKETBALL | ROULETTE |
| AUTO RACE | MOTOCROSS | HORSE RACING |
| TENNIS | ADVENTURE | SUB BATTLE |
| GOLF | CHECKERS | ARMOR BATTLE |
| SOCCER | CHESS | SPACE BATTLE |
| SKIING | MATH FUN | SEA BATTLE |
| BOXING | BACKGAMMON | ARCADE |
| BOWLING | WORD FUN | |

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1310 E. Edinger (714) 953-0604
Santa Ana, CA 92705 TWX: 910-595-1565

Circle 354 on inquiry card.

# QT PRODUCTS

## SBC+2/4 SINGLE BOARD COMPUTER

Features: 1K RAM (which can be located at any 1K boundary) plus one each Parallel and Serial I/O parts on board • Power on jump to on-board EPROM (2708 or 2716) • EPROM addressable on any 1K or 2K boundary • Full 64K use of RAM allowed in shadow mode • Programmable Baud rate selection, 110-9600 • 2 or 4MHz switch selectable • DMA capability allows MWRT signal generation on CPU board or elsewhere in system under DMA logic or front panel control • Two programmable timers available for use by programs run with the SBC+2/4 (timer output and controls available at parallel I/O connector; parallel input and output ports available for use on CPU board).

| | |
|---|---|
| Bare Board | $ 60.00 |
| Kit | $190.00 |
| A&T | $295.00 |

## Z+80 CPU

Features: Power on jump to on-board EPROM (2708, 2716 or 2732) • EPROM addressed on any 1K or 2K boundary; also shadow mode allows full 64K use of RAM • On-board USART for Synchronous or Asynchronous RS-232 Operation (Serial I/O port) • Programmable Baud rate selection, 110-9600 • Switch selectable 2 or 4 MHz • MWRITE signal generated if used without front panel • Front panel compatible.

| | |
|---|---|
| Bare Board | $ 50.00 |
| Kit | $150.00 |
| A&T | $210.00 |

## RAM+16

Features: S-100, 16K x 8 bit static RAM • 2 or 4 MHz • Uses 2114 1K x 4 static RAM chip • 4K step addressable • 1K increment memory protection, from bottom board address up or top down • Deactivates up to six 1K board segments to create "holes" for other devices • DIP switch selectable wait states • Phantom line DIP switch • Eight bank select lines expandable to ½ million byte system • Data, address and control lines all input buffered • Ignores I/O commands at board address.

| | |
|---|---|
| Bare Board | $ 35.00 |
| 4Mhz Kit | $190.00 |
| 4Mhz A&T | $225.00 |

## RAM+ 65

•S-100, 16K x 8 bit static RAM •2 or 4MHz •Uses 2114L (300NS) CHIP •Addressable in 4K steps •Memory protection in 1K increments, from bottom board address up or top down • May deactivate up to six 1K segments of board to create "holes" for other devices • DIP switch selectable wait states • Phantom line DIP switch •Features bank selection by I/O instruction using any one of 256 DIP switch-selectable codes—allows up to 256 software-controlled memory banks.

| | |
|---|---|
| Bare Board | $ 35.00 |
| 4MHz Kit | $210.00 |
| 4MHz A&T | $250.00 |

## EXPANDABLE+ REV II DYNAMIC MEMORY BOARD

NEW

Features: Runs at 4MHz • 3242 refresh controller with delay line • Four layer PC board insures quiet operation • Supports 16K, 32K, 48K or 64K of memory • 24 IEEE-specified address lines • Optional M1 wait state allows error free operation with faster processors • Optional Phantom disable • Uses Z-80 or on-board refresh signal • Bank on/off signal selected by industry standard I/O port 40 (Hex) • Convenient DIP switch selection of data bus bits determines bank in use • 3 watts low power consumption • Convenient LED indication of bank in use.

### Definitely works with Cromemco and North Star

Bare Board $ 75.00

| KIT | | A&T | |
|---|---|---|---|
| No RAM | $230.00 | 16K | $350.00 |
| 16K | $280.00 | 32K | $450.00 |
| 32K | $360.00 | 48K | $575.00 |
| 48K | $480.00 | 64K | $675.00 |
| 64K | $525.00 | | |

## CLOCK/CALENDAR+ FOR APPLE II, S-100 OR TRS-80

Features: Date/Month/Year • Day of week • 24 hour time or 12 hour (a.m./p.m.) selectable • Leap year (perpetual calendar) • 4 interval interrupt timer; 1024Hz (approx. 1 millisec), 1 sec., 1 min., 1 hr. • On-board battery backup • Simple time and date setting • Simple software interface • Time advance protection while reading.

Battery Included

| S-100 or Apple | | TRS-80 | |
|---|---|---|---|
| A&T | $150.00 | A&T Only | $150.00 |
| Kit | $100.00 | | |
| Bare Bd. | $ 60.00 | | |

## WATCH FOR THE FOLLOWING NEW BDS:

- 4 Port Serial Bd (APR)
- E-PROM Programmer (MAY)
- Floppy Disk Controller (JUN)
- Hard Disk Controller (JUN)
- Color Video Bd (AUG)

## I/O+ INDUSTRIAL GRADE I/O BD

Has two serial Sync/Async ports (RS-232, current loop or TTL) with individual Xtal controlled programmable baudrate generators • Four 8-bit Parallel ports; one latched Input port and other three can be programmed in combinations of input, output or bidirectional • Also, has three 16-bit Programmable Timers and an 8-level Programmable Interrupt Controller w/Auto restart (8080 / Z80) • Other features include: on-board clock divisor for timers, completely socketed, wire wrap posts for easy port configuration plus more.

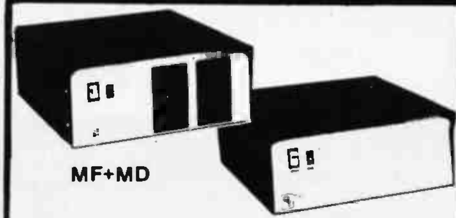
| | |
|---|---|
| Bare Board | $ 70.00 |
| Kit | $200.00 |
| A&T | $375.00 |

## SILENCE+ MOTHERBOARDS

These motherboards are among the quietest on the market. A unique grounding matrix — with each line completely surrounded by ground shielding — eliminates need for termination and gives high crosstalk rejection • They're customer-proven, without crosstalk sometimes operating at 14MHz • A LED power indicator helps eliminate zapped circuits • IEEE S-100 std. compatible, available with 6, 8, 12, 18 or 22 slots • (The 22 slot board fits Imsai chassis and has slot for front panel.)

| 6 Slot | | 12 Slot | |
|---|---|---|---|
| Bare Board | $ 25.00 | Bare Board | $ 30.00 |
| Kit | $ 40.00 | Kit | $ 70.00 |
| A&T | $ 50.00 | A&T | $ 90.00 |
| **8 Slot** | | **18 Slot** | |
| Bare Board | $ 27.00 | Bare Board | $ 50.00 |
| Kit | $ 55.00 | Kit | $100.00 |
| A&T | $ 70.00 | A&T | $140.00 |

## QT MAINFRAMES



MF+MD

MF+

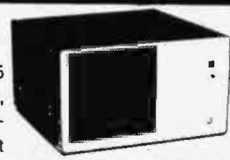
**5¼" Disk Mainframe with 25A Pwr Sup**

| | |
|---|---|
| MF+MD12 (12 slot M/B) | $500.00 |
| MF+MD8 (8 slot M/B) | $475.00 |
| MF+MD6 (6 slot M/B) | $450.00 |
| MF+MD w/o M/B | $400.00 |

**Q.T. Mainframe**

| | |
|---|---|
| MF+12 (12 slot M/B) | $450.00 |
| MF+18 (18 slot M/B) | $500.00 |
| MF+22 (22 slot M/B) | $600.00 |

## MAINFRAME+ DISK DRIVE



Includes cabinet, 25 amp power supply, IEEE S-100 compatible 6, 8 or 12 slot motherboard and dual 8" disk drive with disk drive power supply.

| | |
|---|---|
| MF+DD6 | $625.00 |
| MF+DD8 | $650.00 |
| MF+DD12 | $675.00 |

## DDC-8 SINGLE 8" DISK CABINET

Accepts one 8" disk drive (Shugart, Remex, PerSci, Siemens, etc.) • Fan cooled, with data cable and AC line filter to eliminate EMI • Operates from 100-125VAC/200-250VAC at 50-60Hz • Disk drive NOT included.

DDC+8 $195.00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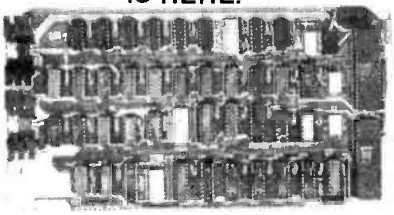
# S-100 HEADQUARTERS

DETACH OUR CATALOG FROM THE NOV. BYTE

## GODBOUT

### THE DUAL PROCESSOR BOARD IS HERE!



### GBT161 8085 CPU BOARD
### GBT1612 8085/8088 CPU BOARD

- 8088 & 8085A CPU
- S-100 IEEE COMPATIBLE
- SWITCHABLE CPU'S
- 5 MHZ OR 2 MHZ SWITCHABLE
- POWER ON JUMP TO ANY 256 BYTE BOUNDARY
- POWER ON JUMP CAN BE DISABLED
- CPU CAN JUMP ON POWER ON ONLY OR POWER ON AND RESET.
- 24 BIT EXTENDED ADDRESSING
- IMSAI FRONT PANEL COMPATIBLE
- AVAILABLE WITH 8085A ONLY

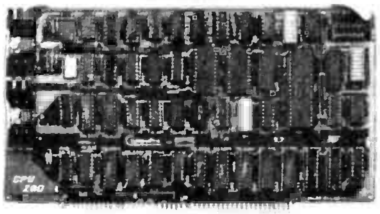
**BOARD WITH 8085 ONLY**

| | | List Price | Our Price |
|---|---|---|---|
| GBT161A | Assembled & Tested | $325.00 | $305.00 |

**BOARD WITH 8085 & 8088**

| | | | |
|---|---|---|---|
| GBT1612A | Assembled & Tested | $425.00 | $399.00 |

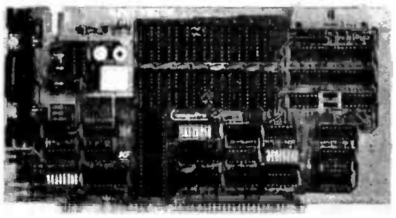
### ENHANCED Z80 S-100 CPU BOARD



### GBT160
### Z80 CPU

- 4-6 MHz Z80 CPU
- IEEE S-100 Bus Compatible
- On Board Prom Sockets For Up To 8K Prom
- Power On Jump Start To Any 256Byte Boundary
- On Board Memory Manager For Direct Addressing For Up To 16 M-Bytes
- Fully Maskable Vectored Interrupts
- Wait State Generation For All Machine Cycles
- Bypassing Of All Supply Line To Suppress Transients
- All IC's Are Socketed

| | | List Price | Our Price |
|---|---|---|---|
| GBT160U | Unkit | | $225.00 |
| GBT160A | Assembled & Tested | $295.00 | $280.00 |



### SPECTRUM
### S-100 COLOR GRAPHICS BOARD

- Uses the MC6847 LSI IC
- Uses 1372 color encoded/generator
- Alphanumeric/graphics in 8 colors
- Ultra dense 256 x 192 full graphics
- 8K bytes. on-board low power RAM
- One full duplex parallel I/O port with attention. enable & strobe bits with power for running joysticks. keyboards. etc.
- A parallel port for graphics mode control
- Board may be used as a 4MHz RAM for program storage

| | | LIST PRICE | OUR PRICE |
|---|---|---|---|
| GBT144U | UNKIT | | $299.00 |
| GBT144A | A&T | $399.00 | $349.00 |
| GBT20 | SUBLOGIC UNIVERSAL GRAPHICS INTERPRETER SOFTWARE | | $35.00 |

## GODBOUT

### INTERFACER I

Our I/O board gives you inparalleled flexibility and operating convenience. We include such features as:

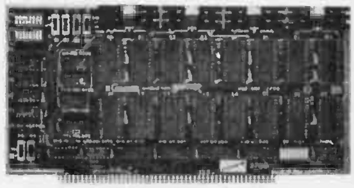
- 2 Independently addressable serial ports (dip switch selectable addresses)
- Real LSI Hardware UARTs for minimum CPU housekeeping
- RS232C. current loop (20mA). & TTL signals on both ports
- Precision. crystal-controlled Baud rates up to 19.1 KBaud (Individually dip switch selectable)
- Transmit & receive interrupts on both channels. Jumperable to any vectored interrupt line
- Industry standard RS232 level converters with five RS232 handshaking lines per port
- Optically isolated current loop with provisions for both on-board & off-board current sources
- UART parameters. interrupt enables. & RS232 handshaking lines are software programmable with power-on hardware default to customer specified hard-wired settings for maximum flexibility
- Port connectors mate directly to ribbon cable & DB25 connectors in standard pinouts
- RS232 lines will conform to either master or slave configurations
- Board gives full feature operation with both 2 & 4 MHz systems
- Low power consumption: +8V @ 450mA: +16V @ 150mA; -16V @ 70mA max.
- No software initialization required for board operation. although board parameters may be altered by software

| | | LIST PRICE | OUR PRICE |
|---|---|---|---|
| GBT133U | UNKIT | | $199.00 |
| GBT133A | A&T | $249.00 | $219.00 |

### INTERFACER II 3PTS

- 1 independently addressable serial port
- RS232C: 20mA current loop. & TTL signals
- Precision crystal controlled Baud rate generator
- Up to 19.2K Baud
- Transmit and receive interrupts. jumperable to and vectored interrupt line
- Five RS232 handshaking lines
- Optically isolated current loop
- 3 parallel I/O
- Utilizes LSTTL octal latches for latched I/O data with 24mA drive current
- Enable & strobe bits on each port (each with selectable polarity)
- Interrupts for each input port
- Separate 25 pin connector with power for each channel and a status port for interrupt mask & port status

| | | LIST PRICE | OUR PRICE |
|---|---|---|---|
| GBT150U | UNKIT | | $199.00 |
| GBT150A | A&T | $249.00 | $219.00 |



### ECONOROM 2708

Has provisions for wait states for 4MHz operations. Configured as four 4K blocks—each independently addressable and disable. Power-on jump. Does **NOT** include 2708s. Includes all support chips, sockets, regulators, heat sinks, etc. Sold in UNKIT form only. Shipping Weight 2 lbs.

GBT125U Unkit ........................ $85.00

## *NEW!*
### DISK 1 HIGH PERFORMANCE FLOPPY DISK CONTROLLER

Finally, a floppy disk controller worthy of bearing the CompuPro name is now available for integration into your S-100 system. The DISK 1 floppy controller incorporates numerous features that were previously unavailable on a DMA floppy disk controller board. DISK 1 fully complies with the IEEE 696 bus standard, INCLUDING DMA ARBITRATION!

- Third generation INTEL 8272/NEC 765A LSI floppy disk controller.
- High speed cycle stealing DMA interface for processor independent data transfer between system memory and flexible disk.
- Handles up to four 8 or 5.25 inch floppy disk drives.
- Single or double density / single or double sided capability.
- Supports IBM 3740 soft sectored formats.
- 24 bit DMA addressing with data transfer across 64K boundaries for data transfer throughout the 16Mbyte memory map.
- I/O mapped Interface allows contiguous system memory. (DISK 1 occupies no memory space)
- On board Phantom boot EPROM for automatic startup.
- On board serial port for initial system startup.
- Board compatible with MP/M, OASIS, CP/M-80 and CP/M-86.
- Board supplied with BIOS for CP/M-80
- CP/M-80 and CP/M-86 available for DISK 1.
- CPU speed independent data transfer for operation up to 10MhZ.
- Fully arbitrated DMA Interface as per IEEE 696 for allowing multiple DMA devices without conflict.
- May be interrupt driven for multi-user environments.
- Up to 600K bytes per side (8 Inch drive) for an on-line total of up to 4.8M bytes (4 drives - double sided -double density)

| | | LIST PRICE | OUR PRICE |
|---|---|---|---|
| GBT-171BA | Disk 1 A&T | $495.00 | $445.00 |

### SYSTEM SUPPORT 1 MULTIFUNCTION BOARD

This multi-purpose S-100 board provides your computer with the most needed system support functions -at less cost than buying numerous single function boards. Includes sockets for 4K of extended address EPROM or RAM (2716 pinout), 1 socket with battery backup; crystal controlled month/day/year/time clock with BCD outputs; optional high speed math processor (9511 or 9512); full RS-232 serial port; three 16 bit interval timers (cascade or use Independently); two interrupt controllers service 15 levels of interrupts; power fail indicator with provision to switch CMOS memory to battery backup; and comprehensive owner's manual with numerous software examples. Conforms fully to all IEEE 696/S-100 standards.

Want to make your S-100 system more versatile? System Support 1 is the answer.

| | | LIST PRICE | OUR PRICE |
|---|---|---|---|
| GBT-162U | unKit | | $295.00 |
| GBT-162A | A&T | $395.00 | $360.00 |
| GBT-9512 | Match Clip | | $195.00 |

### Static S-100 Memory

### 32K ECONORAM XX

32K Bank Select. IEEE S-100 compatible. Features one 32K block that can be addressed on 4K boundaries. Compatible with the IEEE proposed standard of 24 address lines as well as all currently used bank select configurations. Any or all of the eight 4K byte blocks may be disabled to create as many windows in memory to avoid any system memory conflicts.

| | List Price | Our Price |
|---|---|---|
| GBT164A16 16K RAM A & T | $399.00 | $329.00 |
| GBT164A24 24K RAM A & T | $539.00 | $455.00 |
| GBT164A32 32K RAM A & T | $699.00 | $569.00 |

VISA master charge

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# IMAGINE THE STO
# AN 8 INCH FLOPPY

**315K BYTES PER SIDE ON 5 1/4" OF COURSE!** Micropolis, the worlds largest manufacturer of high density 5 1/4" disk drives, has been doing it for years. And reliably at that.

An ordinary 5 1/4" floppy provides just 35/tracks per side and stores only 70K bytes. This is not nearly enough for anything useful, so instead, Micropolis uses 77 tracks per side. Each track is then formatted with 16 sectors (hard) at 256 bytes per sector yielding an impressive 315K bytes per side.

Micropolis drives have a larger capacity than many 8" disk drives, though it only occupies the space of a 5 1/4" floppy. The 315K byte capacity is roughly 4 times the capacity of a standard 5 1/4" drive. This is what we call QUAD DENSITY.

To achieve the high density capability, you may think Micropolis had to sacrifice speed or reliability. NOT SO! The track to track access time is only 30ms with a high speed data transfer rate of 250,000 bits per second.

By creating this high density format, Micropolis is able to keep your initial subsystem costs to a minimum. Your cost is less than $.002 per byte. Thats a BIG VALUE in a small package.

MICROPOLIS disk subsystems are expandable to keep up with your ever increasing needs. Up to four drives/heads may be daisy-chained on one S-100 controller board. With all four drives/heads in operation, you have access to over 1.2 MEGABYTES of on-line storage.

WITH MICROPOLIS, complete means COMPLETE. Each subsystem comes complete with controller interface, cable, and software. The software includes the MDOS operating system, extended basic, assembler and editor. Everything you need to get "On Line" in one complete package.

MICROPOLIS provides total integration which means they control everything from beginning to end. The result is a better drive for you, backed by a full 120 day factory guarantee.

Anyone can cut price by cutting out capacity or valuable features. But there's no long term advantage in it. Not for the user. Or the builder.

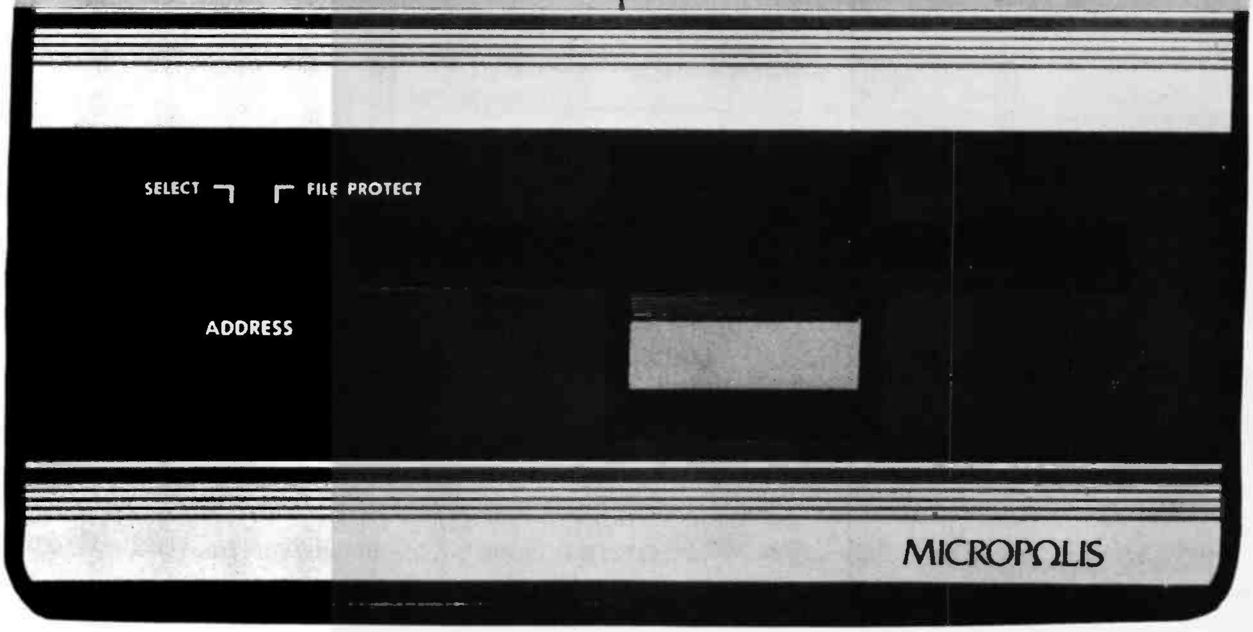
MICROPOLIS takes a better approach, even though it's harder, using advanced design to provide more capability while also lowering cost.

For example, most 5 1/4-inch floppy disks cut costs by using a cheap, less accurate plastic cam or cam follower to position the read/write head. Most 8-inch floppy disks use a better approach, with a rolled steel lead screw for this function.

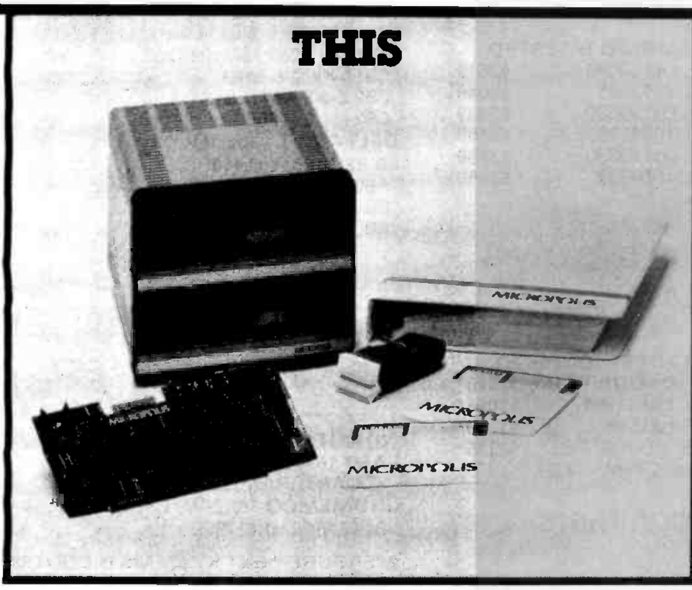
We go them one better and use an all-steel system, with a precision-ground steel lead screw and steel follower. It costs more but gives us greater storage capacity with lower cost per thousand bytes. Not so incidentally, our steel construction (compared to plastic) significantly increases reliability, too. There's even a built-in File Protect feature that prevents accidental loss of valuable data. (A file protected diskette cannot be written on.)

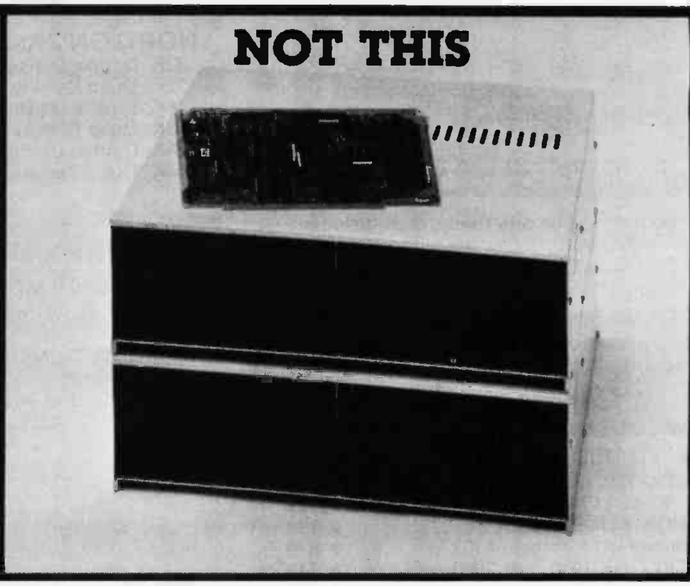
Heat can cause numerous read and write errors that can become hazardous to your data. The major heat producing power supply components are mounted to a large heat sink, external to the cabinet, by the power switch and fuse (located at the rear of the cabinet). This design is to assure that the drive components are kept as cool as possible to assure reliable data recovery.

MICROPOLIS has a reputation for getting along with most everybody. Compatability is not a problem with MICROPOLIS. Their disk drives and/or subsystems can be easily integrated into systems such as Polymorphic, Cromemco, CCS, Ithica Intersystems, Godbout, Northstar, Jade Big Z, QT SBC 2/4, and many others. Many OEM manufacturers rely on MICROPOLIS to get the job done efficiently. Companies like Commodore, Exidy, Harris, and Vector Graphics to name just a few. Years from now, you can look back with a secure feeling knowing you made the best choice: MICROPOLIS.



# AGE CAPACITY OF
# IN 5 1/4" FORMAT




Because of our incredible purchasing power, PRIORITY ONE ELECTRONICS is able to buy MICROPOLIS disk drives by the thousands and receive special pricing. That special pricing we receive is passed on to you in the form of tremendously discounted prices. Now all that remains is for you to take advantage of this truly incredible buy.

| MODEL | DESCRIPTION | LIST | SALE PRICE |
|---|---|---|---|
| **S-100 SUB-SYSTEMS** | | | |
| MCP-1053-4 | 1.2 MB 2 HEAD DUAL | $2605.00 | $1395.00 |
| MCP-1053-2 | 630 KB DUAL | $1895.00 | $995.00 |
| MCP-1043-2 | 315 KB SINGLE | $1145.00 | $695.00 |
| MCP-1041-2 | 315 KB SINGLE, NO PS | $1045.00 | $639.00 |
| MCP-1042-1 | 143 KB SINGLE | $795.00 | $625.00 |
| MCP-1041-1 | 143 KB SINGLE, NO PS | $695.00 | $595.00 |

COMPLETE W/S-100 CONTROLLER, CABLES, MANUALS AND MICROPOLIS MDOS AND BASIC

**ADD-ON DRIVES**

| | | | |
|---|---|---|---|
| MCP-1033-2 | 630 KB DUAL | $1395.00 | $895.00 |
| MCP-1023-2 | 315 KB SINGLE | $645.00 | $495.00 |
| MCP-1021-2 | 315 KB SINGLE, NO PS | $545.00 | $475.00 |
| MCP-1022-1 | 143 KB SINGLE | $545.00 | $375.00 |
| MCP-1021-1 | 143 KB SINGLE, NO PS | $445.00 | $360.00 |

REQUIRES ACCESSORY ADD-ON CABLES

## GOOD NEWS FOR TRS-80* OWNERS

We now have a complete line of TRS-80* Model 1 compatible MICROPOLIS add on drives in matching colors. These drives simply plug into the expansion interface via a disc data cable.

197K BYTES PER SIDE FOR YOUR TRS-80*, that's easy! Just order a 77 track add on drive and the New DOS-80 operating system. Among the many features of New DOS-80, is its ability to control any mix of 35, 40, or 77 track drives on the same cable.

**TRS-80® DISK DRIVES**

| | | | |
|---|---|---|---|
| MCP-1027-1 | 35 TRACK SINGLE | $545.00 | $279.00 |
| MCP-1037-1 | 35 TRACK DUAL | $1195.00 | $695.00 |
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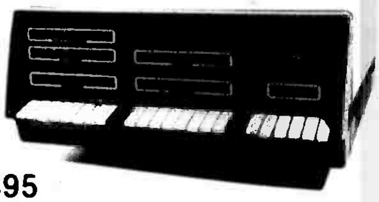

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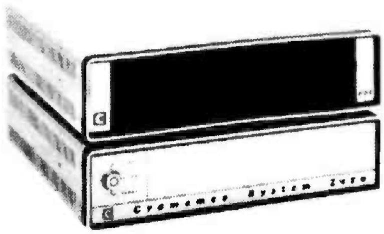

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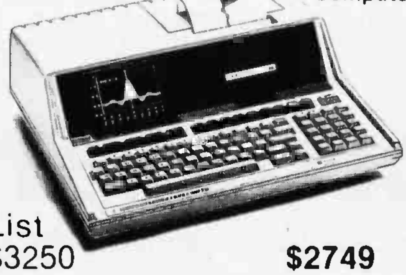

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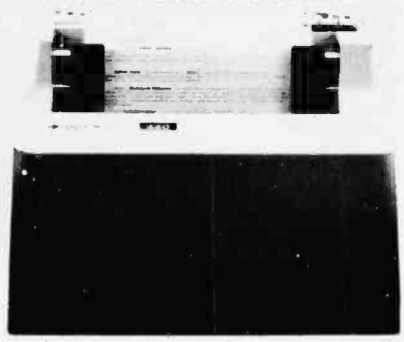

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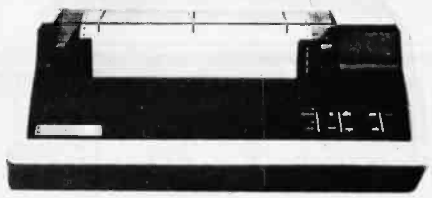

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These notices are free of charge and will be printed one time only on a space available basis. Notices can be accepted from individuals or bona fide computer users clubs only. We can engage in no correspondence on these and your confirmation of placement is appearance in an issue of BYTE.

Please note that it may take three or four months for an ad to appear in the magazine.

**FOR SALE:** Apple Pascal language system. Never used, still in original packing with factory warranty for $400. M Antonovich, Box 6020, Wyomissing PA 19610.

**FOR SALE:** Moving, must sell; complete Texas Instruments 9900 minicomputer. Processor board with operating system in prom, 2 K cache programmable memory, 9900 processor, and I/O interface. Memory board with 32 K bytes of programmable memory and complete buffering. Cassette interface and 9600 bps digital cassette player/recorder. Complete system software: Assembler, Linking Loader, Text Editor, Super BASIC, and lots of games. All contained in a fan-cooled chassis. Total price for entire hardware/software computer system is $1800. Bernard H Penney, 31 Wheeler Dr, Peekskill NY 10566, (914) 945-1044 day/(914) 528-1612 night.

**FOR SALE OR TRADE:** Kenwood amateur radio equipment: TS520S transceiver, frequency readout, AT200 tuner, 6- and 2-meter transverters, and variable frequency oscillator. All service manuals and cables included. Will sell or trade for Heath H-89 or H-8 computer system. Edward H Hill Sr, 3046 Stuart St, Indianapolis IN 46218, (317) 545-8886.

**FOR SALE:** PDP-11. DEC PDP-11/05 processor boards with 4 K core memory, 16 to 64 K programmable memory, and parity controller. All working. Also, TI Silent 743 (new) with full ASCII keyboard. Sell all, separately, or trade for line printer or what have you. Make offer. Jack Kreska, 1429 Warwick St, Garland TX 75042, (214) 495-2680.

**FOR SALE:** Microcomputer magazine collections. BYTE 10/76 (#14) to 12/80 (51 issues) for $50. *Kilobaud Microcomputing* 1/77 (#1) to 12/80 (all 48 issues published) for $70. *Interface Age* 7/76 (#8) to 8/80 (48 issues plus several original SCCS journals) for $35. All plus book rate postage. John Cameron, POB 1517, Palo Alto CA 94301, (415) 327-0341.

**HELP:** I need any information at all about a Compucord 1210 digital cassette tape transport made by Compucord Inc of Waltham, Massachusetts. The company no longer exists, at least in Waltham. Any information regarding this device, the manufacturer, or any source of documentation is eagerly sought. I will be happy to pay for copying, or copy and return all material by return mail. Fred Goldberg, 29 Clearview Rd, E Brunswick NJ 08816, (201) 257-8753.

**MUST SELL:** One slightly used Cray-1—too big for my apartment. Hardware included: light-dimmer interface, toaster interface, one homebrew 64-bit parallel I/O port with Nixie-tube indicators, coat hangers, extra buffing powder for instruction buffers, one box of bootstraps. Software included: CAL assembler on thirteen cassette tapes in Kansas City format, Morse-code trainer, tic-tac-toe game, 8080 emulator. Price is negotiable. A Pritful, POB 463, Peanutbutter NH 03458.

**FOR SALE:** TI-59, PC-100A (in perfect working condition), three modules (Master, Statistics, Mathematics and Utilities), eight specialty packettes (Engineering, Science, Securities, Marketing, etc), 20-roll paper for PC-100A, and many finance utility programs. If brand new, you would pay $640. Now all can be yours if you send a cashier's check for $460. C M Chen, 120 Columbus Pl, Stamford CT 06907, (203) 322-7857.

**WANTED:** MMD-1 microprocessor trainer in operating condition. Please state asking price in first offer. D C Shoemaker, 2000 A Foxridge, Blacksburg VA 24060, (703) 552-5764.

**FOR SALE:** 48 K Apple II plus complete with two paddles, some programs, and cassette recorder with interface jack. Only three months old and in great condition. $1300. Eric Podell, 14949 Wellwood Rd, Silver Spring MD 20904.

**FOR SALE:** Sold system, must sell software at super reduced prices. Dozens of CP/M, languages, business s/w (G/L, A/R, A/P, etc). Send SASE for complete list and prices. Dee B Moser, Box 638, Great Bend KS 67530.

**WANTED:** June 1977 and October 1980 issues of BYTE. Will pay cash or trade March 1978, July 1980, August 1980, September 1980 issues. Also, I have for sale a Godbout 8 K S-100 4 MHz programmable memory board, assembled and working; $50. Thomas Kryst, 5242 E 24th St Apt D, Anchorage AK 99504.

**FOR SALE:** Speak & Spell with Speak-2-Me-2 installed by Percom Data. 230-word vocabulary plus program to form words from parts of vocabulary words. Complete with modified printer interface cable, user's manual, and driver programs. Set up for TRS-80 Level II with 16 K. Instructions for other computers. Worth $200, sell for $150. Joseph Wear, Rt 1 Box 83A, New Egypt NJ 08533, (609) 758-7193.

**FOR SALE:** Okidata Model CP-110 friction-feed line printer, with RS-232 serial interface and uppercase/lowercase character set. Prints 80 columns bidirectional at 110 cps. Uses 8½-inch roll paper. Excellent condition. Cost $1349, asking $650. Virgilio DeCarvalho, Columbia-Princeton Electronic Music Center, 632 W 125th St, Room 318, New York NY 10027, (212) 280-3050.

**FOR SALE:** H-8, serial I/O board, 20 K programmable memory, cassette, Extended BASIC. Up and running, all documentation included. First $600 takes. I ship. M H Endres, Box 8, Spirit Lake ID 83869, (208) 623-5911.

**FOR SALE:** Magic Wand for TRS-80 Model II. Original disk and manual; $200. A A Schwartz, 6454 Camino Teatro, La Jolla CA 92037.

**FOR SALE:** Burroughs Series B9352 video terminal. Has printer output, uppercase, and full cursor control. $300 plus freight. Steve Nelson, Box 150, Webster MN 55088.

**FOR SALE:** PET 8 K computer with Soundware sound for PET, five tapes with programs including Microchess 2.0, and *COMPUTE* magazine for the PET. Original PET cost over $800, will settle for $675. Also, have ELF II computer complete with documentation and newsletters. Cost over $200, would like to trade for HP-41C card reader. Am interested in HP-41C equipment, willing to negotiate with PET and ELF II. Shajl Jacob, 827 Lincoln, Fort Morgan CO 80701, (303) 867-8162.

**FOR SALE:** TI #751 Silent 700 type printer. 10, 15, 30 cps, thermal, Baudot code, receive-only. Complete, but needs electrical work. With five rolls of paper and complete documentation. $100, you pay shipping, or trade for Heath H-9 terminal. Tom Hamilton, 1405 Washington, Birmingham MI 48009, (313) 647-5420 after 5 PM ET.

**FOR SALE:** OSI Superboard with expansion, 18 K programmable memory, 8 A power, 9-inch Sanyo monitor, and full enclosure; $650. 12-slot S-100 motherboard with 15 A power supply and termination; $150. Microdiversions Screensplitter 46 by 80 video display for S-100, brand new; $350. Plus much used equipment. Glenn Barnas, 280 Carmita Ave, Rutherford NJ 07070, (201) 935-0271.

**FOR SALE:** SwTPC CT-64 terminal; $300 or best. AC-30 cassette interface, works on any 300 bps RS-232 line; $80 or best. MP-A2 6800 processor card with SWTBUG; $120 or best. All assembled and tested. USR-310 modem; $130. Keyboard; $50. Must sell soon. Charles Duff, 7007 N Sheridan #317, Chicago IL 60626, (312) 386-0311 leave message.

**FOR SALE:** Multiterm printer Model T-4000: 55 cps, Diablo Hytype mechanism, tractor feed, ribbons, print wheels, many additional features, auto-underline, etc. $1700 or offer. Also, two Centronics 306C printers. $1200 each or offer. Michael Sloat, POB 982, Loma Linda CA 92354, (714) 796-2757.

**FOR SALE:** PET owners, I have sixteen 4108 programmable memory circuits guaranteed good. Will sell for $2.50 each or the entire lot for $35. Also, if your PET uses 4108s and they are in sockets, and you would like to upgrade to 32 K inexpensively, send $1 plus SASE for guaranteed instructions. I am also looking for an inexpensive printer with 40/80 lines and Centronics-type parallel input. Harry E Leggans, Box 1179, APO New York 09023.

**FOR SALE:** Alpha 16 mainframe includes processor, clock/controller, teletypewriter interface, 4 K memory, floppy-disk controller, and power supply. Also, much software and all manuals. $500 or offer. Edwin Karlow, Department of Physics, Loma Linda University, Riverside CA 92515, (714) 785-2143.

**FOR SALE:** Siemens FD100 mini floppy-disk drives with manuals, power supplies, and cases. $250 each or best offer. Western Digital 1771 floppy-disk controller circuits. $8 each. Marcy Durkee, 10265 Meadowwood Ln, Overland MO 63114.

**WANTED:** Used computer-science books. Reasonably priced, in good condition; for personal use—only one copy of a title wanted. Examples: programming languages, Knuth (volume 2), programming techniques, compiler design, applications, etc. J R Berman, 494 Forest Ave, Teaneck NJ 07666.

**FOR SALE:** TRS-80 Model I, Level I, 4 K. Like new, hardly used. $500. Also, Apple games for trade—Invader, Asteroids, Sargon, etc. Randy Strouth, RR 5 Box 63, Faribault MN 55021, (507) 334-6585.

**FOR SALE:** Digital Group Z80, Diskmon, Business BASIC, 64-character, 26 K dynamic; $1200. Two 8-inch disk drives and Digital Group controller; $1600. Keyboard (needs repair) and 9-inch monitor; $250. Whole system for $2800. Wayne Dirks, 801 E 10th, Hutchinson KS 67501, (316) 663-3998 days.

**FOR SALE:** TRS-80 Model III computer with 48 K programmable memory, brand-new condition. Complete documentation plus several TRS-80 books. $950. Also, HP-41C programmable calculator with card reader plus blank cards, four memory modules, and MATH and STAT modules. $500. Alan J Grant, 530 44th St, Brooklyn NY 11220, (212) 436-1714 weekends or after 6 PM weekdays.

**FOR SALE:** Commodore PET 2001 computer with 8 K programmable memory and new 2.0 read-only memories. Has on-board cassette and small keyboard. $50 deposit for shipping by UPS collect, balance due of $475. Dan Rubis, 19713 Alger, St Clair Shores MI 48080, (313) 771-1392.

**WANTED:** User's manual for Processor Technology 32KRA memory board. Steve Grant, 6055 E Washington Blvd, Suite 1035, Commerce CA 90040, (213) 725-1563.

**FOR SALE:** Heath H-8, dual-drive H-17, H-9 video terminal, three 8 K programmable memory cards, serial/cassette interface. Entire system for $1500 or sell in parts. Richard Berhain, 142 Jefferson Ave, Hasbrouck Heights NJ 07604, (201) 288-1693.

**FOR SALE:** North Star 2 system. Double-density, 48 K, with D C Hayes modem. Two serial and one parallel ports, SOROC IQ 140 terminal, and Centronics 779 tractor printer. Includes $2000 in business software. Six months old, in original boxes. $4895 or best offer. Also, D C Hayes modem 100; $325. Don, (615) 526-7651.

**FOR SALE:** Heath H-9 terminal; Heath H-10A reader/punch; TI 9900 single-board 16-bit microcomputer. Complete manuals and software included. Best offer. D Montgomery, Box 27, Oakland FL 32760, (305) 656-4293.

**FOR SALE:** Super ELF with expansion board, 4 K static programmable memory, two I/O ports, Super Monitor, ASCII keyboard, 4-slot expansion case, power supply, RF modulator, Tiny BASIC cassette, and manuals; $250. Electric Crayon I/O-driven color graphics unit with 2 K memory, graphics firmware, manual, and built-in RF modulator. Alphanumerics and graphics expandable to 256 by 192. $200. Brent Elder, 7422 N Campus #7, Cornell University, Ithaca NY 14853, (607) 256-6750.

**FOR SALE:** Model 33 ASR teletypewriter with manuals, paper-tape reader and punch, and stand. Mint condition, less than 100 hours on usage meter. $595 plus shipping. Automatic motor control installed and tested is $30 extra. Ken Brand, 421 Fairview Ave, Winchester VA 22601, (703) 662-0665 after 6 PM.

**WANTED:** January and May 1979 BYTE. May and June 1978 *Creative Computing*. January, May, July, and December 1978 *Kilobaud Microcomputing*. Name your price. Robert Lansdale Jr, 18 Ashfield Dr, Etobicoke Ontario, M9C 4T6 Canada.

# BOMB
# BYTE's Ongoing Monitor Box

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## January BOMB Results: Hand-Held Computers

Readers responded to our January theme by voting top honors for "The Panasonic and Quasar Hand-Held Computers: Beginning a New Generation of Consumer Computers" by Gregg Williams and Rick Meyer (January 1981 BYTE, page 34). Because Gregg is an employee of BYTE, the $100 prize will go to Rick.

Steve Ciarcia captured second place for his article "Electromagnetic Interference," page 48 and receives $50.

Third place was taken by Teri Li for his article "Whose BASIC Does What?" Fourth place went to Michael Keith and C P Kocher for their article "The NEC PC-8001: A New Japanese Personal Computer."

With the January issue, we began to collect votes for the BOMB (BYTE's Ongoing Monitor Box) through responses on one of the reader-service cards. This resulted in an increased number of votes and many favorable comments from readers. ■

# Reader Service



To get further information on the products advertised in BYTE, fill out the reader service card with your name and address. Then circle the appropriate numbers for the advertisers you select from the list. Add a 15-cent stamp to the card, then drop it in the mail. Not only do you gain information, but our advertisers are encouraged to use the marketplace provided by BYTE. This helps us bring you a bigger BYTE. The index is provided as an additional service by the publisher, who assumes no liability for errors or omissions. *Correspond directly with company.

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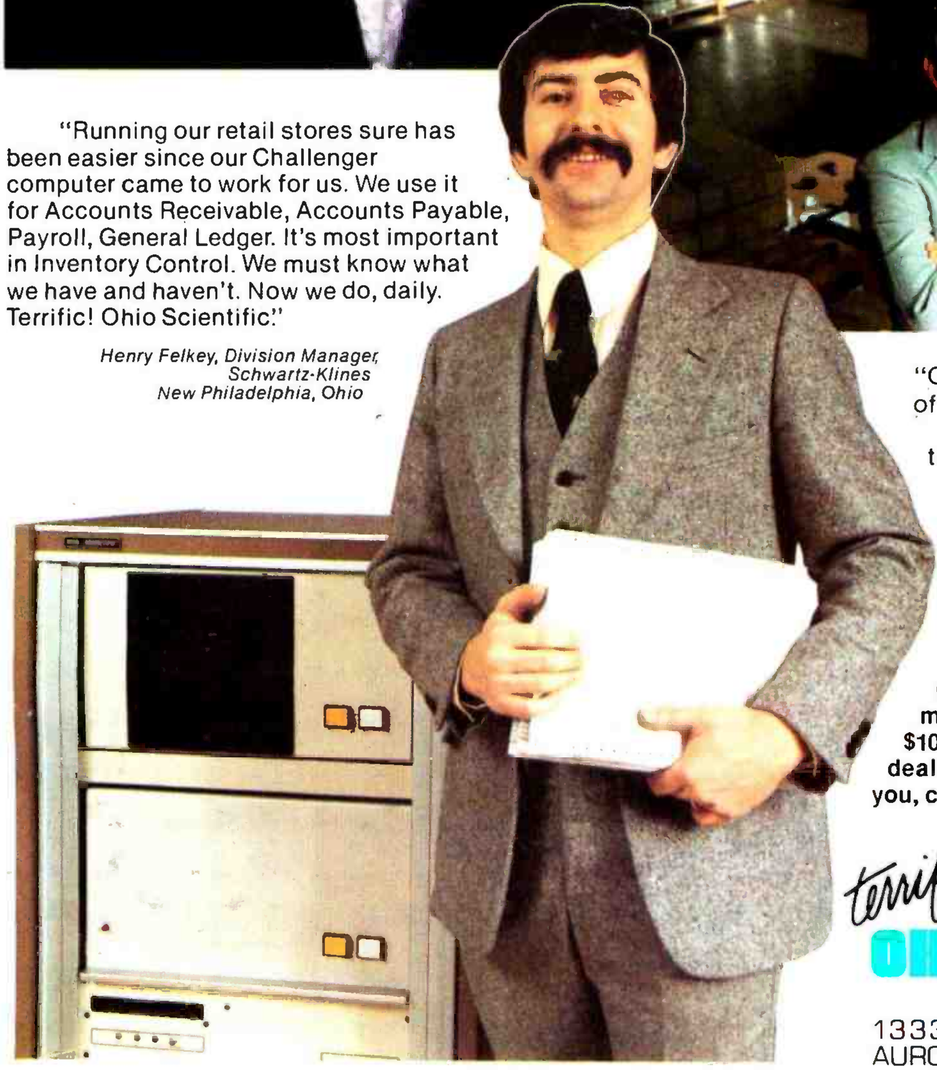
*Holly Quarles, President, Commonwealth Capital Corp.
Charlottesville, Virginia*



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