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# BYTE

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GRAPH THEORY

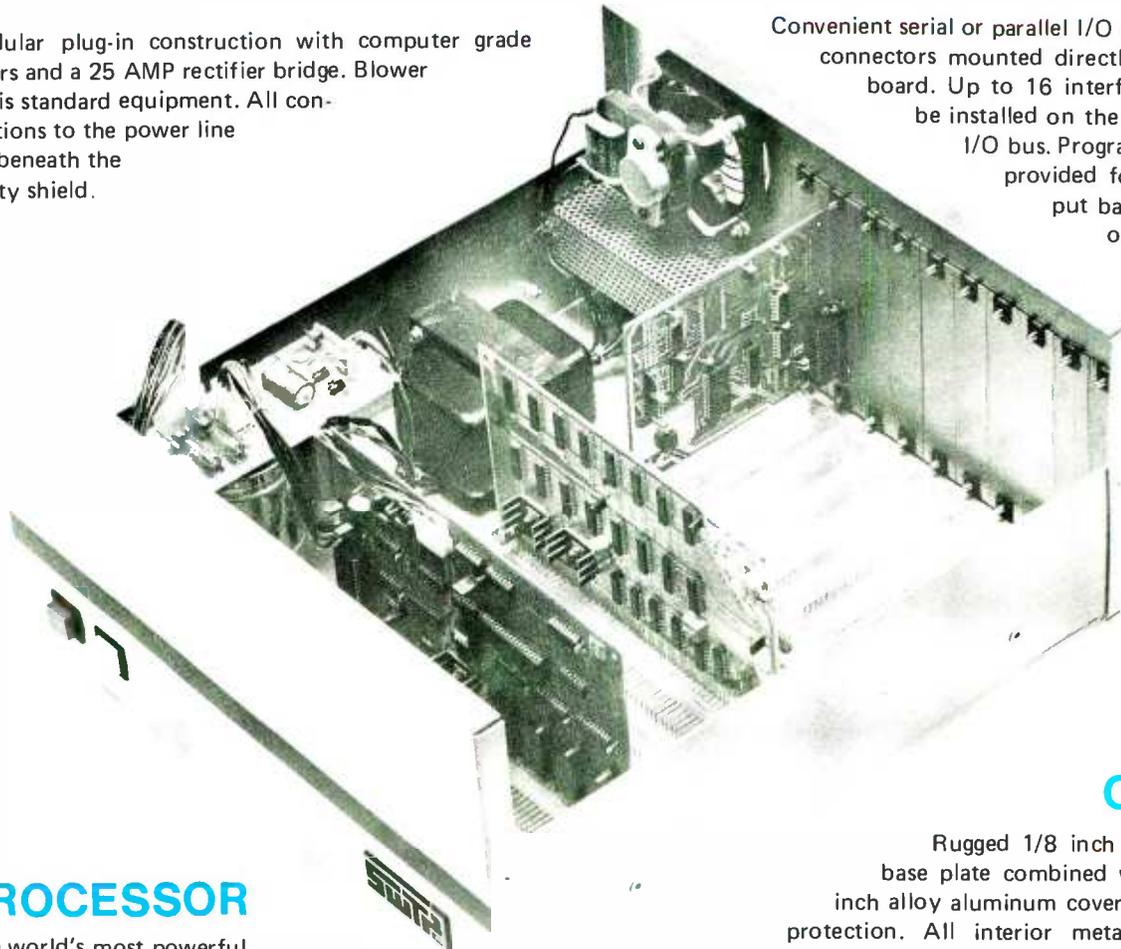
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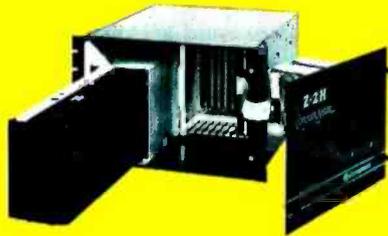
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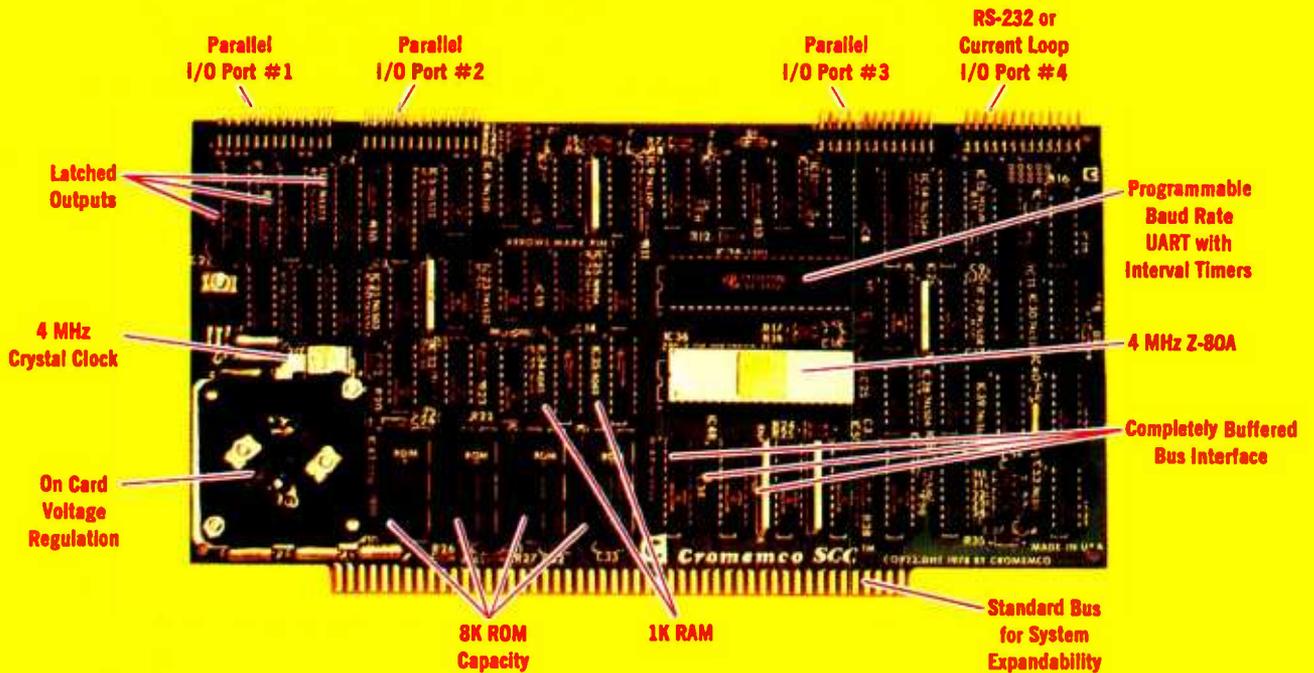
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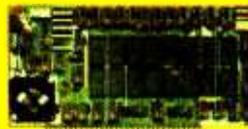
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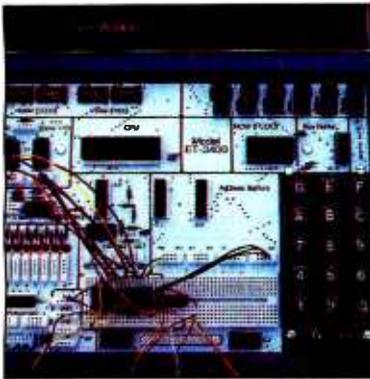
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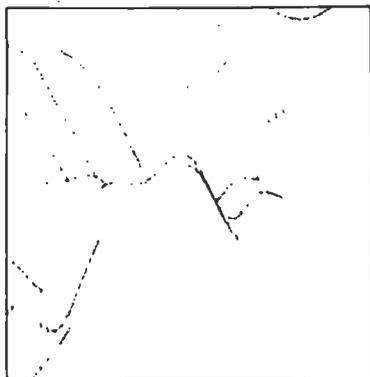
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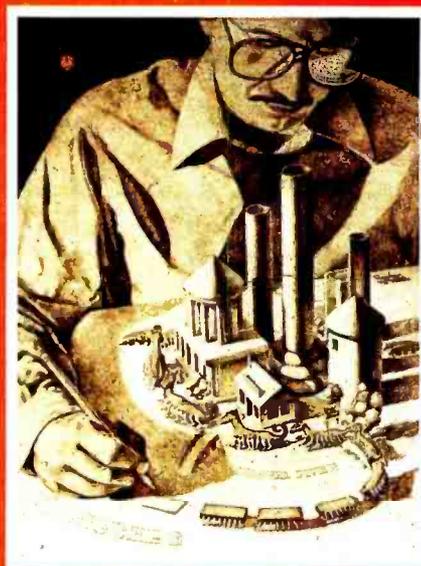
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## ON THE COVER

*Topology is the theme of this month's cover painting, "The Seven Bridges of Königsberg" by Robert Tinney. It is a fanciful representation of a classical, topological problem made famous by the Swiss mathematician Euler, and it has a more than passing resemblance to the works of the Swiss artist M C Escher. The celebrated problem is discussed in detail by Carl Helmers in this month's editorial, and the painting is also loosely inspired by the theme article, "A First Look at Graph Theory Applications," by Ashbrook and Zinn. Sharp-eyed readers might spot a visual reference to another famous mathematical problem hidden in the cover.*

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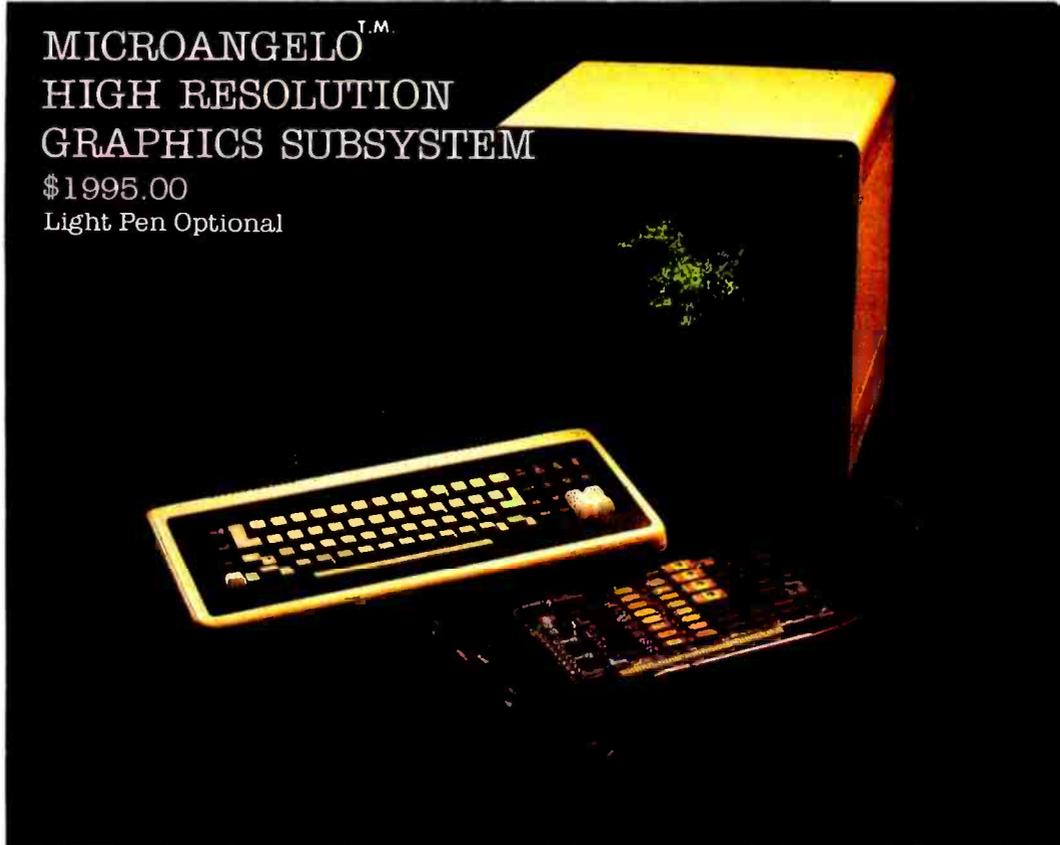
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# Editorial

## The Seven Bridges of Königsberg

by Carl Helmers

Covers, like editorial themes, are sometimes drawn from interesting subjects intended as themes for an issue. But divergences can occur. This month, the nominal theme for the issue is the topic of graph theory. It takes only one article to suggest such a cover theme, and the article "A First Look at Graph Theory Applications" by Michael Ashbrook and Helmut Zinn provided the initial suggestion. But our actual cover is inspired by a historical problem in mathematics which led to the definition of a much broader field: topology.

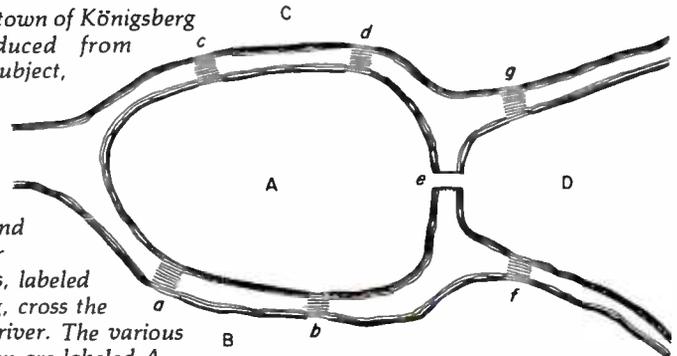
This generalization occurred as a result of trying to find a nice neat visual image that fits the topic of graph theory. In order to concoct a cover idea on graph theory, the first step is to start searching around for some theme on a diagram of nodes and interconnecting segments which is not some hackneyed abstract pun. In order to construct a visual image for a cover, I needed to find some seminal problem with dramatic visual import. This problem must define and suggest the general field of endeavor. So, I proceeded to hunt around.

A good forest in which to hunt mathematical images is an excellent four-volume set of books entitled *The World of Mathematics*, by James R Newman, published by Simon and Schuster in 1956, and still available at a cost of \$39.95. On the covers of the four volumes we find the description "a small library of the literature of mathematics, from A'h-mose the Scribe to Albert Einstein, presented with commentaries and notes." These books present a selection of original papers by mathematicians, with introductions and commentary by the editor. As serious or recreational reading for those interested in mathematical subjects, I highly recommend it.

So, naturally, I turned to the index of Mr Newman's book. I knew that somewhere in that 2535-page work I might find some visual image with which artist Robert Tinney could work to create a cover. It did not take long to find the appropriate image. On pages 570 thru 599 we find Mr Newman's commentary on graph theory, which is really an illustrative subset of a much more general field, topology. Following three pages of editor's commentary, the two papers reproduced in this section of the book are Leonhard Euler's memoir "The Seven Bridges of Königsberg" (1735) and a survey article "Topology," by Richard Courant and Herbert Robbins, taken from their book *What Is Mathematics?* (Oxford University Press, 1941). When I encountered the problem of the Seven Bridges of Königsberg in the form of Euler's paper, I knew we had a cover image.

The problem is quite simply stated: a city, Königsberg, is built on an island in the river Pregel (see figure 1). We wish to find out if it is possible to cross all seven bridges in an afternoon's walk without crossing any bridge more than once.

Figure 1: Map of the town of Königsberg in Prussia, reproduced from Euler's paper on the subject, first published in 1735. Within the town there is an island called Kneiphof, labeled A in the figure, around which flows the river Pregel. Seven bridges, labeled a, b, c, d, e, f, and g, cross the two branches of the river. The various land areas of the town are labeled A, B, C, and D.



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What Euler did, in an eminently readable argument in his paper, is to prove that it is indeed *not* possible. He proves that the popular hobby of the Königsberg folk of seeking that magic path could never succeed. In so doing, he helped to found the science of topology. According to Newman in his commentary on the paper,

*The problem — to cross the seven bridges in a continuous walk without recrossing any of them — was regarded as a small amusement of the Königsberg townsmen. Euler, however, discovered an important scientific principle concealed in the puzzle. He presented his simple and ingenious solution to the Russian Academy at St Petersburg in 1735. His method was to replace the land areas by points and the bridges by lines connecting these points. The points are called vertices; a vertex is called odd or even according as the number of lines leading from it are odd or even. The entire configuration is a graph; the problem of crossing the bridges reduces to that of traversing the graph with one continuous sweep of the pencil without lifting it from the paper. If the graph contains more than two odd vertices, it may be traversed in one journey but it is not possible to return to the starting point. The general principle is that if the graph contains  $2n$  odd vertices where  $n$  is any integer, it will require exactly  $n$  distinct journeys to traverse it. . . .*

*Thus began a "vast and intricate theory [topology]," still young and growing, yet already one of the great forces of modern mathematics.*

Now we had the general outline of the image. Fine details remained to be worked out with Robert. Now, Robert Tinney and I know of a number of artists that we regard as extremely interesting in general style and subject matter. There are, for example, the direct and conscious influences of Maxfield Parrish and Norman Rockwell on Robert's style of painting as often seen in covers of *BYTE*. However, we have of late been getting immersed in the fascinating art of M C Escher. Part of this fascination has been lying dormant since Martin Gardner's series of articles on Escher and tessellations of the plane in *Scientific American* (see his "Mathematical Games" column in the July 1975 (page 112), August 1975 (page 112), December 1975 (page 116), January 1977 (page 110), and June 1978 (page 18) issues). The fascination is of course greatly rekindled by the recent publication of the book *Gödel, Escher, Bach* by computer scientist Douglas R Hofstadter.

So, given the theme of the seven bridges of Königsberg, the added input of a recursive-programming computer-science pun clearly evident in the image, and a fascination with Escher's style, Robert chose to produce a cover image inspired by the art of Escher. The result is what you see. ■

#### In Next Month's *BYTE*

The March 1980 *BYTE* will be devoted to "Computers and the Sciences." The theme articles will cover diverse topics such as "Electron Behavior in Chemical Bonds," "Electronic Planimetry," "Chemistry Program for the Apple Computer," and a "Deraileur Speed-Calculation Program."

#### An Update on Direct Cursor Addressing and UCSD Pascal

In last month's editorial on the Apple Pascal system, I made some comments about difficulties in getting the UCSD System to emit the cursor addressing character of my Computer Peripherals Corp "COPS-10" terminal. This terminal requires the sequence of "control-P, <Y+32>, <X+32>" to directly address a given location on the screen.

It turns out that the UCSD Pascal System (not just the Apple II version) gobbles "control-P" characters on output, whether through use of *WRITE*, *WRITELN* or even *UNITWRITE*. Naturally, it became a challenge to find out how to emit a control-P.

So, trying brute force as a first method of solution, I wrote an assembly language program using the UCSD Pascal System's 6502 assembler. This assembly language program simply set up the parameters for the routine "SHOUT" within the Apple II serial card's read-only memory, then called that routine to emit the control-P character. I proved it worked by writing a Pascal *GOTOXY* procedure and test program.

The UCSD Assembler proved more than adequate for my purposes, in its 6502-oriented version running on the Apple. A most useful feature is its macro-instruction facility with conditional assembly. The Apple documentation of the UCSD System includes examples of assembly language interfaces which proved to be quite a helpful model. There was one convention that I had to worry about for a few assemblies. This was the fact that the assembler only allows hexadecimal integer constants. The assembler also demands uppercase only for tokens, although lowercase works fine in comments.

Of course, the version of the Pascal *GOTOXY* that used this assembly language procedure had to have an external procedure definition. This presented no problem when compiling without any special compiler options. But the manual points out (and experience confirms) that the "{*SU-*" option must be active when compiling the code file that will be linked into the system by *BINDER*. Every time I try to compile with the required {*SU-*} compiler toggle, I get a Pascal syntax error #183, "External declaration not allowed at this nesting level." This was in spite of the fact that the "PROCEDURE *CTRLP3*; EXTERNAL;" sequence is at the outer (PROGRAM) level of nesting.

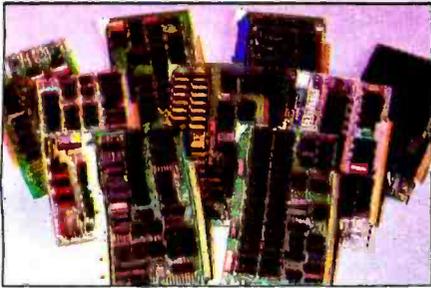
I tried everything I could think of: linking before *BINDER*, not linking, using it with the {*SU*} toggle and without, etc. I even recalled the existence of a magical UCSD Pascal compiler toggle "{*ST+*", which is required for compilation of super-large systems programs. When used with the {*SU-*} option, I could get the program to compile and link with the assembly language program—but then *BINDER* would not accept it. Clearly it was all to no avail. Would I be stuck with the *GOTOXY* cursor kludge of

```
<home> <LF> . . . <LF> <HT> . . . <HT>
```

forever?

# At Intersystems, "dump" is an instruction. Not a way of life.

(Or, when you're ready for IEEE S-100, will your computer be ready for you?)



We're about to be gadflies again.

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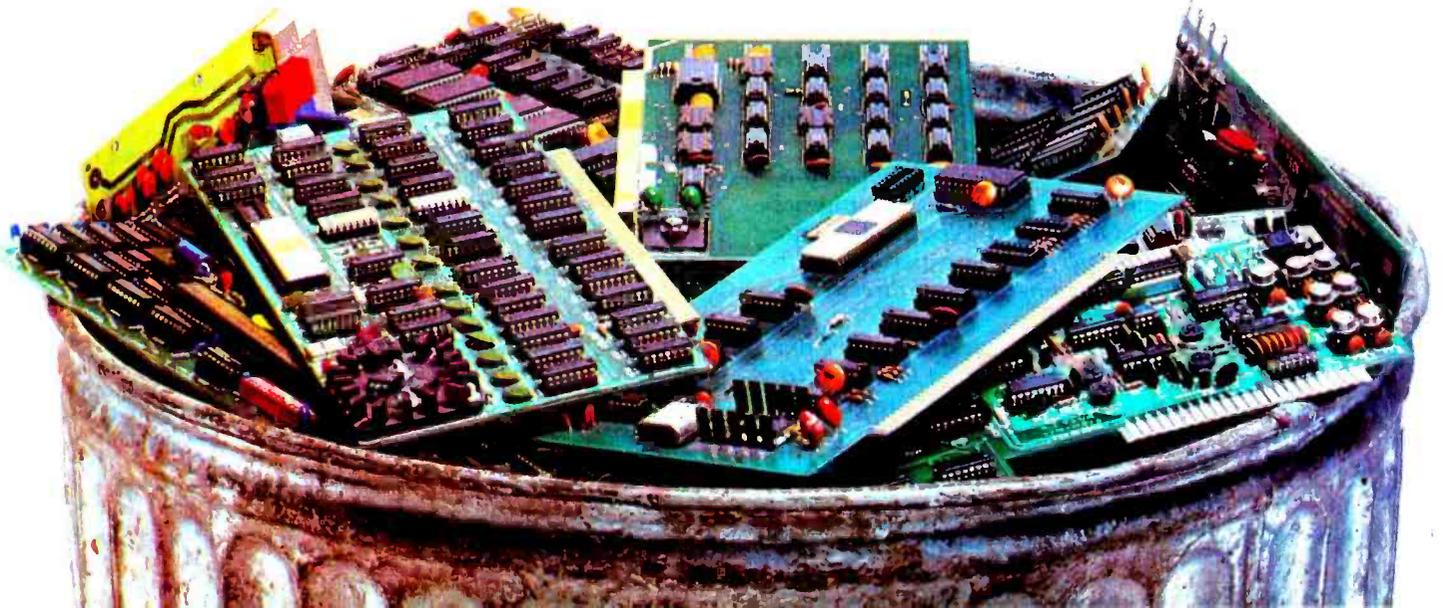
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Well, impossible problems lead to new solutions when frustrations get high enough. One solution would of course be a new terminal that had the necessary cursor control keys (the up/down/left/right arrows) but used a different direct addressing sequence.

On the day I solved the problem, I was talking with Cameron Jones about getting the UCSD Pascal System version for my New England Digital Synclavier music synthesizer. (Cameron Jones, Syndey Alonzo, and Jon Appleton are the co-inventors of the Synclavier.) As the Synclavier and its ABLE/60 computer comes delivered, its native language is XPL. So implementing a UCSD Pascal system becomes a problem of implementing the core interpreter in XPL.

As I was talking on the phone with Cameron, I finally realized what was wrong. The cursor addressing character of my terminal is an ASCII DLE character which is also known as control-P when emitted from a keyboard. And the UCSD System will always eat control-P characters, since this is the spaces-compression escape character of ".TEXT" files! Cameron pointed out that the specification of the UCSD Pascal UNITWRITE routine is that it will do spaces decompression.

So I had to have a character that looks like a control-P to the terminal but not like a control-P to UCSD Pascal. This character is of course a character with the integer value 144. Its value is obtained by turning on the high-order bit in an 8-bit character by adding 128 to the control-P character code's value of 16. While the Pascal program's character data value are 8 bits, the terminal only looks at the low-order 7 bits. Thus, if the low-order looks like a control-P, turning on the high-order bit will keep Pascal from thinking it really is a DLE while allowing the terminal to think it is.

Everything else immediately simplified and fell in place. Listing 1 shows the final version of the GOTOXY procedure, which now emits an 8-bit

pseudo-control-P character that gets interpreted by the terminal as a 7-bit control-P character.

Of course, by getting frustrated by this problem, I explored the use of assembly language features of the UCSD System. I learned how to link successfully to assembly language programs, use the macroassembler that comes with the system, and unwind parameters from the Pascal stack in assembly language programs. I will probably never again use an assembly language program with a Pascal program. But if I need to for some reason of speed, I now know it is possible. This short note and this month's editorial were the first texts I edited using the new version of GOTOXY; the results are quite an improvement — I am no longer limited by rather artificial delays required by last month's cursor addressing kludge.

#### Listing 1:

```
(ssu-s)
PROGRAM GOTOXY
  ( The final version of the GOTOXY procedure, used with Apple Pascal )
  ( and the Computer Peripherals Corporation COPS-10 terminal. The )
  ( ASCII (7 bit) sequence! )
  ( <ctrl P> <+32> <x+32> )
  ( causes direct cursor addressins. )
PROCEDURE FGOTOXY(x_axis,w_axis: INTEGER)
  ( COPS 10 - GOTOXY )
CONST
  control_P = 144 (high order bit on; but no effect 16+128!)
VAR
  x,w : INTEGER;
  abute : PACKED ARRAY[0..03] OF CHAR;
BEGIN
  ( ... how do we send a "control P" when the Pascal UNITWRITE will )
  ( gobble it because it thinks that it is spaces compression chr- )
  ( actor? Well, recognize that the terminal only pays atten- )
  ( tion to 7 low order bits. Thus if we send a control P with )
  ( the high order bit on, then UNITWRITE will saw "aha that is not )
  ( a control P" and the terminal will saw "aha that is a control P" )
  abute[0] := CHR(control_P);
  UNITWRITE(1,abute,1..1);

  x := x_axis + 32;
  w := w_axis + 32;
  IF x > 111 THEN x := 111; (111 = 79 + 32)
  IF x < 32 THEN x := 32;
  IF w > 55 THEN w := 55; (55 = 23 + 32)
  IF w < 32 THEN w := 32;
  abute[0] := CHR(x);
  UNITWRITE(1,abute,1..1);
  abute[0] := CHR(w);
  UNITWRITE(1,abute,1..1);
END (soLoxy);

BEGIN ( # DUMMY MAIN # )
END.
(ssu-s)
```

### On Eclipses, Next Month's Editorial and the West Coast Computer Faire. . .

As you read this February 1980 issue of BYTE, I will be embarking on a journey to make the technological fantasy of last July's editorial ("Computers and Eclipses," page 8) real. In the March 1980 editorial, I plan to describe some of the details of the computer system which will control my Nikon F2A camera in automatic photography of the 1980 solar eclipse from Kenya in Africa.

I am scheduled to leave for Kenya on February 6, 1980, joining a small expedition of solar physics experimenters organized by Norm Whyte of Monte Rio, California. Norm is performing experiments involving a custom designed camera under direct computer control of an Apple II.

The only uncertainty is what the weather will be like at our observation site on the morning of February 16, 1980. Whatever the weather, readers who are going to the West Coast Computer Faire in San Francisco in March 1980 will be able to see the results in a talk

entitled "Microcomputers in Africa: A Travelogue of The 1980 Eclipse."

Norm and I will be presenting this talk as part of the technical program. It will feature slides made during the trip showing the setup and equipment (as well as scenery) and—weather permitting—slides of the eclipse itself. . . .CH

#### Articles Policy

BYTE is continually seeking quality manuscripts written by individuals who are applying personal computer systems, designing such systems, or who have knowledge which will prove useful to our readers. For a more formal description of procedures and requirements, potential authors should send a large (9 by 12 inch, 30.5 by 22.8 cm), self-addressed envelope, with 28 cents US postage affixed, to BYTE Author's Guide, 70 Main St, Peterborough NH 03458.

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It generates both U.S. and European TV rates and meets the new IEEE S-100 standard. Other features include keyboard input, black on white or white on black, one level of grey, underline, strike thru, blinking char., blank-out char., and programmable cursor. Software includes a CP/M compatible driver and a powerful terminal simulator.

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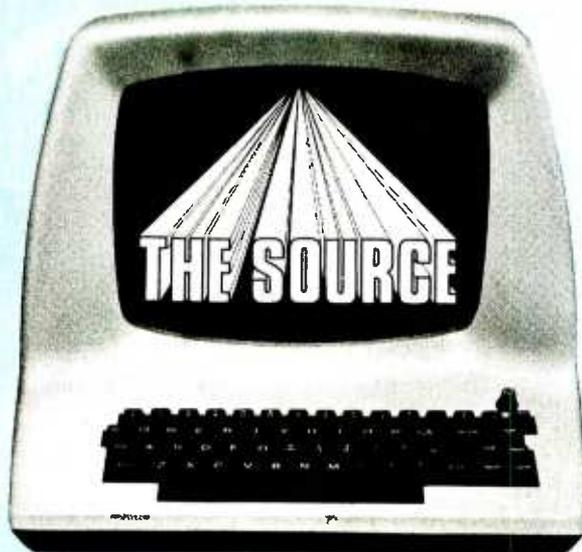


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# Letters

## 8086 Software Needed

I am interested in designing systems based on 8086 processors. Does anyone have some useful systems software to sell? I am particularly interested in file-handling software and operating systems in general. I am interested in purchasing source listings and I am prepared to visit software houses on my next trip to the US.

Martin Healey  
Computer Systems Consultant  
9 Ennerdale Close  
Penylan, Cardiff CF2 5NZ  
GREAT BRITAIN

## Battle of the Buses

In the October 1979 "BYTE News," page 107, Sol Libes contends, in an item about the S-100 bus, that "those who wish to have a machine capable of get-

ting the maximum benefits of microprocessors must go the S-100 route." While Mr Libes was comparing the S-100 bus to all-in-one systems, such as the TRS-80 and PET, his statement leaves out a number of computer systems with as much capability as S-100 systems, perhaps more in some cases. For example, the SwTPC S/09 and the Ohio Scientific Challenger III Series are two systems that come to mind. The former uses a 6809 processor with the SS-50 bus (see October BYTE, inside front cover), and the latter uses 6800, 6502, and Z80 processors and apparently OSI's own bus (see back cover, same issue). Both of these systems have a 20-bit address bus for large memories. SwTPC and several other companies make SS-50 bus systems using the 6800. Other non-S-100 bus systems include the Heath H8 and H11. Any of these systems, and probably others that I have left out, can be as good for serious personal computer

users as any S-100 bus computer. The S-100 bus is *not* the only possible route.

Mr Libes also writes that "the S-100 bus is not processor dependent." This statement is debatable, in spite of the existence of S-100 boards for a number of microprocessors. Several signals on the S-100 bus are generated *ONLY* by the 8080. Any other processor must be "bent" into generating (or responding to) these 8080-specific signals.

Personal computing could use a truly processor-independent bus. I feel that the S-100 bus will not be totally satisfactory in this role.

The mention of specific products in this letter does not necessarily constitute endorsement of these products. My point is simply that there are other buses besides the S-100, and that systems using these other buses can be just as capable as S-100 systems.

Jim Howell  
5472 Playa Del Rey  
San Jose CA 95123

## Author Libes replies:

Thank you for your letter regarding my comments on S-100 systems in the October BYTE News column. Despite the views expressed in your letter, I still stand by my view that "those who wish to have a machine capable of getting maximum benefits of microprocessors must go the S-100 route." I agree with you that SS-50 and OSI Challenger III systems offer more power than integrated systems such as the TRS-80, Apple and PET. However, they still leave much to be desired compared to S-100. I will explain shortly.

Further, I also stand by my statement that "the S-100 bus is not processor dependent." The fact is that presently there are manufacturers selling six different 8-bit processor boards (8080, 8085, Z80, 6502, 6800 and 6809) and five different 16-bit processor boards (9900, LSI-11, 8086, Z8000 and Pascal Microengine) for S-100 systems. This means that eleven microprocessors have already been interfaced to the S-100. I do not know of any other system with this processor independence. Many of these microprocessors could not even be interfaced to buses such as the SS-50 or OSI without sacrificing performance.

When it comes to maximum power and flexibility the S-100 offers the following advantages over all other systems:

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- There are currently close to two dozen different manufacturers of S-100 mainframes and about fifty manufacturers of over 400 S-100 plug-in boards. This is many times more than for any other system.
- There is greater computer power capability with S-100. What other system has direct addressing of up to 16 megabytes of memory (24 address lines) and 64 K input/output ports (16 address lines), up to eleven vectored interrupt lines, up to sixteen masters on the bus (with priority), up to twenty-three plug-in slots on the motherboard, up to 10 MHz clock on the bus, plug-in operator front panel, and more.
- The S-100 bus is now standardized by the Institute of Electrical and Electronic Engineers (IEEE) assuring conformance among manufacturers.

Regarding your reference to the H8 bus, note that Heath has discontinued production of this unit. Besides, it was dedicated exclusively to the 8080 and therefore was destined to an early death. The Heath H11 is essentially the same as and uses the same bus specifications as a Digital Equipment Corp LSI-11. Few other firms support the LSI-11 with products within the price range of the

typical hobbyist. The hardware and software facilities, compared to the S-100, are limited and expensive.

Again, thank you for reading my column and I welcome any further comments you wish to make regarding my opinions.

Sol Libes

---

### Pi in the Sky

---

As I get older, I forget more and more often that the "tricks" I sometimes use may not be common knowledge. I have recently come across several short programs that evaluate  $\pi$  to five or six decimal places. These are good programs, and I salute their authors. I, however, use the shortest of all programs for  $\pi$  and would like to pass it on. It gives an approximate answer that is in error by 27 parts in 100 million. Since this is well within the allowable error of most computers, I use it without hesitation in all computer programming expressions.

Here goes. To enter  $\pi$  accurate to six decimal places, write in its place  $1/(113/355)$ . That's all there is to it! The value of that expression is 3.14159292, while  $\pi$  is 3.14159265 . . . .

This little gem was taught to me for use on the slide rule, back during the 1940s. I pulled it out of my memoirs recently when I got my first microcomputer.

Please note that the denominator is easily remembered as the first three odd integers, doubled. The order of their appearance is obvious.

Emory W Sprenkle Jr  
POB 542 (53 Allen Rd)  
Billerica MA 01821

---

### Keep Telling It Like It Is . . .

---

Thank you for the November editorial regarding pseudoscience and biorhythms in particular. It was certainly refreshing to have a hobbyist magazine of BYTE's reputation so clearly delineate between harmless biorhythm algorithms for the sake of computing recreation and the unscientific foundations of biorhythmic theory. Too many supposedly educated and intelligent people seem to have fallen into the "computer generated, therefore true . . ." trap you described. Perhaps you have caused some of them to *critically examine* the unsupportable premises of biorhythmic theory. Now if I could just get the campus radio station to stop broadcasting horoscopes . . .

Thomas Dolash  
Assistant Professor of Physics  
Physics and Engineering Dept  
Vincennes University  
Vincennes IN 47591

---

### Good Humor Needed

---

I have found your magazine to be very educational and of excellent quality. I look forward to getting the new issue each month. However, I have a suggestion that I think might make your magazine even better and would be enjoyed by all your readers. Why not add a "Jokes & Riddles" column and a comic strip or two, and maybe a few "one-framers"? I realize that your magazine tries to present a serious approach, but I think that this addition would be a plus, and a bit of humor would make it more fun for everyone. So how about it?

William P Carlson  
Rosewood Cir  
North Syracuse NY 13212

*You would not believe the number of unsolicited cartoons we get that are anchored in the dark ages of computing prior to personal computing.*

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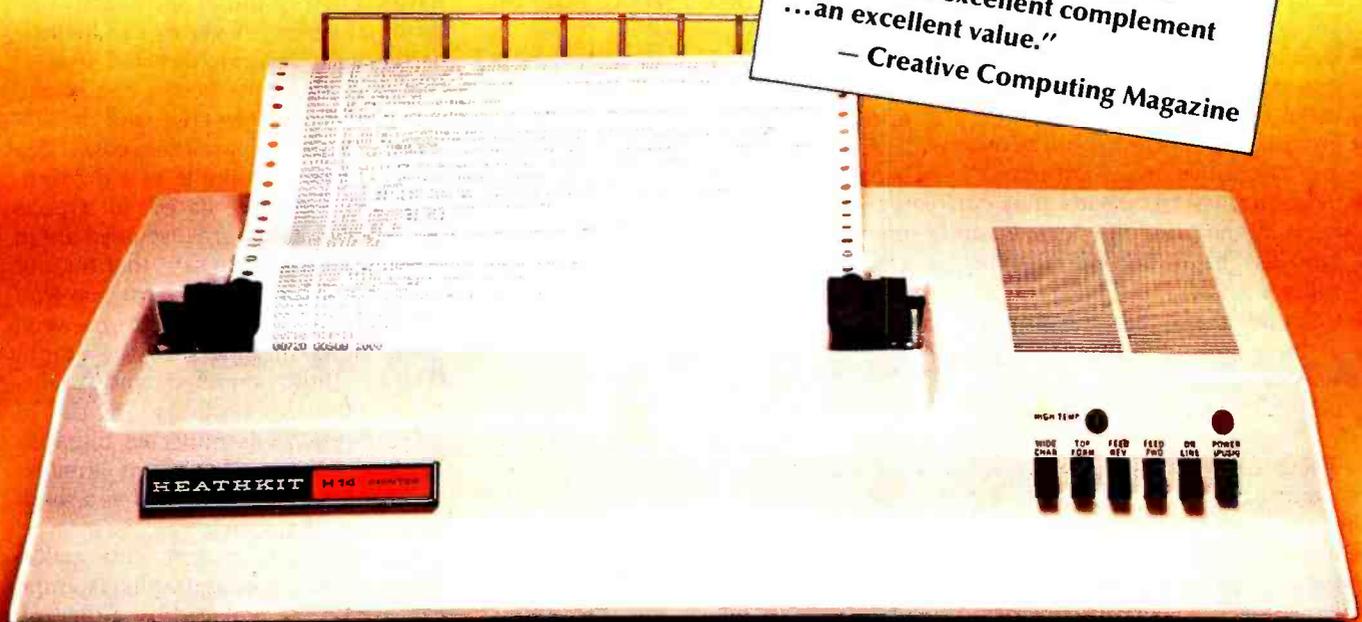
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# A First Look at Graph Theory Applications

---

Michael Ashbrook  
Helmut Zinn  
Wilhelm Epstein Str 27  
6000 Frankfurt am Main 50  
WEST GERMANY (BRD)

---

What do the following problems have in common?

- Finding the shortest route between two particular cities on a complicated road map.
- Finding the shortest route between any two cities on a road map.
- Selecting a set of roads that connects all the cities on your map and has less total mileage than any other such set.
- Calculating the maximum amount of liquid that can flow through a system of interconnected pipelines per unit of time.

These four real-life problems can be interpreted in terms of graph theory and can be solved by remarkably simple and efficient programs. The problems belong to a much larger category of operations-research problems; these were selected as examples because of their comparative simplicity. Algorithms for solving such problems along with the necessary background for understanding them will be examined.

While our terminology follows that of Narsingh Deo, our programs are quite different from his. If you become interested in solving more graph-theoretic problems on your own, you will find his book a stimulating introduction. (See *Graph Theory with Applications to*

*Engineering and Computer Science* by Narsingh Deo, Prentice-Hall, Inc, 1974.)

## Fundamental Technology and Concepts

A *graph* consists of a set of *vertices* (singular: *vertex*) and a set of *edges* that connect the vertices. In the previous examples the cities are the vertices and the roads are the edges. In drawings and diagrams the vertices of a graph are shown as dots or as tiny circles; the edges are shown as lines. A vertex and an edge are said to be *incident* if they touch. This relation of being incident holds the graph together.

A *digraph* (short for directed graph) consists of a set of vertices and a set of *directed edges*. Real-life examples of digraphs include systems of canals in which the water flows from point to point only in the downhill direction, electric networks in which the current flows only in one direction, and systems of one-way streets. The vertex from which a directed edge starts is called the *initial vertex* of the edge; that would be the point at the higher end of a canal. The vertex at which a directed edge ends is called the *terminal vertex* of the edge; that would be the point at the lower end of the canal.

Remember that each edge is incident (touches) with exactly two ver-

tices, therefore every directed edge has exactly one initial and exactly one terminal vertex. A vertex can be incident with several directed edges, therefore the same vertex can be the initial vertex of one edge and the terminal vertex of another edge. See figure 1 for an example of a digraph.

Unless explicitly stated, all graphs and digraphs that are discussed are in one piece. That is to say, that for any two vertices there is at least one way to travel back and forth between them along the edges of the graph. Graphs (both directed and undirected) with this property are said to be *connected*. Disconnected digraphs are not discussed in this context because they can be treated as a set of connected digraphs.

For a similar reason, this article will concentrate on digraphs. A graph can usually be replaced by a digraph with the same set of vertices and exactly two directed edges, going in opposite directions, for every undirected edge of the original graph.

There are many ways to represent a digraph in a computer. Each method

---

### About the Authors

Michael Ashbrook became interested in operations research after first studying mathematics. Helmut Zinn became involved with small computers through his work in electromechanical engineering. Both collaborate at the Technische Hochschule in Darmstadt.

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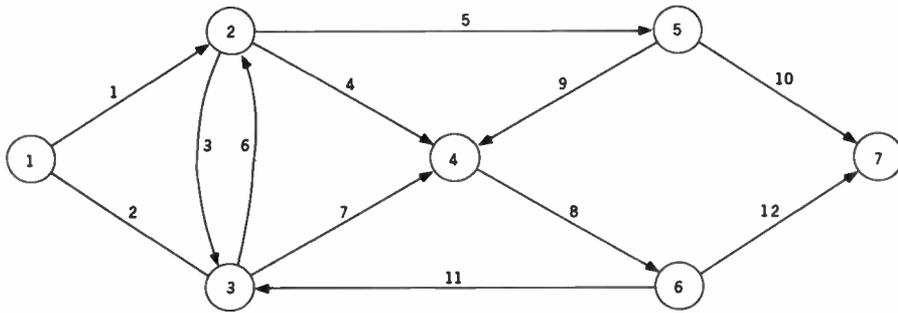


Figure 1: Example of a digraph (directed graph) that has seven vertices and twelve directed edges.

has its advantages and its drawbacks; each has its applications. The two basic methods used to encode a digraph will now be discussed.

### A Matrix Called DIGRAPH

Consider a digraph containing a certain number of vertices  $n_v$ . The  $n_v$  vertices of this digraph are represented by the natural numbers from 1 to  $n_v$ . The edges of the digraph are represented by the entries of an  $n_v$  by  $n_v$  matrix called DIGRAPH. If the digraph has a directed edge from the vertex  $i$  to the vertex  $j$ , then the entry

DIGRAPH( $i, j$ ) of matrix DIGRAPH that is in the  $i$ -th row and the  $j$ -th column has a nonzero value, DIGRAPH( $i, j$ )  $\neq 0$ . If there is no edge from vertex  $i$  to vertex  $j$ , the matrix entry DIGRAPH( $i, j$ ) is 0.

The matrix DIGRAPH can be used to store additional information about the digraph. If DIGRAPH is the mathematical model of a road map, the nonzero entries can be used to represent the distance from city  $i$  to city  $j$ . If you need to store no more data about an edge than the two vertices  $i, j$  which it connects, then the

A directed graph (digraph) consists of a set of vertices and a set of directed edges.

presence of the edge in the digraph is usually indicated by setting DIGRAPH( $i, j$ ) = 1.

The matrix DIGRAPH is best suited for small-scale applications which involve no more than roughly fifty vertices. A digraph with  $n_v$  vertices can be stored as a matrix that requires  $(n_v)^2$  storage locations.

### Disadvantages of Matrix Storage

In large-scale applications involving several hundred vertices, the matrix DIGRAPH often becomes sparse (or sparsely populated). The proportion of entries that are equal to zero increases. This happens because the real-life structures that are being stored as digraphs have relatively few edges compared to the number of edges which they could have.

Every town in the United States could be connected with all of the other towns by a direct road. As a practical matter, however, any given town is linked directly to only a few neighboring communities. Therefore, the DIGRAPH matrix of the total road system consists almost entirely of zeroes that mean nothing but the absence of a direct road between most combinations of two given towns. This matrix is very large and cannot be stored efficiently.

### Increasing Storage Efficiency

In order to solve large-scale problems using a limited amount of storage space, a more efficient way of storing digraphs is necessary. Space should not be wasted on 0s that represent nonexistent edges.

As before, the  $n_v$  vertices of the digraph are represented by the numbers 1 to  $n_v$ . The edges are listed as pairs of numbers; the edge from vertex  $i$  to vertex  $j$  is shown as the pair ( $i, j$ ).

Suppose the digraph has a certain number of edges,  $n_e$ , then these edges can be expressed as an  $n_e$ -by-2 array called EDGE. Each row ( $i, j$ ) of the EDGE array specifies one edge; the first entry  $i$  stands for the edge's initial vertex  $i$ , and the second entry  $j$  stands for the terminal vertex  $j$  of the

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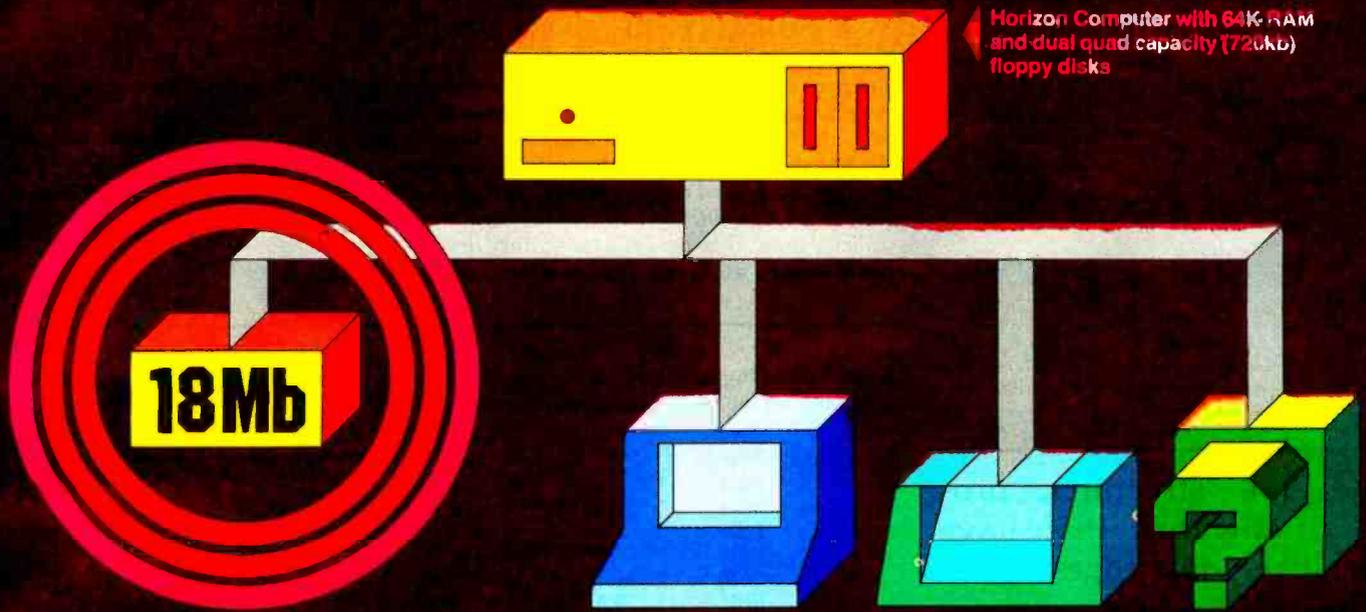
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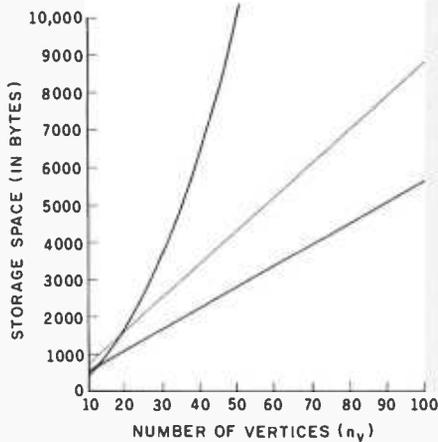
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**Figure 3:** Graph showing storage space requirements ( $st$ ) of a digraph plotted as a function  $st(n_v)$  of the number of vertices ( $n_v$ ) in a given digraph. It should be assumed that four bytes are required to store a decimal number.

The upper curve (black) shows the function  $st(n_v)$  when you use the method of storing your digraph representation in the matrix DIGRAPH.

Storage requirements of the list-oriented storage scheme vary according to the number of edges ( $n_e$ ). The equation is  $st(n_v, n_e) = 2n_v + 4n_e$ . If the digraph has some constant  $k$  times as many edges as it has vertices (represented by the equation  $n_e = kn_v$ ), then the equation of storage space becomes

$$st(n_v) = 2n_v + 4kn_v = (4k + 2)n_v$$

The curve for the case  $k=3$  is shown in red (when there are three times as many edges as vertices), and the curve for  $k=5$  is shown in blue.

One fact illustrated by this diagram is that the list-storage approach is more efficient in use of storage space than the matrix approach so long as the digraph being stored has few edges compared to the number of edges that it could have (a sparsely populated [or just sparse] digraph). In terms of the equations here, sparseness means that  $k$  is much smaller than  $n_v$ . The list-oriented storage method becomes relatively more efficient than matrix storage as digraphs become more sparse.

Real-life structures produce digraphs that have relatively few edges.

The list-oriented digraph representation is illustrated in figure 2.

### Searching the Lists

Suppose you want to find those edges that have  $i$  as their initial vertex. Look at VERTEX( $i$ , 1); if its value is zero, there are no such edges in the digraph. If its value is some nonzero value  $x$ , the first such edge is found in the  $x$ -th row of EDGE. If the value of the edge's initial pointer, PTR( $x$ , 1), is zero, there are no more such edges in the digraph. (POINTER is a reserved word in our BASIC interpreter, so we have to use the abbreviation PTR.) If PTR( $x$ , 1) equals some nonzero value  $y$ , the next such edge is found in the  $y$ -th row of EDGE and the new pointer is found in PTR( $y$ , 1).

Continue to follow the pointers from edge to edge until a pointer with the value zero is found, which tells you that you have now found all the edges that have  $i$  as their initial vertex. If you substitute the value 2 wherever 1 occurs in the preceding paragraph, then there is an adequate explanation of the systematic search for all edges that have  $i$  as their terminal vertex.

The same scheme that has been

**Listing 1:** The digraph input and concatenation program in BASIC. This program was developed on an Exidy Sorcerer computer system.

```

10 REM .....
20 REM *
30 REM * DIGRAPH INPUT AND CONCATENATION *
40 REM *
50 REM * COPYRIGHT 79/4 BY *
60 REM * MICHAEL ASHBROOK & HELMUT ZINN *
70 REM * FRANKFURT AM MAIN *
80 REM *
90 REM .....
100 REM READ AND LINK EDGE LIST
110 INPUT "NUMBER OF VERTICES"; NV
120 INPUT "NUMBER OF EDGES "; NE
130 DIM VERTEX(NV, 2)
140 REM VERTEX(V, 1) = EDGE WITH V AS INITIAL VERTEX
150 REM VERTEX(V, 2) = EDGE WITH V AS TERMINAL VERTEX
160 DIM EDGE(NE, 2), PTR(NE, 2)
170 REM EDGE(E, 1) = INITIAL VERTEX OF EDGE E
180 REM EDGE(E, 2) = TERMINAL VERTEX OF EDGE E
190 REM PTR(E, 1) = NEXT EDGE WITH THE SAME INITIAL VERTEX
200 REM PTR(E, 2) = NEXT EDGE WITH THE SAME TERMINAL VERTEX
210 FOR E=1 TO NE
220 PRINT E; "EDGE (INITIAL VERTEX, TERMINAL VERTEX) ";
230 INPUT EDGE(E, 1), EDGE(E, 2)
240 NEXT E
250 REM SETTING UP THE POINTERS
260 REM L=1 IMPLIES INITIAL POINTER OR VERTEX
270 REM L=2 IMPLIES TERMINAL POINTER OR VERTEX
280 FOR L=1 TO 2
290 FOR E=1 TO NE
300 V=EDGE(E, L)
310 IF VERTEX(V, L)=0 THEN PTR(E, L)=0: GOTO 330
320 PTR(E, L)=VERTEX(V, L)
330 VERTEX(V, L)=E
340 NEXT E
350 NEXT L
360 PRINT
370 PRINT " VERTEX LIST";
380 PRINT TAB(20); "EDGE LIST";
390 PRINT TAB(40); "POINTER LIST"
400 N=NV: IF NV < NE THEN N=NE
410 FOR I=1 TO N
420 IF I > NV THEN GOTO 440
430 PRINT I; VERTEX(I, 1); VERTEX(I, 2);
440 IF I > NE THEN GOTO 470
450 PRINT TAB(20); I; EDGE(I, 1); EDGE(I, 2);
460 PRINT TAB(40); I; PTR(I, 1); PTR(I, 2);
470 PRINT
480 NEXT I
490 END

```



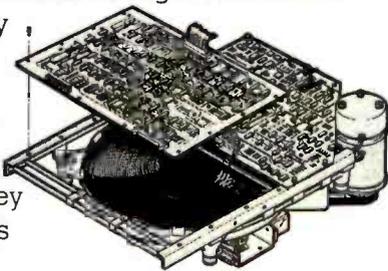
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Listing 2: A sample execution of the program of listing 1 using data from figure 1. An interpretation of the output is given in figure 2.

```

RUN
NUMBER OF VERTICES? 7
NUMBER OF EDGES ? 12
1 EDGE (INITIAL VERTEX, TERMINAL VERTEX) ? 1,2
2 EDGE (INITIAL VERTEX, TERMINAL VERTEX) ? 1,3
3 EDGE (INITIAL VERTEX, TERMINAL VERTEX) ? 2,3
4 EDGE (INITIAL VERTEX, TERMINAL VERTEX) ? 2,4
5 EDGE (INITIAL VERTEX, TERMINAL VERTEX) ? 2,5
6 EDGE (INITIAL VERTEX, TERMINAL VERTEX) ? 3,2
7 EDGE (INITIAL VERTEX, TERMINAL VERTEX) ? 3,4
8 EDGE (INITIAL VERTEX, TERMINAL VERTEX) ? 4,6
9 EDGE (INITIAL VERTEX, TERMINAL VERTEX) ? 5,4
10 EDGE (INITIAL VERTEX, TERMINAL VERTEX) ? 5,7
11 EDGE (INITIAL VERTEX, TERMINAL VERTEX) ? 6,3
12 EDGE (INITIAL VERTEX, TERMINAL VERTEX) ? 6,7

```

VERTEX LIST	EDGE LIST	POINTER LIST
1 2 0	1 1 2	1 0 0
2 5 6	2 1 3	2 1 0
3 7 11	3 2 3	3 0 2
4 8 9	4 2 4	4 3 0
5 10 5	5 2 5	5 4 0
6 12 8	6 3 2	6 0 1
7 0 12	7 3 4	7 6 4
	8 4 6	8 0 0
	9 5 4	9 0 7
	10 5 7	10 9 0
	11 6 3	11 0 3
	12 6 7	12 11 10

READY

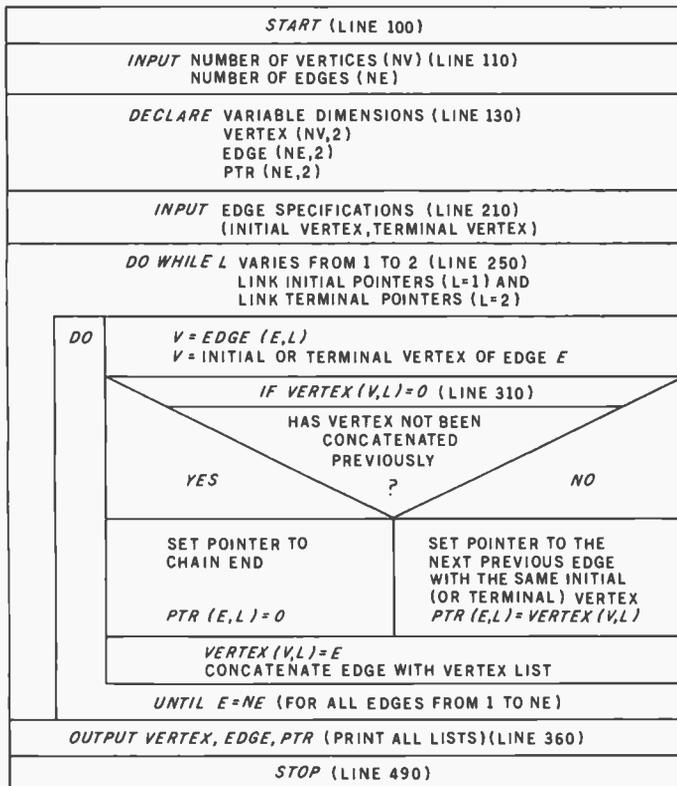


Figure 4: A Nassi-Schneiderman chart showing the algorithm used by the BASIC program of listing 1. Nassi-Schneiderman charts are a system of stylized flowcharts that are designed for use with structured programming techniques. The chart is read from top to bottom. Line numbers refer to lines in the BASIC program in listing 1.

introduced to store digraphs can be used for storing undirected graphs by ignoring the distinction between initial and terminal vertices and pointers. In the case of undirected graphs, a single pointer would serve as well as two pointers and occupy less storage space. If you are enterprising, you can work out the details of this variation and write the appropriate program yourself. Figure 3 compares storage requirements.

### Generating Lists Under Program Control

Have you wondered why the lists have been searched from bottom to top and why the pointers are linked backwards? By doing so, you can simplify the task of generating the pointer lists.

The Nassi-Schneiderman chart given in figure 4 shows the logic followed by the BASIC program of listing 1. Here is some additional explanation. Numerals refer to line numbers in listing 1.

- 300 Assume that you are linking the initial pointers (with  $L=1$ ). The initial vertex of edge  $E$  is stored in  $V$ .
- 310 If the vertex number  $V$  has not been recorded as an initial vertex up to now, you have found the end of its chain of initial pointers. Skip line 320 because there is no previous pointer to link up with.
- 320 If  $V$  has been previously recorded as an initial vertex, get the location of its earlier occurrence in EDGE from VERTEX and set the initial pointer  $PTR(E, 1)$  of edge  $E$  to point to this location.
- 330 Record the location  $E$  of  $V$  in list EDGE in  $VERTEX(V, L)$ . This is the lowest location of  $V$  in EDGE that is known at this time. If  $V$  occurs again as an initial vertex further down in EDGE, this lower location will be recorded.

### Graph Applications

Some obvious examples of graphs and digraphs that occur in the real world have been mentioned: communication and transportation networks. There are more abstract systems that also have an undirected or directed graph structure.

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thousands of interdependent *tasks* are often planned with the aid of graph-theoretic methods. The tasks can be considered as the vertices of a digraph; their interdependencies can be expressed as directed edges.

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which these methods were successfully applied was the development of the Polaris missile system. Today, use of *project networks* is a standard management technique.

If you are interested in applying graph theory to the social sciences, you should read *Structured Models: An Introduction to the Theory of Directed Graphs* by Harary, Norman, and Cartwright.

### Closing Observation

This article cannot end without observing that almost all users of computers are intimately familiar with one form of directed graph, the flowchart. ■

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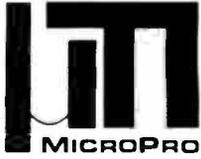


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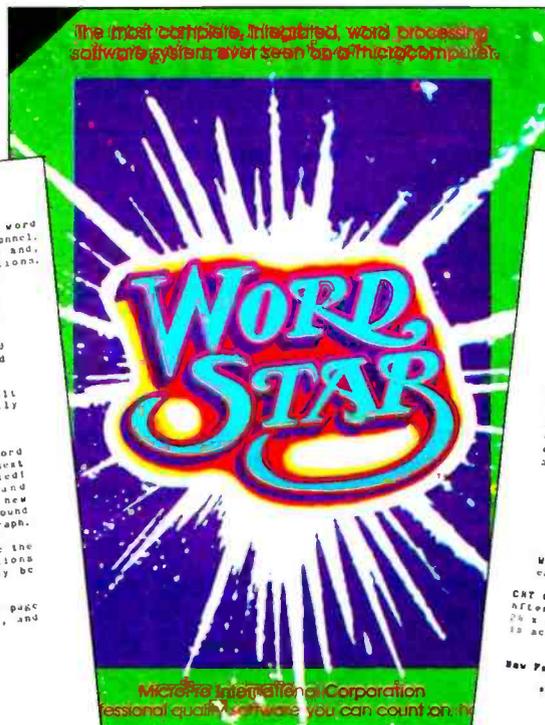


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## A Computer-Controlled Wood Stove

Steve Ciarcia  
POB 582  
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"Come inside, Roger, and get out of the cold." I held my kitchen door ajar as he crossed the front yard towards me. Great clouds of leaves blown by the cold wind furiously encircled him. The landscape was stark and gray, and all weather indicators pointed toward an impending snowstorm.

Roger, a local electrician, had come by to discuss some electrical work I needed done on a new garage I was building. As he stepped through the doorway he remarked, "Sure looks like snow. Have you got enough gas for your Jeep in case you need to plow yourself out of this wilderness?"

Roger's remark reminded me that the terms "picturesque" and "remote" are often synonymous when describing a home in Connecticut. The only place I had been able to buy a house with more than half an acre of land was 25 miles from civilization. And while Roger's controlled, old Yankee humor prevented him from laughing out loud as he spoke, the thought of me, basically a kid from the city, independently plowing my 300 yards of driveway seemed to produce a slow-forming look of amusement.

The Jeep he was referring to was about 20 years old and was used only for plowing. I rather enjoyed the straightforward task of rearranging snow with it. A certain spirit of excitement came over me each time I stepped into the driver's seat and

asked myself the all-important question posed by every adventurer: "I wonder if this heap will start?"

My neighbor, who shares the chore of plowing, thought I was a sissy when I finally added lights to the Jeep for night driving. Somehow, not seeing the rocks makes hitting them



Photo 1: The Hydrostove is installed in the corner of the Circuit Cellar. Take note of the two copper pipes coming out the rear of the stove into the wall. The pipes, which are buried behind the wall and above the ceiling, go to the furnace, which is 35 feet away.

more fun for him. I never did ask him how he had broken the driveshaft the previous year.

I continued my masochistic thoughts of the Jeep. "It should be okay," I said, "but frankly, if it breaks down, I think I'll just hibernate in the cellar for the winter."

Roger still had not taken his coat off as he added, "You might expect to enjoy such an arrangement, but I think you will find that you need outside services more than you think."

"Give me an example."

Roger uncomfortably shrugged his shoulders. Something other than the conversation was bothering him.

"Oil is a good example. You heat with oil, right? How do you propose to fill your oil tank if the truck can't get down the driveway? I'll bet this glass barn you have here almost requires a direct pipeline to the refinery."

I did not exactly relish having my contemporary home called a glass barn but there was some merit to his statement. I retorted, "Who needs..."

Roger interrupted me in mid-statement. "Speaking of heat... what are you running here, a sauna?"

"Take your coat off, Roger. Maybe then you won't be so hot. I'm not so sure you even need both the wool shirt and sweater you have on."

Tossing his coat across to the nearest chair and tugging on his sweater, he continued. "Whenever I

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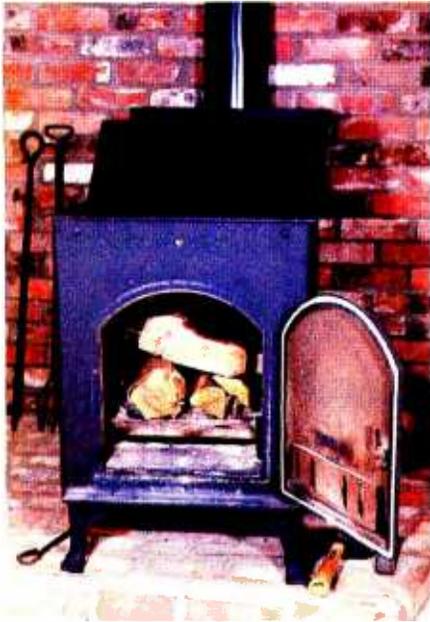


Photo 2: Logs up to 24 inches in length are placed in a grate which consists of water-filled tubes.

visit anyone during the winter I presume their house is at 60 degrees like mine. It must be 12 degrees outside, and..." he walked over to the thermostat, "according to this it's 75 degrees in here!"

"I don't usually have it this warm, I was just testing the heating system now that it's computer-controlled."

"What's there to control? Turn the oil burner on longer and it gets hotter."

"Who said anything about an oil burner?"

"Electric heat is even worse!" he quickly added.

"We have oil heat... but it hasn't been on for two days. All I have now is one wood stove."

Roger's momentary blank stare and open mouth were instantly replaced with a look of disbelief. Standing there by the thermostat he quickly scanned the room. With extreme skepticism he replied, "What are you handing me? A twelve-hundred-square-foot room, twelve-foot ceiling, three hundred square feet of glass and seventy-five degrees? I don't see any stove!" Roger walked over to a hot-air duct near one of the windows, stooping down and holding his open palm over the opening he exclaimed, "Wood stove, phooie! There's hot air coming out of this duct. You have the oil burner on!"

"No, Roger. I have a wood stove down in the Circuit Cellar that is plumbed directly into the central heating system."

"A wood stove? In a hot-air heating system?"

"Well actually, Roger, my heating system is both hot water and hot air, and the wood stove heats water. It's called a hydronic wood stove."

"What the heck is a hydronic wood stove?"

Roger was definitely at a loss for words. I put my hand on his shoulder

and said, "Think of it as Yankee ingenuity. Come on downstairs and I'll explain how it works."

### A Hydronic Wood Stove

A hydronic wood stove is just what the name implies. It is a wood stove that heats water. The particular wood stove that I have is trade-named Hydrostove and it is made by Hydro-Heat Division, Ridgeway Steel, POB 382, Ridgeway PA 15853. Photo 1 shows it installed in the corner of the Circuit Cellar.

The Hydrostove looks like an ordinary wood stove. It is constructed of cast iron and weighs about 400 pounds. The difference between it and a regular wood stove is in the method of heat removal from the burning wood and the ability to channel the energy output into the central heating system.

A regular wood stove produces only radiant energy and is generally a one-room heater unless fans or convection registers are employed to spread the heat around. The surface temperature of such stoves can approach the temperature of the burning wood itself, and great care must be taken to keep combustible material more than 4 feet away.

Typical wood-stove operation is to put in a full load of wood, get it good and hot (warming up the room to around 75° F), and then close the dampers to reduce the heat output. This is the only way to keep the room from becoming unbearably hot. An unfortunate byproduct of this process is that a slow, smoldering fire creates creosote buildup in the chimney. Since only the area directly around the stove is heated, it is likely that an adjacent room will be terribly cold unless fans are used to blow the heat around.

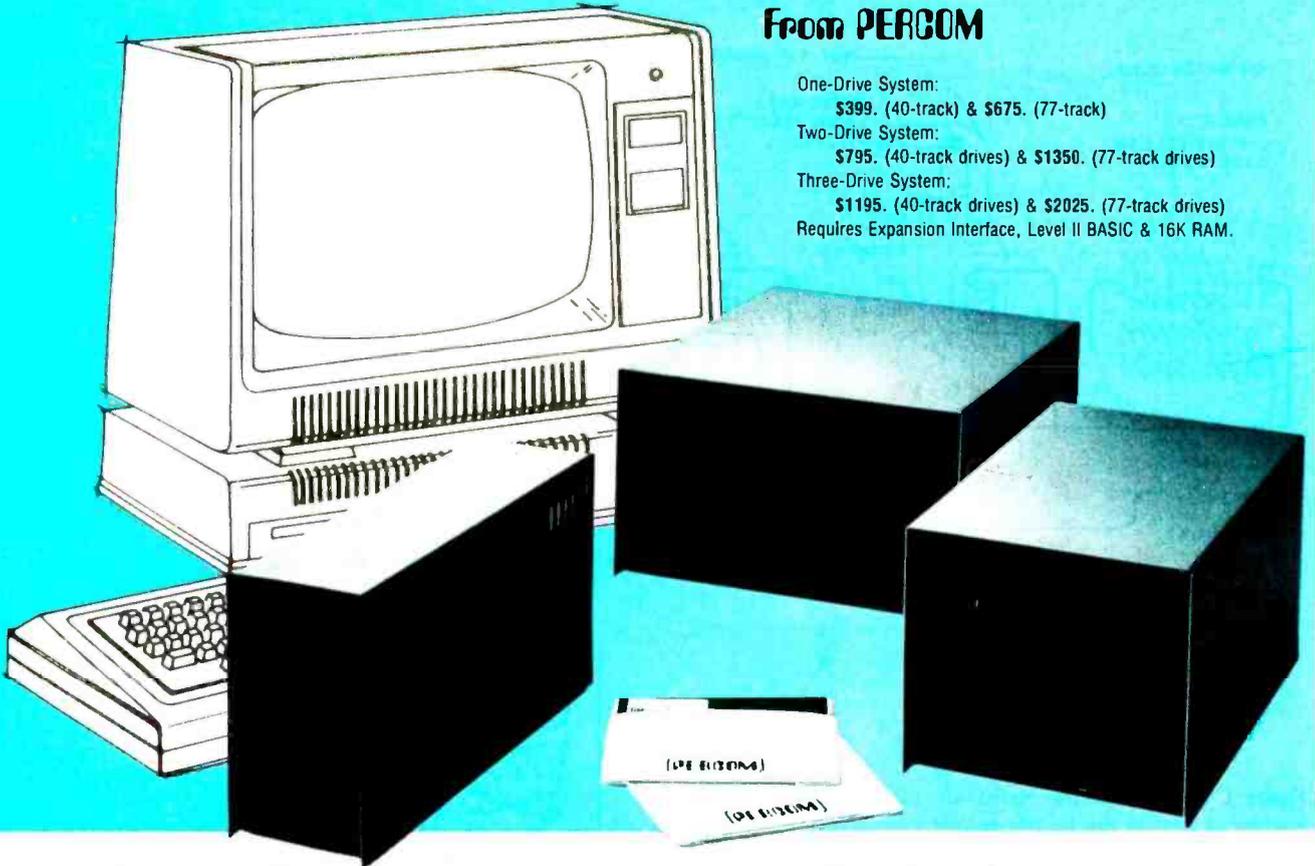
The Hydrostove looks like a regular wood stove, but it operates quite differently. Rather than a solid cast-iron grate, the hydronic stove's firebox is a network of water-filled pipes. These pipes completely encircle the fire, with the burning wood being placed directly on the pipes. Photos 2 and 3 demonstrate this. The inlet and outlet of this water jacket are accessible through two pipe fittings on the rear of the stove. (Since I knew that I wanted a hydronic stove when I built the Circuit Cellar, I had the pipes installed behind the brick wall and



Photo 3: In operation, the heat from the fire warms the water in the tubes. This is a relatively small fire. The fire box is usually filled.

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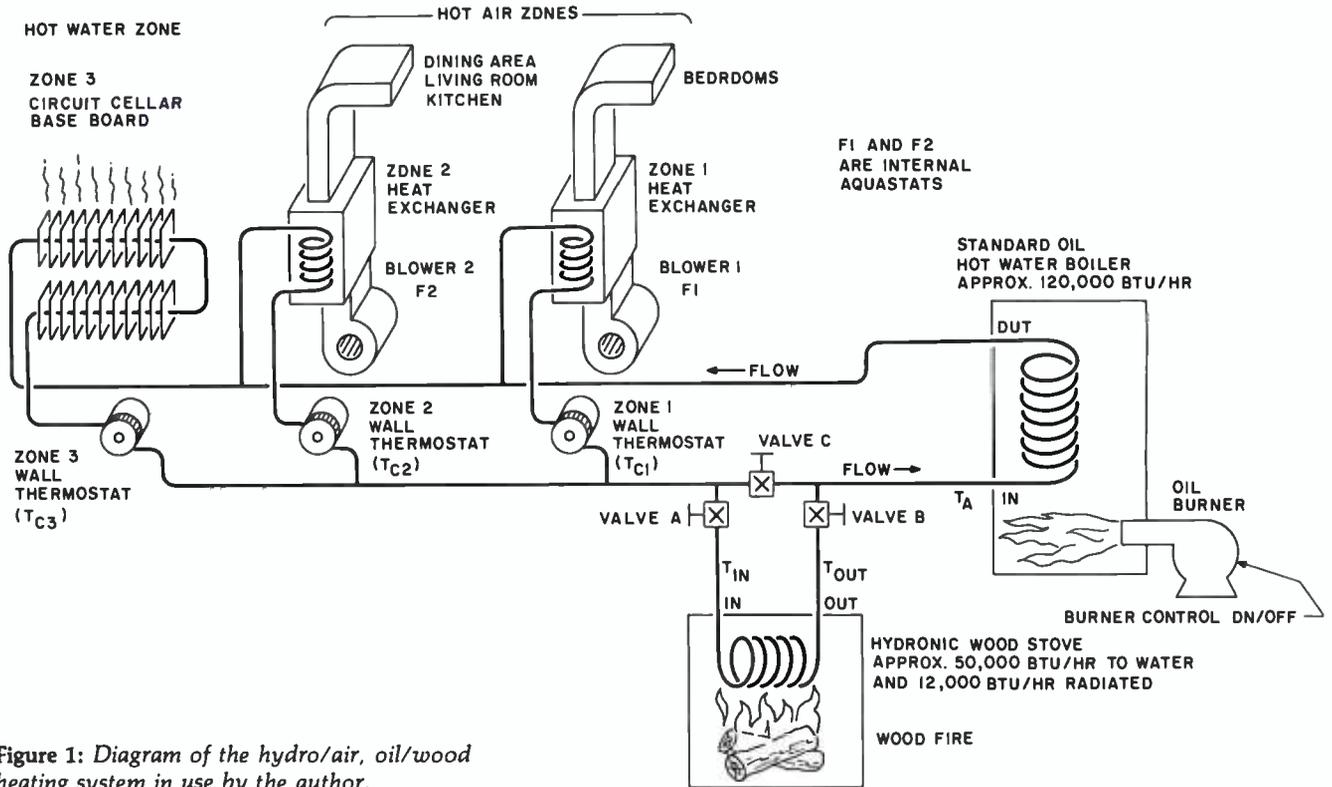


Figure 1: Diagram of the hydro/air, oil/wood heating system in use by the author.

through the ceiling. The oil burner is about 35 feet from the Hydrostove.) When a fire is started in the stove, the heat is extracted through the water rather than being radiated directly into the room.

With dry, hard wood, the stove generates about 62,000 BTU per hour (with an additional 12,000 BTU per hour going up the chimney) and is quoted by the manufacturer to be about 85% efficient. I cannot say at this time exactly how much of this is transferred to the water as opposed to how much is radiated. I can only state my experience: with the stove burning at full capacity for 6 hours, the brick wall 1 foot from the stove is on-

ly warm to the touch, and wood can be piled next to the stove (about 2 inches away) with no possibility of ignition. For this same 6-hour period, the Circuit Cellar temperature will never exceed 75° F unless a higher temperature is set on the central heating system thermostat. You would definitely know that it is a hot stove, but anyone inspecting the raging fire inside is usually quite surprised how little heat is felt in comparison to a regular wood stove.

### A New England Experiment—First, the Basics

The heating system shown in figure 1 is commonly called a hydro/air

system. It consists of an oil hot-water boiler and hot-air heat distribution. The oil burner heats water, which in turn circulates through a hot-water heat exchanger. A fan blows over the heat exchanger coils and circulates the hot air through the ducts to each room. Such a system combines the even-temperature, residual-heating benefits of a hot-water circulator with the pleasant, humidified, filtered warmth of a hot-air system. A third zone of baseboard heat was added when the Circuit Cellar was built.

Perhaps the best way to start is to explain how an oil-fired hot-water heating system works. Neglect for a moment zones 1 and 2 and the

*Note: The heating system in this article is installed in my home and was built to my specifications. I do not intend this as a general construction article, but rather a documented discussion of the elements of the system with emphasis on the controls involved. I must point out that while this article specifically describes a computer-controlled hydro heating system,*

*general use of a Hydrostove does not require the sophisticated control I have outlined. It is only the unique combination of machinery and an empirically determined operating algorithm that suggests ease of operation through computerization. In truth, the computer's primary value is in the addition of a significant measure of safety rather than the convenience*

*implied. Through its attachment as a supervisory controller, the computer can more accurately maintain safe operating temperatures and dump excess heat in an overtemp condition. As of the time of this writing, two cords of wood have been burned in the stove testing this complete system and the result has been safe, satisfying, and reliable operation.*



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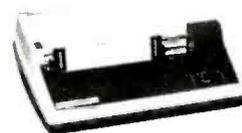
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Hydrostove in figure 1. Think of it strictly as the oil burner connected to one circulator pump and the zone 3 baseboard. This is essentially what many homes have. There may be multiple rooms, but only one circulation loop.

Most people think that the thermostat on the wall turns the oil burner on. Actually, this thermostat only controls the on/off operation of the circulator pump; it generally has no direct connection to the burner itself. Operation of the boiler depends upon the temperature of the water flowing into the heating coil section and the temperature setting  $T_A$  of the *aquastat* (water conduit thermostat). Water flows from the hot-water boiler to the baseboard and is drawn back through the circulator pump to the boiler again. If the temperature of this water is greater than the aquastat setting, the burner stays off. If however, the temperature is below  $T_A$ , the burner turns on, adding heat until the water in the loop reaches  $T_A$ . Usually  $T_A$  has a wide hysteresis; the high and low limit of variation is separated by about 20° F. For most boilers the low setting is 160° F, and the high is 180° F. The hysteresis reduces the frequency of oil burner starts.

To get heat in a room, you turn up the wall thermostat, which starts the pump. As the water moves through the baseboard, it loses heat to the room. The water is then reheated by the oil burner.

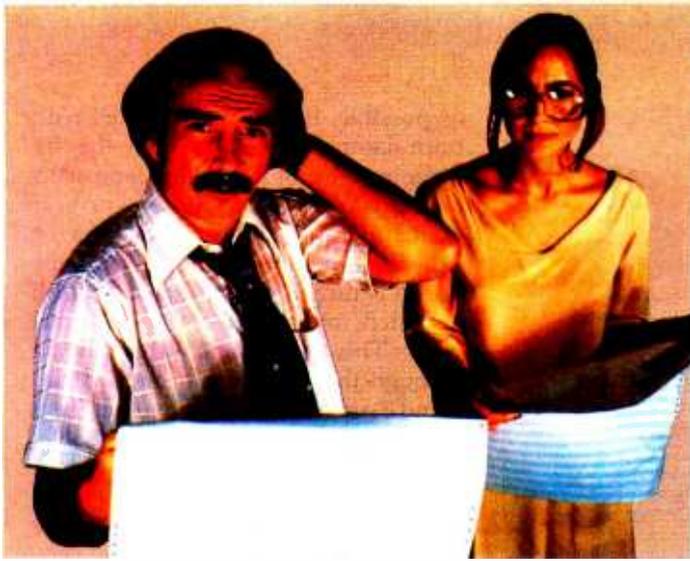
Now, consider the addition of the Hydrostove as shown in figure 1. Any water circulating through zone 3 will necessarily pass through the coils of the stove if valves A and B are opened and C is closed. This circulation in itself does nothing to the operation of the heating system. If, however, you build a fire in the Hydrostove as in photo 3, heat is added to the water returning from the baseboard and flowing into the boiler. If the fire is large enough, the temperature of the water flowing out of the Hydrostove is greater than  $T_A$ , the oil burner never turns on, and the house will effectively be heated by the Hydrostove.

There are a few other considerations. Unlike the oil burner which can be selectively turned on when heat is needed, once the wood stove is on, it runs for quite a while and the heat

must be *continuously* removed; otherwise, the water in the pipes will turn to steam. Pressure-relief valves will keep the system from exploding, but who wants a steam bath in their living room? In a single-zone system, the circulator pump must remain on until the fire is out. In a gravity-feed system, the pump must stay on until the fire is lowered to the point where the water stays below the boiling point and can effectively be radiated by the heating loop.

Consider the Hydrostove as a continuous source of heat. If the Hydrostove is cranked up to produce 40,000 BTU per hour, then 40,000 BTU per hour must somehow be removed. The task of heat dumping is much easier on a multi-zone system. Take for example, three zones with capacities of 40,000 BTU, 30,000 BTU, and 20,000 BTU, respectively. Whether or not a room thermostat is calling for heat, you must turn on either the pump for zone 1, or the pumps for both zones 2 and 3. Consider the case when zones 2 and 3 are used as heat dumps. If the zone 1 thermostat were to trip suddenly, the control system would have to make a choice. It could add zone 1 to the pool and share 40,000 BTU among three zones or immediately drop zones 2 and 3 off the line and send everything to zone 1 until it reaches its thermostat setting again. While the previous choice can easily be made, load sharing is an interesting consideration. It is much easier to switch zones on and off while performing load sharing than to try to directly control the heat output of the wood fire to any degree.

An additional complication occurs when using heat exchangers. Heat exchangers cannot effectively transfer heat unless the blower is on. The fans in these units are thermostatically controlled. When the water flowing through the exchanger reaches a set temperature, the fan turns on, extracting heat. There is considerable delay and overshooting in the operation of these units. While the *average* hourly heat transfer of a heat exchanger might be 40,000 BTU, it may be 10,000 BTU with the blower off and 50,000 BTU with it on. In a quick heat-dump situation, it is sometimes necessary to override the blower thermostat and force the



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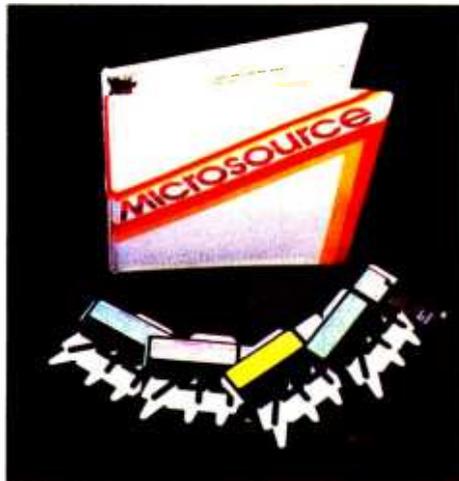
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Photo 4: The computer I/O interface for the heating control system is attractively housed. It includes a display of either the input or output temperature of the Hydrostove and a real-time status display of the circulators and blowers.

blower on to maintain stable conditions throughout the rest of the system.

### Using a Hydrostove

How much you benefit from the addition of a hydronic wood stove depends quite heavily on the rest of your heating system. Above all, it must be capable of taking the full heat

output of the wood fire. This can be 62,000 BTU per hour. Since my oil burner is rated at 120,000 BTU per hour, and I had added the third zone of baseboard to the Circuit Cellar, I concluded that the connection would be quite safe.

My usual method of manual operation is to use the stove only on very cold days and to build as large a fire

as possible. It is initially started with both dampers open, but once the fire is going strong the flue damper is closed to reduce the amount of heat going up the chimney. At the time the fire is started, the zone 1 circulator pump is turned on continuously with a switch, overriding the motor-start relay. This keeps some water flowing through the stove at all times. Zones 2 and 3 are normally left in their "heat on demand" thermostat-controlled mode. If the Circuit Cellar cooled down and its circulator pump kicked in, it would be drawing heat from the stove along with zone 1.

Our house is large, but given my method of use, no single heating zone can sustain the full output of the Hydrostove for long periods of time. Generally, the water temperature will be between 75° and 90° C. To maintain a 20° to 22° C (68° to 72° F) temperature through the house on a very cold day, I have to keep the fire box continually filled. This means filling the stove with wood every 3 to 4 hours. (Before you choke and compare it to 12 hours for a regular airtight stove, remember that I am talking about heating a whole house). After a few hours of use, even in this large house, the temperature in the rooms in zones 2 and 3 will reach the wall-thermostat set points, no longer continuously demanding heat from the stove. This leaves all the heat going to zone 1.

Soon, the temperature of the water coming out of the wood stove starts to climb above the safe high limit of 88° C (measured 35 feet away at the furnace). When the indicator hits around 98° C, a loud noise can be heard in the pipes because the higher temperature water nearest the hot coals within the stove is turning to steam. Unless you want the safety valve to blow, filling the room with steam, you have to override the automatic settings of either or both of the thermostats of zones 2 and 3 to get rid of some of the excess heat. It may also be necessary to manually turn on the heat-exchanger blowers for zones 1 and 2 for the reasons I previously outlined.

This occurrence is rare, and I generally have about 10 minutes to react to the situation and throw all the manual switches required. After using the system and determining that this is a potential problem, I installed a digital temperature indicator that

Control Outputs Signal	Type	Function
TC <sub>1</sub>	Contact closure 200 mA	Circulator pump - zone 1
TC <sub>2</sub>	Contact closure 200mA	Circulator pump - zone 2
TC <sub>3</sub>	Contact closure 200 mA	Circulator pump - zone 3
F <sub>1</sub>	Solid state relay 5 A 220 VAC	Heat exchanger blower zone 1
F <sub>2</sub>	Solid state relay 5 A 220 VAC	Heat exchanger blower zone 2
XFER	Contact closure 5 A 115 VAC	Oil burner power
Inputs Status	Level	Function
TC <sub>1</sub>	TTL	
TC <sub>2</sub>	TTL	0 pump off 1 pump on
TC <sub>3</sub>	TTL	
F <sub>1</sub>	TTL	0 blower off 1 blower on
F <sub>2</sub>	TTL	
T <sub>in</sub>	Analog	
T <sub>out</sub>	Analog	range 40° to 240° F 4° to 115° C

Table 1: Computer I/O lines used with the heating control system.

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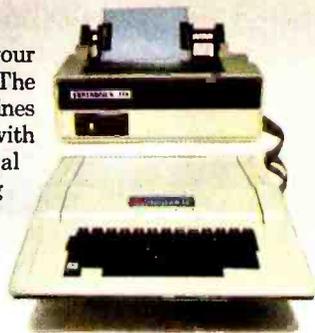
## Serial Interface.

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



## Parallel Interface.

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



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allowed me to monitor the system as I worked at my desk in the Circuit Cellar. When I saw that the temperature was going above 88° C, I would throw the manual override on the zone 2 circulator pump. If the temperature did not drop, I would continue with the other heat dumping methods. It has never gotten to a point where these maneuvers prove insufficient or where the fire has to be put out. Experience has shown that zone 2's volume of 15,000 cubic feet provides a terrific sink for excess heat. Normal use in this mode barely raises its temperature more than 2° F above its nominal 66° F thermostat setting. (I do not want to leave you with the impression that there is one 90° F room in the house.)

I have not described anything thus far that specifically requires computerization other than for convenience. The real reason is a rather insignificant detail that is discovered only after actually using the stove. A Hydrostove definitely saves oil, as stated. When its output temperature is greater than the aquastat set point, the oil burner does not come on. The problem arises during startup and shutdown when the stove output temperature ( $T_{out}$ ) is less than the setting of the aquastat ( $T_A$ ). The circulator pump has to remain on while there is a fire but, because the circulation loop is running and returning at less than  $T_A$ , the oil burner keeps coming on. *Catch 22!!*

If this were a matter of 10 minutes or so, it would not be so bad; but shutdown to the point where the circulator pump can be turned off can take several hours. The alternative is to cut the power to the oil burner when the wood stove is on and restore it when the fire is out. This is what I initially did, until I was staying up all night to shut the stove off. The alternative was to wake up to a very cold house, turn the oil burner on, and have to wait a half-hour to take a hot shower.

Aside from taking in a tenant who would watch the Hydrostove temperature in exchange for room and board, the only reasonable alternative was a more intelligent control system. With the proper sensors, a device could monitor the heat output of the stove ( $T_{out} - T_{in}$ ), and when it dropped to a predetermined safe point, automatically restore power to

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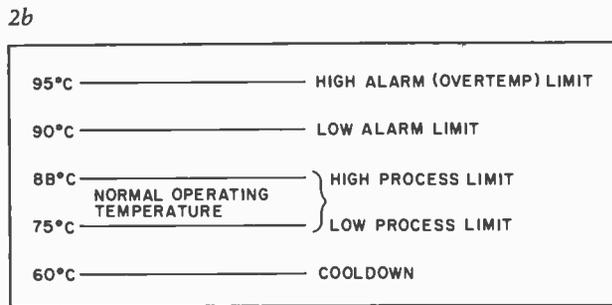
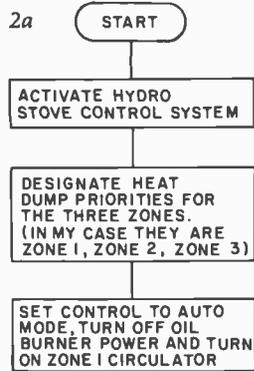


Figure 2: (a) Logic flow for the automatic distribution of Hydrostove heat when output in a three-zone combination hydro and air heating system. (b) Points of importance in the operating temperature range of the system. The actual set points for process and alarm limits depend upon placement of temperature sensors and may vary a few degrees.

In BYTE, algorithmic flow is assumed to proceed down and to the right unless an arrowhead is present to indicate otherwise.

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Type of wood Hardwoods	Pounds per cubic foot	BTU per cord	Equivalent gallons (gallons per cord) fuel oil
1. White Ash	37.5	23,037,000	165
2. Cherry	31.0	19,043,920	136
3. Hickory	45.0	27,644,400	198
4. Maple (red)	33.5	20,579,720	147
5. Oak (chestnut)	41.0	25,187,120	180
6. Walnut	34.5	21,194,040	151
7. Willow	24.0	14,743,680	105
Softwoods			
8. Douglas Fir	30.0	18,429,600	132
9. Ponderosa Pine	25.0	15,358,000	110
10. White Spruce	25.0	15,358,000	110

Table 2: Comparison of wood heat values for various species of wood available in North America and their equivalent in gallons of fuel oil per cord of wood. (These estimates are generally accepted by industry.)

the burner and shut off the circulator-pump override.

### Computer-Controlled Heating System

My heating system is not technically a computer-controlled wood stove. It is rather a system designed specifically to efficiently distribute the heat from a wood stove, to safely dump excess heat in an effective manner, and most importantly, to restore the entire system to its standard configuration when the fire is out. I am merely outlining one application of the many that are conceivable when the heating system has been connected to a computer. Complete energy management is a possibility; or, at the very least, total energy out-

put can be closely monitored and recorded. I am working on these areas, but for now, the topic is control.

Virtually any personal computer can suffice as the controller. The logic is straightforward and relatively uncomplicated. It is outlined in the flowchart shown in figure 2. Proper control of the three zones and the Hydrostove requires a special interface to connect the computer to the various blowers and pumps. Table 1 is a list of the signals in question.

The control outputs from the computer are, in essence, all contact closures, whether it be through mechanical or solid-state relays. The use of relays provides electrical isolation between the computer and the

heating system. It further prevents potentially dangerous loops between 115- and 220-VAC powered components.

The three zone thermostats are low-voltage AC circuits that can be directly controlled through a reed relay, as shown in figure 3. The relay contacts are connected in parallel with the thermostat. With the thermostat contacts open, a logic 1 control signal closes the relay and provides an alternate current path to pull in the pump-start relay. By monitoring the voltage across the relay contacts, it is possible to directly monitor the activity of the circulator pump and determine its operational status at any time. If the contacts are open, current flows through the optoisolator light-emitting diode (LED), producing a logic 0 status at the output. When closed, no current flows and the logic value is 1. My application required only the ability to turn on a pump which may not already be running. However, to accommodate complete functional control of the pumps, the thermostat can be disconnected as shown.

The interface to the heat exchanger blowers, shown in figure 4, is similar. This time however a solid-state 7 A 220 VAC relay is used. The power to the blower is 5 A 220 V rather than low voltage AC as before. A 7 A solid-state relay was chosen because of its size and low cost.

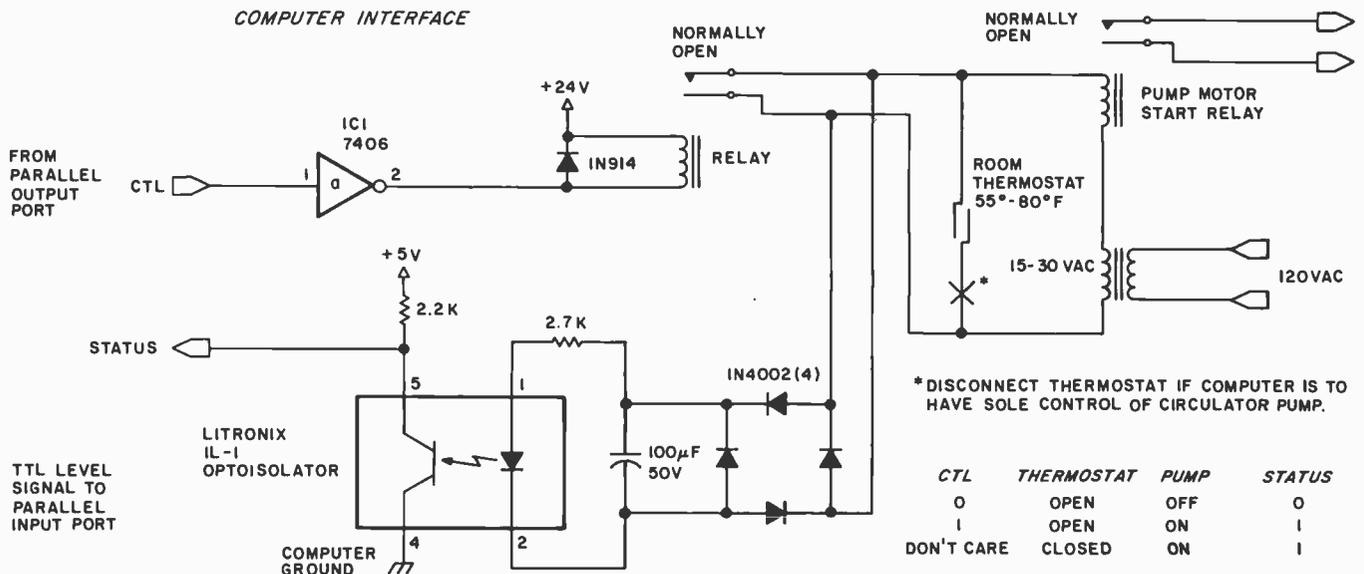


Figure 3: Isolated interface for computer control of a typical oil-fired, hot-water, 1/4-horsepower circulator pump. The 7406 open-collector inverter (IC1) requires a 5 V supply to pin 14 and a ground connection to pin 7.

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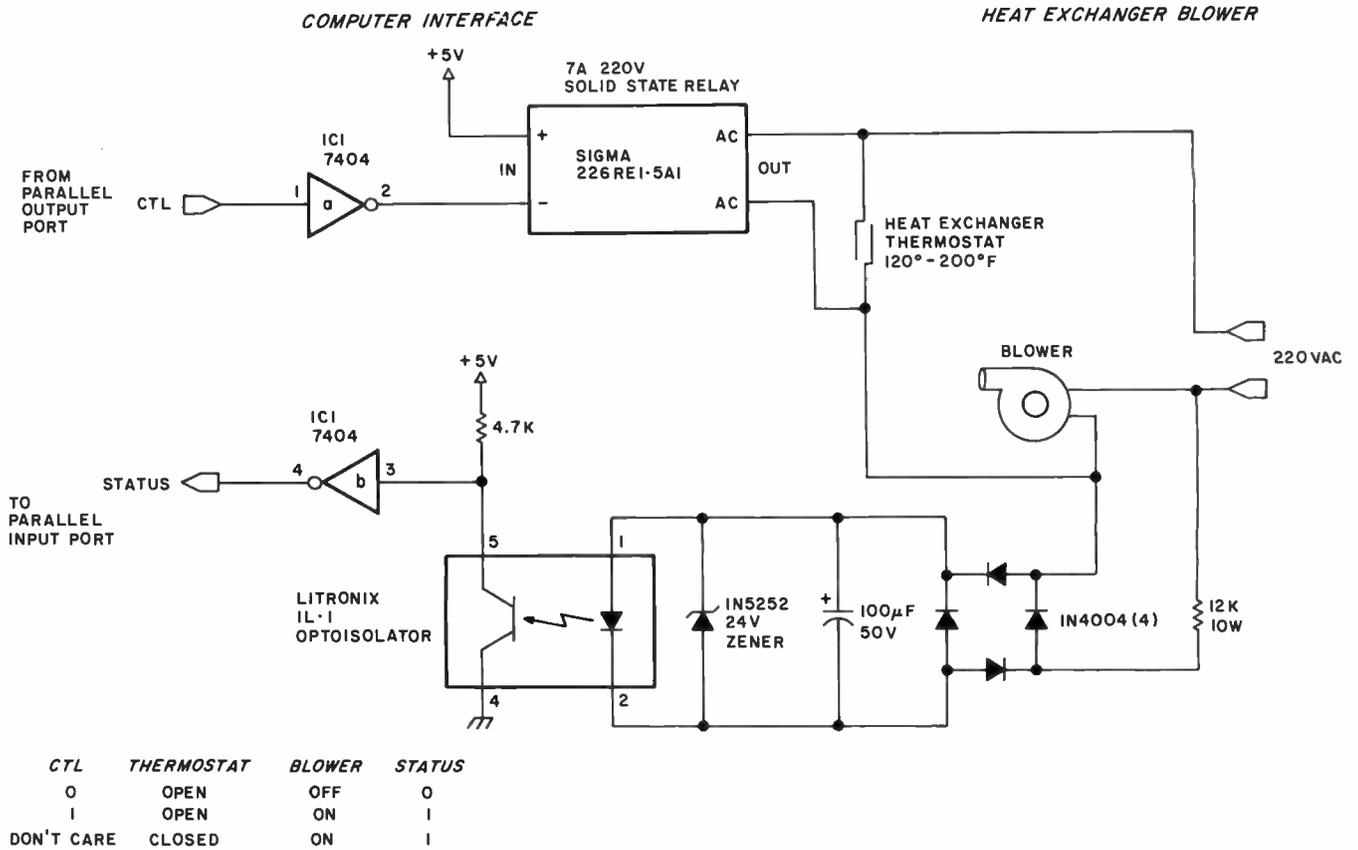


Figure 4: Isolated interface for computer control of a heat-exchanger blower fan. The 7404 hex inverter requires a 5 V power supply to pin 14 and a ground connection to pin 7.

Monitoring the activity of the blowers is accomplished simply by checking the voltage across the motor. The 220 V present when the motor is on is reduced and rectified to run an optoisolator as before. With

voltage present, the status output is high (logic 1).

Finally, the computer must be able to monitor the output temperature of the Hydrostove. This signal is an analog voltage that is proportional to

temperature. Various sensors such as thermistors or thermocouples could be used, but a more practical device is a temperature sensor device such as the LM334 from National Semiconductor. When configured as in figure 5, the output of IC1 (monitored at  $V_{in}$ ) is 10 mV per degree Celsius. It may have a nominal offset of something like 2.5 V, but if the temperature rises 10° C the output will go up 100 mV. ICs 2 and 3 provide gain and offset adjustment and are configured to prohibit accidental negative excursion of the output if the temperature sensor goes open circuit. The result is a circuit that converts a change in temperature to a change in voltage. By adjusting the gain and offset, 0° C can be an output of 0 V and 100° C can be 1 or 10 V. A Fahrenheit scale can be just as easily calibrated by setting a different gain and offset.

To read this signal, the computer must have an analog-to-digital converter interface. This can be either a true successive-approximation analog-to-digital converter as in figure 6, or the discrete set-point level detector of figure 7. The choice

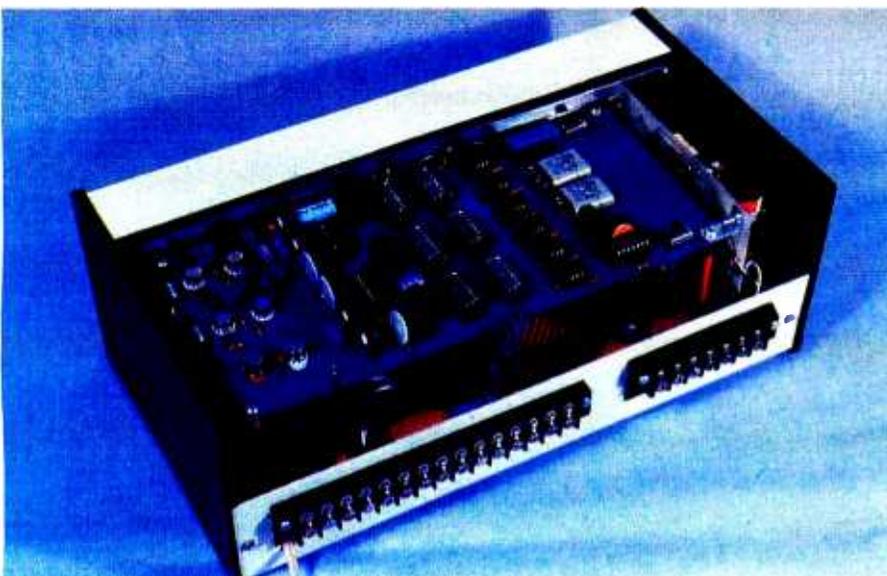


Photo 5: An internal view of the I/O controller containing relays, optoisolators, and analog interface components.

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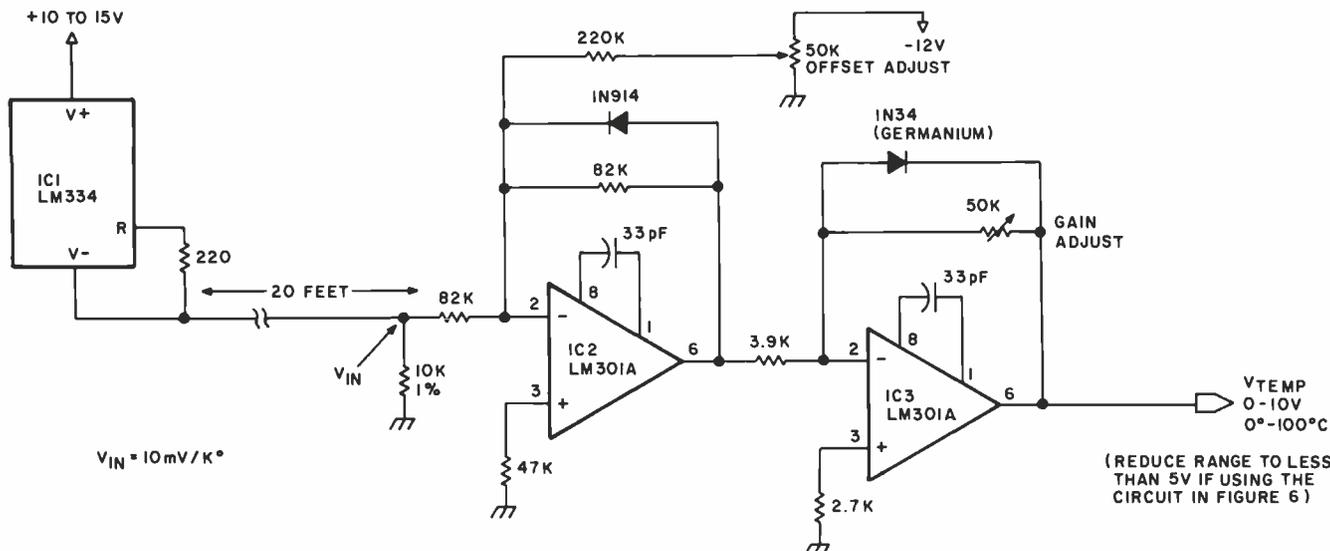


Figure 5: Solid-state temperature sensor. The range of the output voltage ( $V_{TEMP}$ ) is reduced to less than 5 V if the circuit in figure 6 is used.

depends upon whether you need to know the exact temperature or just significant set points.

If data acquisition is the dominant consideration, then consider the circuit of figure 6. IC8 is an 8-channel, 8-bit analog-to-digital converter that is bus-compatible with most microprocessors. Figure 8 outlines its internal structure. As configured, it is attached to function as ports F8 through FF, with port F8 corresponding to input channel 0, and port FF corresponding to channel 7. The volt-

age on channel 0 is read by initiating an output to port F8. This causes the address of 000 to be stored and the conversion process started. After about 100 microseconds, the time necessary for conversion, the channel analog value can be obtained by reading an input from port F8. A similar procedure is used to set and read the other channels.

If you are interested strictly in control, then the circuit of figure 7 is much simpler to use. If a 0 to 10 V input represents a range of 0 to 100° C and there are eight comparators, each could be set to trigger 12.5° C higher than the preceding one. A better approach is to arrange the majority of set points to cover the control and alarm range rather than to cover insignificant temperature ranges. For example, bit  $b_0$  could be set to trigger at 60° C. It is not necessary to care much about temperatures below that point. The range of prime interest is

from about 75° C to 95° C. Dedicating 5 set points within this range, another perhaps between 60° C and 75° C and a final overtemp indicator at 98° C should prove more than adequate.

My system uses a combination of both interfaces, using set points for control inputs and a true analog-to-digital converter to determine actual heat output from the stove.

A further enhancement is a visual display indicating the real-time status of the system components and a readout of the actual temperature. The prototype controller is shown in photos 4 and 5. It serves as the interface between the heating system and the computer, and contains most of the electronics described in this article as well as other enhancements not discussed at this time. While all the control decisions are actually made by the computer, the display gives me

*Text continued on page 56*

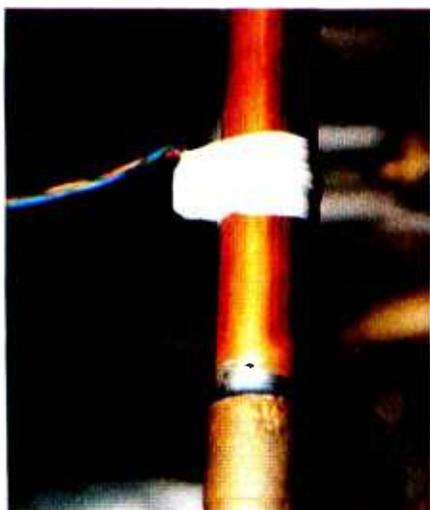


Photo 6: To effectively use this control device, it is important to have accurate temperature measurements. The LM334 temperature sensor is easily attached to the Hydrostove return pipe by wrapping Teflon plumbing tape around it.

Number	Type	+ 5 V	GND	- 12 V	+ 15 V
IC1	LM334	see figure 5			
IC2	LM301A			4	7
IC3	LM301A			4	7
IC4	LM339		12		3
IC5	LM339		12		3
IC6	REF-01	see figure 7			
IC7	LM301			4	7
IC8	ADC0808	see figure 6			
IC9	74LS30	14	7		
IC10	74LS02	14	7		
IC11	7400	14	7		

Table 3: Power and ground connections for the integrated circuits that are used in the circuits of figures 5, 6, and 7.



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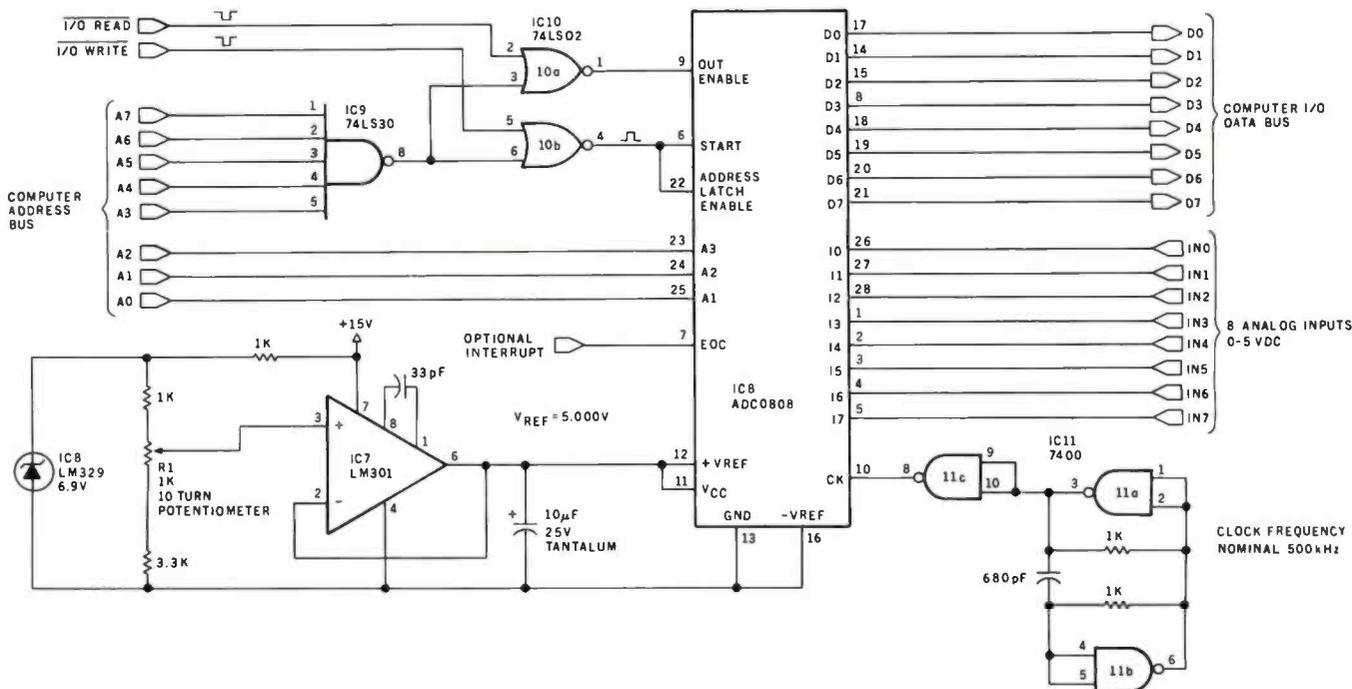


Figure 6: An 8-channel, 8-bit analog-to-digital (A/D) converter using a National Semiconductor ADC0808 data acquisition device.

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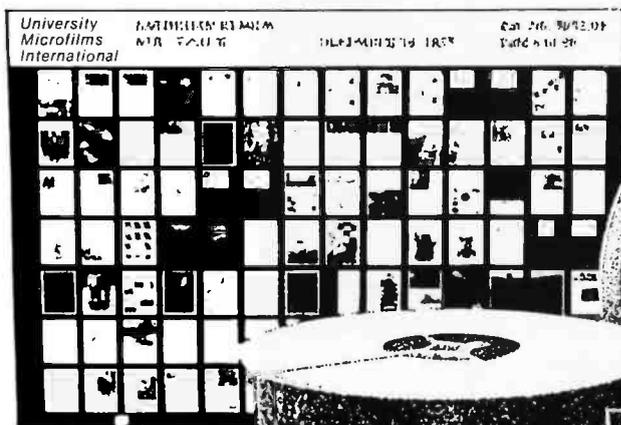
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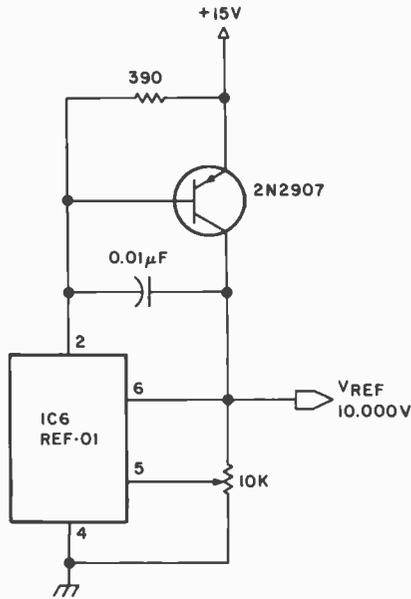
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NOTE: COMPARATOR OUTPUT IS LOGIC 0 WHEN  $V_{IN}$  IS LESS THAN SETPOINT.  
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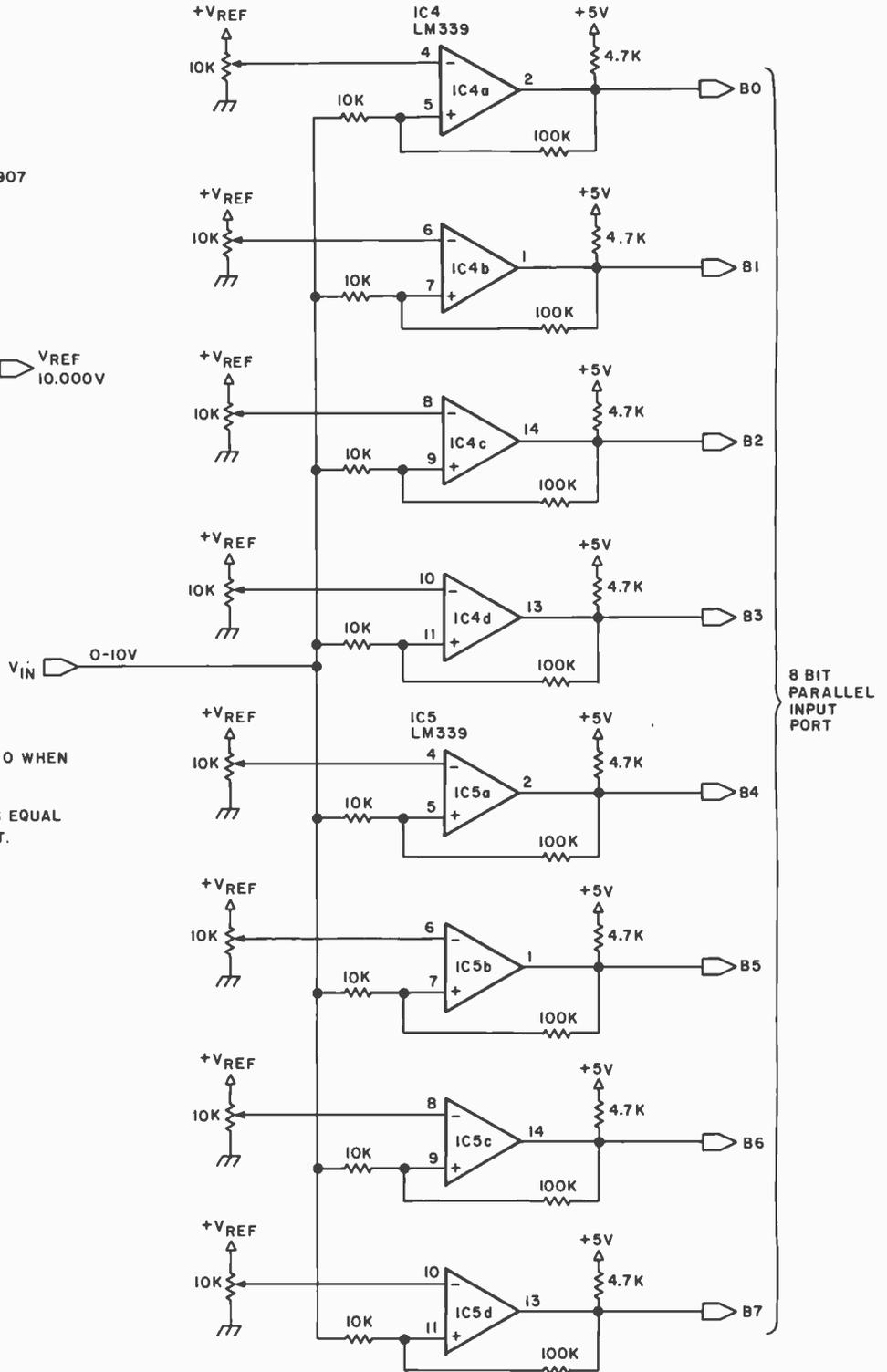


Figure 7: A discrete set-point-level detector. This method is cheaper than the method shown in figure 6 and can be used only when it is necessary to detect a small number of temperature ranges. The eight comparators on the right-hand side of the figure are wired to have their outputs go from logical 0 to logical 1 when a certain temperature (determined by the position of the 10 K potentiometer) is exceeded. The status of the eight bits can be used to determine what range of temperature the interface is currently in. The voltage reference integrated circuit REF-01 (IC1) may be obtained from Precision Monolithics, 1500 Space Park Dr, Santa Clara CA 95050.

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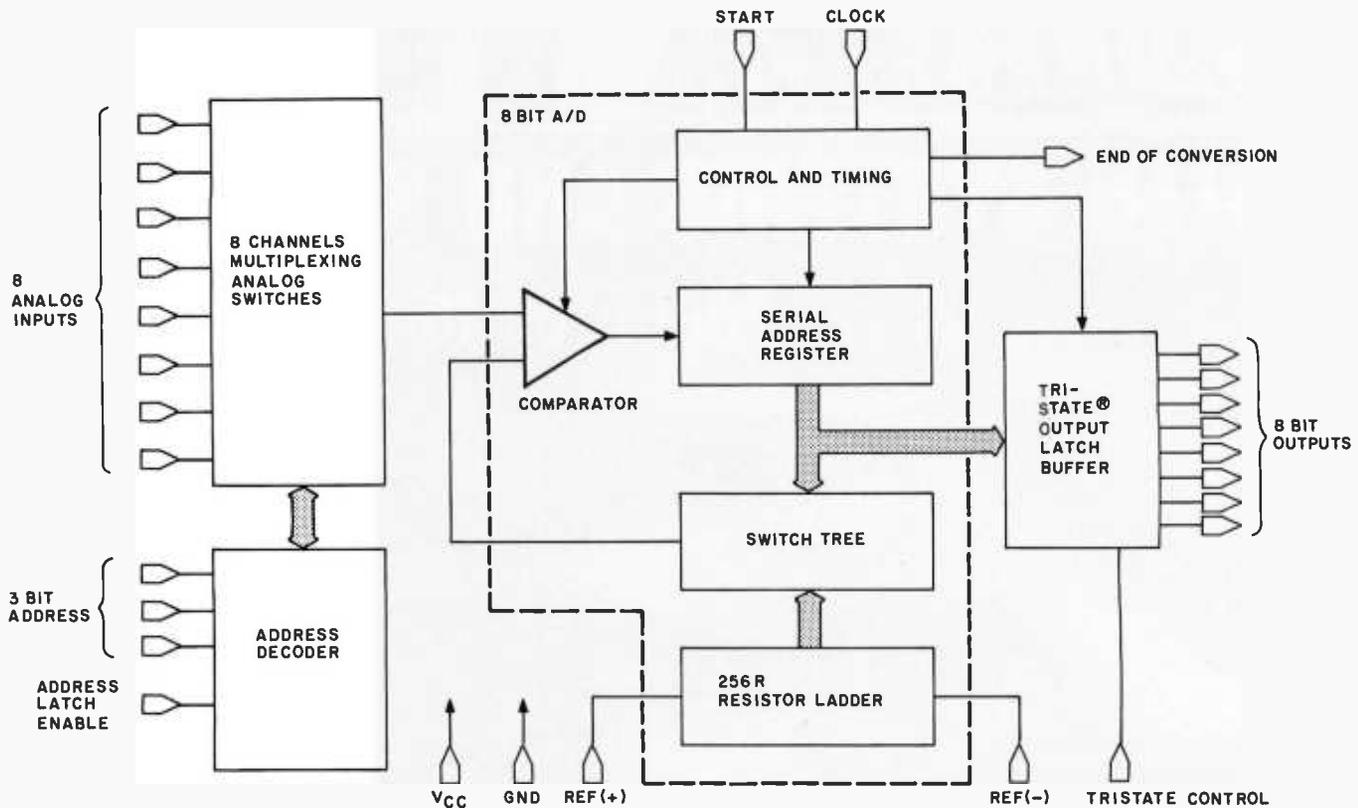


Figure 8: National Semiconductor's ADC0808/0809 CMOS data acquisition system. The 8-bit converter uses successive approximations. The device interface is to most 8-bit microprocessors.

Text continued from page 50:  
the added satisfaction that everything is working correctly.

### Back to Roger's Visit

Roger studied the stove very carefully. He was surprised at the simplicity of the idea of supplemental wood heat, but somewhat aghast at the overall complexity of the entire system. The concept of computer control did not concern him in the least but I sensed that my apparent independence from OPEC fostered a little competitive jealousy.

"What about wood? You still will have to get wood for the stove," Roger commented, pointing out a possible serious limitation.

"I'm surprised you didn't notice when you drove in. There are eight cords of wood piled outside. I don't expect to use them all this winter. Wood, unlike oil, is one of those things you can easily stockpile if you have enough storage space."

"Oh yeah, I did notice a few piles beside the driveway."

Roger was perplexed. He had obviously begun to believe the petroleum company propaganda. The thought of missing an oil delivery meant total destruction of civilization

as far as he was concerned. But he just could not believe that the addition of a wood stove meant independence. Suddenly he smiled as he thought of a sobering reality that I might have overlooked.

"You have to keep the circulator pumps running when the stove is going, right? And if the fire is real hot you may in fact need the blowers on as well?"

"Sure, why?"

Roger had found the Achilles' heel of my heating system. The Hydrostove as I had it configured needed power to run all the pumps and blowers. The actual heat might come from a wood fire, but distribution of the heat throughout the house depended upon the local electric utility. Roger quickly commented, "What happens if the power goes out?"

"Well, I suppose I should be concerned, but I'll have four or five minutes to react."

Roger laughed. "React to what? Living in a steam bath?"

"Perhaps I should show you. Follow me." I led Roger out of the cellar into the garage. In one corner was a large mechanical contraption, part of which was a two-cylinder

engine. Pipes and wires came to it from different directions, all converging at a central control box adjacent to the motor. Without explaining the intricate details involved with this permanent installation (the heating system was enough for Roger this time) I said, "If the utility power goes out, I throw the emergency transfer switch and start my 5-kilowatt generator. It's large enough to run the whole house and then some."

Hesitating, then striking out with one last effort, "You still need gasoline and that doesn't look like a very big tank."

"Sorry Roger, I thought of that too. This particular unit runs on both gasoline and propane. There's a 100-gallon propane tank outside the garage just for the generator"

"I give up!"

It is just as well that he did. Eventually he would notice the trench going across the driveway from the house to the new garage. When he is installing the wiring for it I hope he doesn't ask why I am running insulated copper pipes underground across to the garage.

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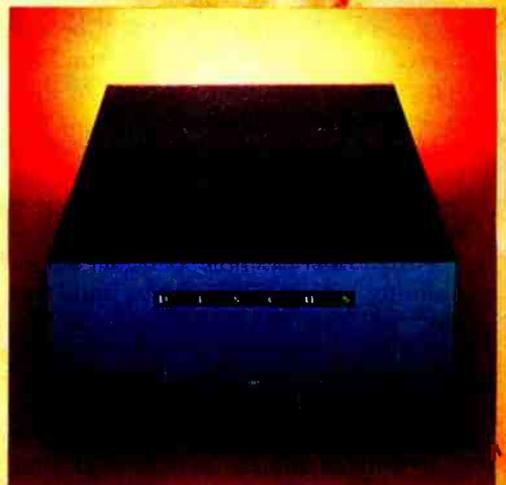
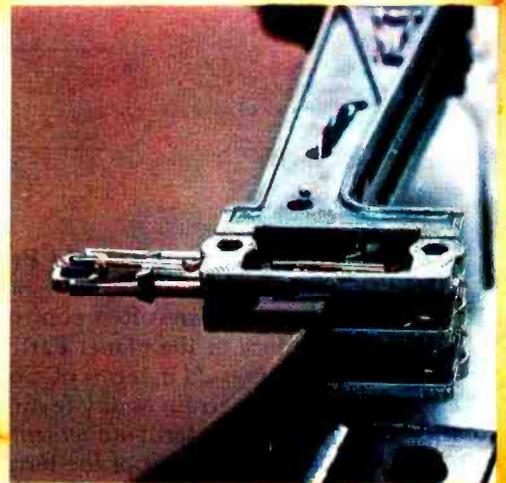
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# Solving Problems Involving Variable Terrain

## Part 1: A General Algorithm

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Scott T Jones  
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---

### A General Definition of Terrain Problems

In business, in industry, and especially in conflict simulation, problems are often confronted that involve terrain, the surface of the planet Earth. These problems can usually be expressed in terms of movement on a map. This article defines terrain as any feature on the map that affects movement. The term *movement cost* will be defined as the quantitative effect of the terrain on movement.

An example of a hiker traveling cross-country from one town to another town will be used. The hiker may travel one mile across level ground in 15 minutes, while requiring 30 minutes to travel one mile when the ground is sloping gradually upward. It can be said that the *movement cost* for the terrain called level ground is one, while the movement cost of the terrain called upward-sloping ground is two. Here the movement cost is in terms of time.

For another example, consider a construction company building a road. The cost to build one mile of roadway over solid ground might be \$100,000, while the cost to build one mile of road over marshy ground might be \$500,000. Thus, you can say that the movement cost is one for solid terrain and five for marshy terrain. In this case, the movement cost is expressed in terms of money.

In both examples, there is an existing problem of moving from one point to another across a terrain map while incurring the minimum movement cost. Now examine another variation of this problem.

Consider a cable television company that is investigating the extension of underground coaxial cables out to a new area. It is known that these new cables will provide a fixed return on investment due to the increased number of customers. Therefore, only a fixed amount of money can be spent to place these cables. Using a map of the terrain and the known costs of placement over the various types of terrain to be encountered, the company can decide whether the extension is feasible.

The purpose of this article is to describe a general solution to these and other related problems.

### Representing Generalized Terrain Problems

The first step in solving a terrain problem is to superimpose a grid on the map that is to be used. This will allow you to refer to each location on the map via its coordinates and identify a particular type of terrain with each location.

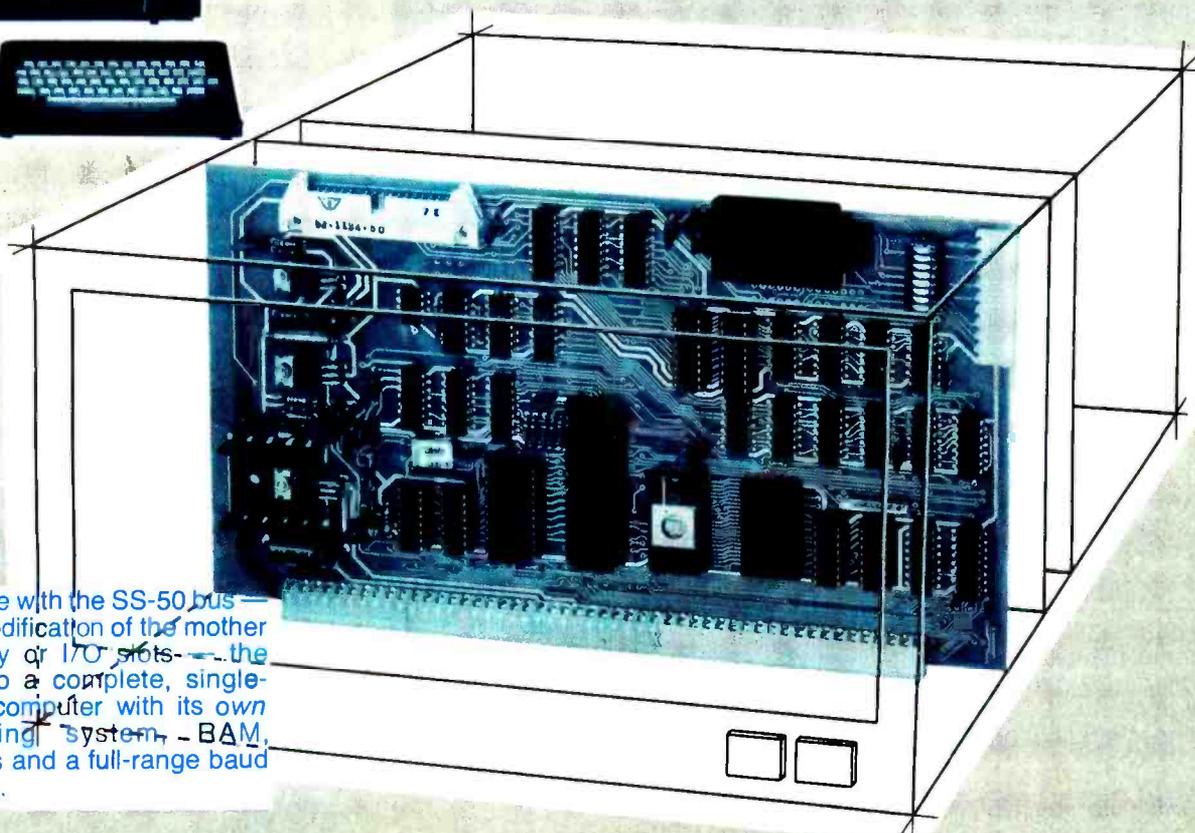
For simplicity, a standard rectangular grid and coordinate system will be utilized. The map is now a matrix of squares that can be referred to by their row and column in the matrix. The size of the squares should be chosen so that each square effectively has only one type of terrain in it.

The second step is to determine the movement cost for each type of terrain. This requires that a study be made to determine the type of cost involved in the problem. This cost must then be scaled so the movement-cost figure for

*Text continued on page 62*

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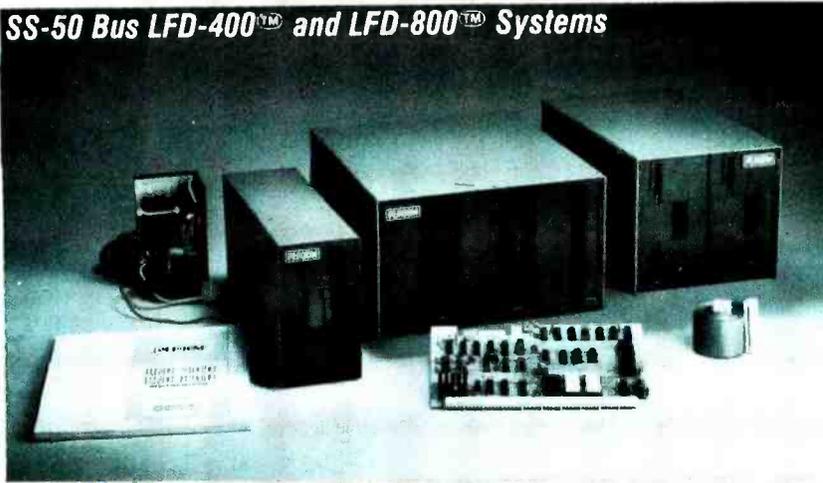
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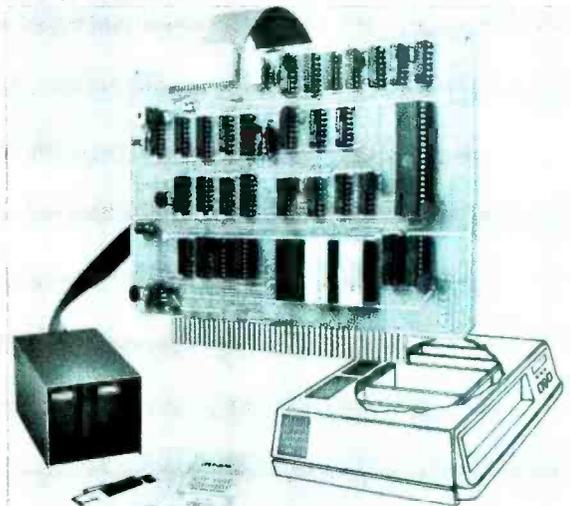
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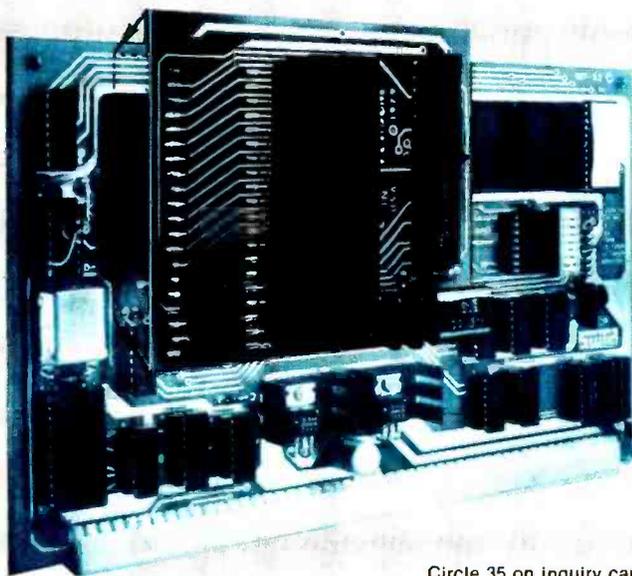
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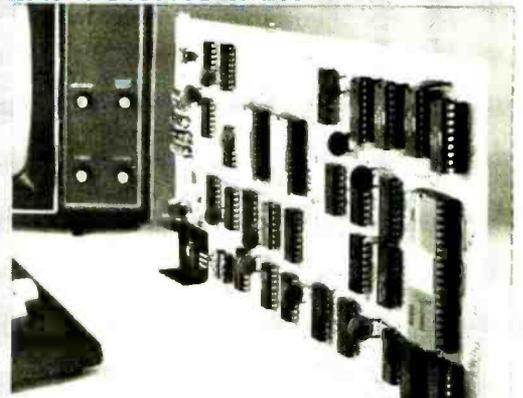
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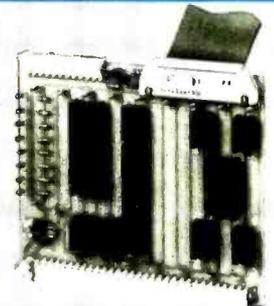
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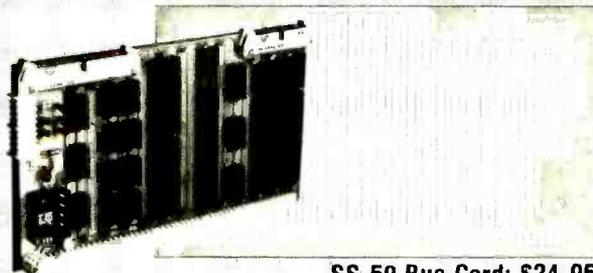


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Text continued from page 58:

each type of terrain is an integer multiple of the cost unit.

The movement cost for any one square on the terrain map is considered to be the cost to *enter* the terrain area represented by that square. If you are currently in square X, and wish to move to square Y, then consider the cost of moving *into* square Y as the movement cost for square Y. The movement cost of square X, the current square, has no effect on the calculation; the movement cost is affected only by the nature of the terrain you are about to enter.

The result of determining movement costs is a cost matrix, C, where  $C(I,J)$  is the movement cost of the terrain in the square in the I-th row and J-th column of the map. For all terrain which is effectively impossible to enter, or for which entrance is prohibited,  $C(I,J) = 0$  is assigned.

The third step is to generate *terrain masks*. First determine *max*, which is the maximum value found among all the movement costs in C. Then for all values  $k$  such that  $1 \leq k \leq C_{max}$  you define the terrain mask  $T_k$  where  $T_k(I,J)$  is 1 if  $C(I,J) = k$ , and  $T_k(I,J) = 0$  otherwise.

Now you should define a *scatter function* for the problem. The function will produce scatter mappings for use with the terrain masks generated above. The input to this

W W W W W W W W	blank	=	Clear
W W R R W W			
W R R W	R	=	Rough
W R J J J W	J	=	Jungle
W J J J W			
W J W W			
W W W W W	W	=	Water
W W W W W W W W			

Figure 1: Map of a small island with clear, rough, and jungle terrain. The map is represented on a rectangular grid.

0 0 0 0 0 0 0 0	
0 0 2 2 1 1 0 0	
0 1 2 2 1 1 1 0	
0 1 2 3 3 3 1 0	C
0 1 3 3 3 1 1 0	
0 1 3 1 1 1 0 0	
0 1 1 1 0 0 0 0	
0 0 0 0 0 0 0 0	

Figure 2: A movement cost matrix for the island map of figure 1.

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 1 1 0 0	0 0 1 1 0 0 0 0	0 0 0 0 0 0 0 0
0 1 0 0 1 1 1 0	0 0 1 1 0 0 0 0	0 0 0 0 0 0 0 0
0 1 0 0 0 0 1 0	0 0 1 0 0 0 0 0	0 0 0 1 1 1 0 0
0 1 0 0 0 1 1 0	0 0 0 0 0 0 0 0	0 0 1 1 1 0 0 0
0 1 0 1 1 1 0 0	0 0 0 0 0 0 0 0	0 0 1 0 0 0 0 0
0 1 1 1 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
T1	T2	T3

Figure 3: The three terrain masks that will be superimposed on the movement cost matrix of figure 2.

function is a boolean array of starting positions (1, if yes; 0, if no). The output is another boolean array of ending positions of moves of distance one from the starting positions. Since distance is a factor, you must define a *metric*, or distance function, for this problem.

### Example of the Procedure

In figure 1, there is a map of a small island with terrain of three types: clear, rough, and jungle. The map has been placed on an 8 by 8 rectangular grid, and each grid square is clearly identified as being a single type of terrain.

Let us return to our hiker traveling cross-country on foot. Suppose that he requires 10 minutes to travel through one square of clear terrain, 20 minutes for rough terrain, and 30 minutes for jungle terrain. The terrain type "water" is effectively impassable in this problem. Thus, the movement cost is in terms of 10-minute periods of time, and you can construct the cost matrix C as shown in figure 2. Since 3 is the maximum movement cost value found in C, you will have three terrain masks: T1, T2, T3 as shown in figure 3.

Using a rectangular grid, there is a choice between two obvious distance functions with strictly integer values. The first distance function is the "city" metric, which defines the distance between points  $(a,b)$  and  $(c,d)$  as  $|a-c| + |b-d|$  where  $|x|$  is the absolute value of  $x$ . This function derives its name from the fact that in the rectangular system of streets found in a city, no movement is allowed diagonally through blocks. All distances are in terms of the net distance north or south added to the net distance east or west.

The second distance function is the "square" metric, which defines the distance between points  $(a,b)$  and  $(c,d)$  as the maximum of  $|a-c|$  and  $|b-d|$ . Its name is derived from the fact that the shape of the area containing all squares that are  $N$  or less units distant is a square, for any integer  $N$ .

### Scatter Functions

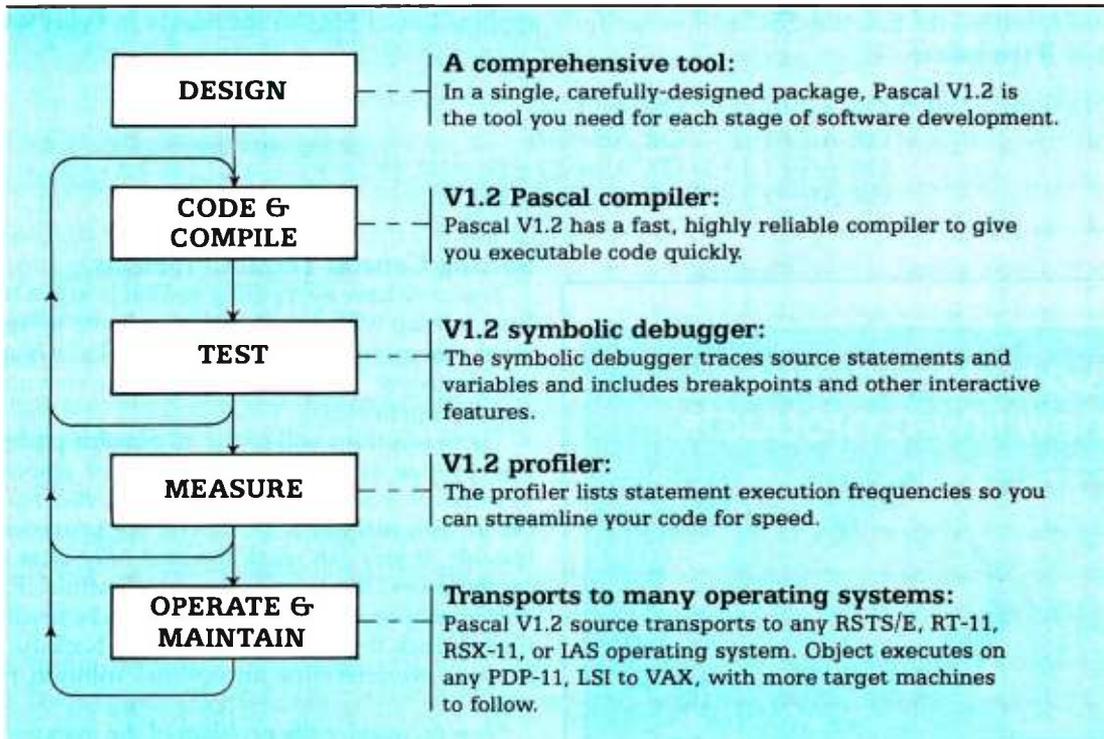
Now it is necessary to define scatter functions CSC and SSC for the "city" and "square" distance functions, respectively. Let A be a matrix the same as C; that is, an 8 by 8 matrix. Let  $A(I,J) = 0$  for all I and J, except for the one location on the map that is to be used as the starting position.  $A(I,J)$  will be 1 for the starting location. Matrix A is the input to the scatter function. B will be designated as the output matrix. The notation  $X(A)$  to represent the results of applying the function X to the matrix A will also be used. For the city distance function, the function

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0 0 0 0 0	0 0 0 0 0	0 0 1 0 0	0 0 0 0 0	1 1 1 1 1
0 0 0 0 0	0 0 1 0 0	0 1 1 1 0	0 1 1 1 0	1 1 1 1 1
0 0 1 0 0	0 1 1 1 0	1 1 1 1 1	0 1 1 1 0	1 1 1 1 1
0 0 0 0 0	0 0 1 0 0	0 1 1 1 0	0 1 1 1 0	1 1 1 1 1
0 0 0 0 0	0 0 0 0 0	0 0 1 0 0	0 0 0 0 0	1 1 1 1 1
a. A	b. CSC(A)	c. CSC(CSC(A))	d. SSC(A)	e. SSC(SSC(A))

Figure 4: Figure 4a is an example of a starting matrix, A. Figure 4b represents the matrix after the CSC (city) scatter function has been applied. The CSC function is then applied a second time to obtain the matrix in figure 4c. Figures 4d and 4e represent the results obtained after applying the SSC (square) scatter function to the matrix in figure 4a once and twice.

CSC will assign to each element of B the value:

$$B(I,J) = \text{CSC}(A(I,J)) = A(I,J) \text{ OR } A(I,J+1) \\ \text{OR } A(I,J-1) \\ \text{OR } A(I+1,J) \text{ OR } A(I-1,J)$$

where OR represents the logical OR operation. For the square distance function, the function SSC will assign to each element of B the value:

$$B(I,J) = \text{SSC}(A(I,J)) = A(I,J) \text{ OR } A(I,J+1) \text{ OR } A(I,J-1) \\ \text{OR } A(I+1,J) \text{ OR } A(I-1,J) \\ \text{OR } A(I+1,J+1) \text{ OR } A(I+1,J-1) \\ \text{OR } A(I-1,J+1) \text{ OR } A(I-1,J-1)$$

In both cases, all matrix elements  $A(I,J)$  that lie outside the matrix A are to be considered zero, such as  $A(0,0)$ .

Figure 4a gives an example of a 5 by 5 starting matrix, A. Figure 4b represents the result of applying the CSC function to that matrix. In figure 4c, the result of applying CSC to the matrix in figure 4b can be seen. Figures 4d and 4e represent the matrices obtained after one and two applications of SSC to the matrix in figure 4a.



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### Solving General Terrain Problems

You now have everything needed to solve terrain problems: a map with a grid and coordinate system, a movement cost matrix, a set of terrain masks, a matrix of starting positions, and a distance function with associated scatter function.

These solutions will probe all possible paths, incrementing by one unit at a time until your resources are exhausted or your goal is reached. If you reach the goal before you run out of resources, the proposed journey is feasible; if you can reach the goal only after running out of resources, the proposal is not feasible. Furthermore, once a proposed journey is proven to be feasible, you can then retrace the path from the goal back to the starting position to determine an optimal solution to the problem.

Now reconsider the problem of the man walking on the island of figure 1. The city metric and the scatter function CSC will be used. Let the walker's starting point be the square (3,5) on the map in figure 1; that is the clear terrain in the third row and the fifth column. During the first 10 minutes the hiker will expend one unit of cost and can, therefore, move one square north to (2,5) or one square east to (3,6). The hiker cannot move south or west to (4,5) or (3,4) since he has not yet expended enough cost units. Figures 5 and 6a show his starting location matrix and his matrix of possible new locations after 10 minutes, since each of these positions requires only one more unit of movement cost. After another 10 minutes, the hiker can reach the clear terrain squares at (2,6) and (3,7) by moving from the squares reached after first 10 minutes. The hiker could also have reached the rough terrain square (3,4). This would be possible by moving west for 20 minutes from the starting position at square (3,5). All



other moves are impossible due to either a lack of sufficient travel time, in the case of the jungle square (4,5), or the presence of impassable terrain, such as the water to the north. Figure 6b shows the possible new locations for the hiker after 20 minutes (two units of movement cost expended).

After 30 minutes, the hiker has finally expended enough units of movement cost to go south from his starting position to the jungle terrain square (4,5). He can now also reach the rough terrain square (2,4) by traveling west for 20 minutes from the clear terrain square (2,5). Figure 6c shows the hiker's possible locations after 30 minutes.

From the above example, it should be clear that movement into terrain with a movement cost of  $k$  depends on the position of the object  $k$  movement cost units before. Refer to each iteration of the example above as a move. Also, designate the matrix of possible locations after  $k$  moves  $M_k$  or the  $k$ -th scatter mapping.

This relation can be expressed as follows: the new terrain squares of movement cost  $k$  that you can reach on

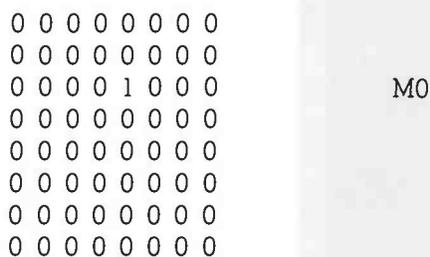


Figure 5: The starting matrix for the island problem with the traveler standing in the clearing at location 3,5.

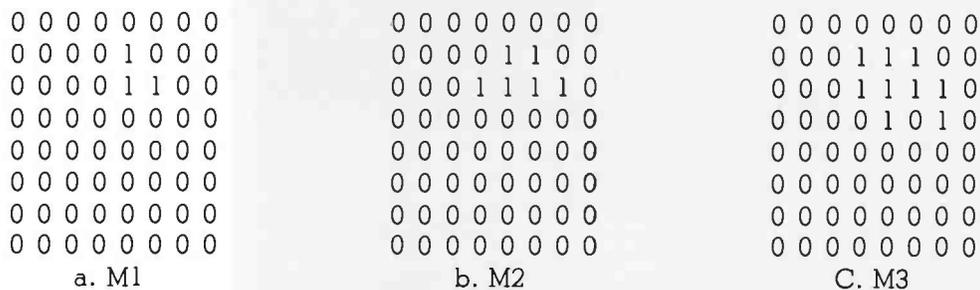


Figure 6: After 10 minutes, the traveler may be in any of three positions (figure 6a). Each of these positions represents a 10 minute or less expenditure of time. After another 10 minutes, the traveler may be in any of the squares indicated by figure 6b. Figure 6c represents squares where the traveler may be after 30 minutes.

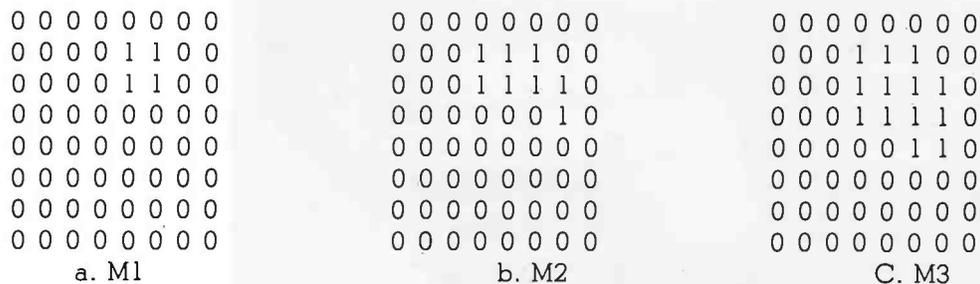


Figure 7: The first, second, and third scatter-function mappings using the square scatter function (SSC) as defined by equations in text.

move  $n$  is represented by the matrix  $A$  where  $A(I,J)$  is equal to  $T_k(I,J)$  AND  $B(I,J)$  where  $B=XSC(M_n-k)$ . (XSC is the scatter function. AND represents the logical AND operation.) From this you obtain the relation:

$$M_n = M_{n-1} \text{ OR } (T_1 \text{ AND } XSC(M_{n-1})) \\ \text{ OR } (T_2 \text{ AND } XSC(M_{n-2}))$$

$$\text{OR } (T_k \text{ AND } XSC(M_{n-k}))$$

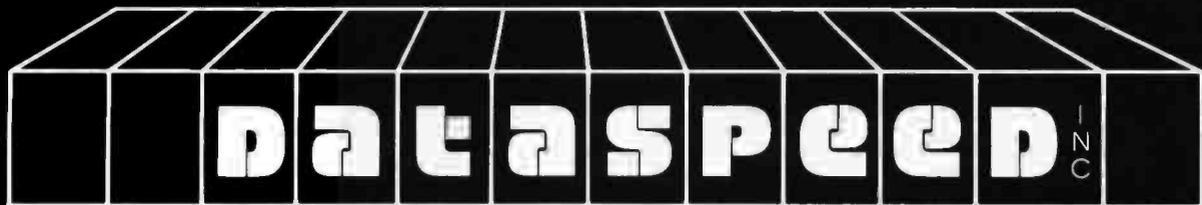
where  $k$  is the minimum of  $C_{max}$  and  $n$ . In both of these relations, function XSC could be replaced by CSC, SSC, or any other scatter function to allow the use of any other metric or even another grid system, such as the hexagonal grid. The hexagonal grid will be discussed in part 2 with reference to conflict simulations. Figure 7 shows the scatter mappings M1, M2 and M3 using the square scatter function, SSC. It is left to the reader to verify that this relation holds for both scatter functions.

Using scatter maps, you can prove or disprove the feasibility of these proposals by determining whether this goal is a possible new location in the scatter mappings.

### Determining an Optimal Path

Suppose that after  $n$  moves, the scatter map  $M_n$  finally contains the goal. Therefore, you know that there exists a path from your starting location to the goal which requires a movement cost of  $n$ , and you know that no less expensive path exists. To find this path it is necessary to first define the matrices  $S_k$  that are the sums of all the

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```
0 0 0 0 0 0 0 0
0 0 0 1 3 2 0 0
0 0 0 2 4 3 2 0
0 0 0 0 1 0 1 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
```

S3

Figure 8: The third scatter sum using the city scatter function (CSC) for the island example. All moves which are made must conform to the city metric (distance function).

scatter maps  $M_0$  through  $M_k$ .  $S_k$  will be referred to as the  $k$ -th scatter sum. Note that  $S_0 = M_0$ . Figure 8 shows the third scatter sum for the function CSC.

The algorithm for finding an optimal path is as follows: beginning at your goal, follow a path of strictly increasing elements of  $S_n$  until you reach your starting position, choosing the most rapidly increasing path if more than one exists. Since all the possible locations in  $M_k$  are in  $M_{k+1}$ , for all  $k$ , the more quickly a location is reached from the starting point, the higher its value will be in each scatter sum.

For example, if the clear terrain square (4,7) was your goal, you would use the third scatter sum, S3, which is in figure 8. Following the movement restrictions imposed by the city function, you will consider only those locations given by the scatter of the current location to determine the next location on your path. Thus, you will choose your next location from the squares (4,8), (4,6), (5,7) and (3,7).

Square (3,7) will be chosen, since it has the maximum value in S3. In the same manner, squares (3,6) and (3,5) will be chosen so that your optimal path from starting point to goal is (3,5) to (3,6) to (3,7) to (4,7). In the same manner, you can find that the optimal path from (3,5) to (2,4) is by way of (2,5).

When you try to find the optimal path and there are, at some point between the goal and start, two or more possible locations from which to choose, you can randomly choose any one of them with equal success. This algorithm, therefore, will find an optimal path, but not necessarily the only such path.

In Part 1 I have discussed some general terrain problems and demonstrated a few solutions using a rectangular grid. This method is very easy to implement with two-dimensional boolean arrays and lends itself well to most of the problems that will be encountered. One notable exception, however, is the conflict simulation or "war game." These games are usually played on terrain maps of a battlefield, upon which a grid of hexagons is superimposed.

This hexagonal grid (or hex grid) resembles a honeycomb. It eliminates the need for two different metrics, since there are no diagonals, but it requires the definition of a new system of coordinates.

In Part 2 I shall define this coordinate system, a distance function, and a scatter function. I shall also discuss the representation of specific terrain-related game features such as directional terrain (roads and bridges) and "no-exit" terrain (zones-of-control). ■

# BYTE News . . .

**VOICE-CONTROLLED CONSUMER PRODUCTS:** At a recent electronics show in Japan, several Japanese manufacturers demonstrated voice-response and voice-activation of many consumer products. Sanyo, Toshiba, Sharp, Sony, Hitachi, and Matsushita demonstrated a wide variety of consumer products that respond to oral commands. Using microprocessor-controlled speech analyzers and synthesizers, the processors controlled television channel selection, volume and color control, and operated video games and clocks. Some units talked back to confirm user commands.

It is expected that many of these products will be commercially available in a year or two. Present technology allows registration of up to three persons in the voice-recognition circuit. Manufacturers agree that the voice recognition is not 100% perfect, but that it will be in time.

**SOME HOME COMPUTERS FAIL FCC RFI SPECS:** The Federal Communications Commission (FCC) has released the results of their tests of personal computer systems for radio-frequency interference (RFI). RFI has become an increasing problem to television and FM radio reception, similar to the citizen's band radio interference problem several years ago. The FCC has proposed as a standard a radiation limit of 100 microvolts per meter at a 3-meter distance.

Early last year the FCC tested the Radio Shack, Apple, Heath, Texas Instruments (TI), Commodore PET, and Southwest Technical Products personal computers. Only the Texas Instruments and Commodore systems met the specification. Atari had submitted and passed the specification earlier.

The standard goes into effect July 1, 1980, and all manufacturers have declared their intention to make necessary modifications to assure compliance with the specifications.

**CENTRONICS REVEALS NEW PRINTING METHOD:** In a press conference held on November 13, 1979, Centronics Data Corp of Hudson, New Hampshire, demonstrated a new method of printing on paper. A single stylus driven by voice coils through a parallelogram flexure mechanism presses a carbon ribbon against paper to form characters in almost the same way as people write using pens and pencils. Character fonts are switched by changing the controlling software; an almost infinite variety of symbols may be produced, including mathematical, Greek, Chinese, Cyrillic, and Arabic character sets. The prototype Quietwriter typewriter devices print with excellent quality at a speed of 17 cps for English-language character sets. Products using the Quietwriter mechanism may be sold beginning about the third quarter of 1981.

**NEW LISP SYSTEM:** The LISP Co (T.(L.C)) of Los Gatos, California, has completed their first version of LISP for the Z80. It is a dialect of the MIT LISP-Machine LISP, complete with strings, I/O streams, Muddle's parameter-description mechanism, and comprehensive documentation. This version was done for a major personal computer manufacturer; (T.(L.C)) will soon announce their own version that will include hardware to support the LISP programming environment.

**HOBBYIST ELECTRONIC MAIL SYSTEM FORMING:** Hobbyists are setting up a low-cost mail system using their microcomputers. This is possible using a \$12 software package from the Personal Computer Network (PCNET) committee. With it, a personal computer owner can set up his machine to automatically dial another system or systems at a preset time (usually late at night), deliver messages, and return a status report (delivered or not delivered).

Hobbyists are also setting up dial-in, free-access message systems for discussion purposes using the FORUM-80 software and Radio Shack TRS-80s. Three forums are already in operation: forums devoted to tracing family histories (in Fairfax, Virginia), information on engineering applications of microcomputers (Olathe, Kansas), and applications of microcomputers for the handicapped (Memphis, Tennessee). For more information on these applications, contact Jon Tara, c/o SEMCO, POB 9578, Detroit MI 48202.

**COMPUTER COMPANIES GO INTO RETAILING:** The latest computer stores are those set up by Digital Equipment Corp (DEC), IBM, and NCR. Following the innovative experiences in computer retailing established by Tandy Corp and independent stores, the traditional computer manufacturers have decided to meet the challenge head on. DEC already has in operation almost twenty "computer stores" where customers can sample the DEC small computers. However, the stores have no inventory and purchases are shipped from a distribution center.

IBM now stocks their 5110 small business systems at fifty centers where a purchaser can get a system on a cash-and-carry basis. These centers were originally opened to demonstrate and train users, and then the retail operation was added. A typical system sells for \$16,000.

NCR has opened two pilot stores in Cincinnati to sell cash registers and small computers in the \$15,000 price range. Data General is selling its MicroNOVA system through fifty independent dealers, and Texas Instruments is beginning computer demonstrations in its San Francisco store.

With the cost of small business computer systems decreasing, the profit margin is no longer enough to support the high-cost selling techniques of large computer systems.

**MOTOROLA, TANDY AND WESTERN UNION INTRODUCE "GREEN THUMB" SYSTEMS:** Sponsored by a grant from the US Department of Agriculture, Motorola and Western Union will set up an experimental agricultural video-telephone information system known as Project Green Thumb. Tandy Corp will manufacture the terminals to be located in 200 farm homes in Kentucky. Farmers, via telephone lines, will be able to access weather, market, and agriculture data from remote computers.

**RANDOM NEWS:** Atari has filed an appeal with the Federal Communications Commission (FCC) to stay the decision (reported in last month's BYTE News) in which the FCC granted Texas Instruments a waiver on permissible interference standards for personal computers. Atari feels that if other companies can pass the specification, then the TI request should not have been granted . . . Texas Instruments will soon have competition in the voice synthesis area. National Semiconductor Corp and ITT Semiconductor are both showing samples of their new synthesizer parts. These integrated circuits are aimed at low-price consumer applications such as talking clocks, telephone-answering equipment and automobile warning devices . . . Texas Instruments has introduced four new terminals that have dual-matrix print heads. The head prints two characters with each pass across the page enabling the unit to print 120 characters per second . . . MIT (Massachusetts Institute of Technology) has received a development contract worth several million dollars from Heath Co and Exxon Enterprises. The contract calls for the MIT Computer Science Laboratory to develop an advanced cartridge-disk-based 16-bit microcomputer system for use in office automation. Although initial plans called for MIT to use Zilog's 16-bit microprocessor, it is reported that they have switched to the Motorola 68000 to use memory more efficiently. Both Heath and Exxon will have nonexclusive manufacturing rights, and Exxon will have exclusive software rights . . . Chuck Peddle, the developer of the 6502 microprocessor, the KIM-1, and PET computers, has a new product. It is the Commodore 4500 4-bit microprocessor. It represents a radical departure from the 6502 architecture . . . Researchers at Bell Labs announced the development of an improved electrochromic display using iridium. It consumes less power and could be cheaper to produce than light-emitting diode and liquid-crystal type displays. It does not have to be energized continuously and is pulsed to turn on and off.

**APOLOGY DUE:** In the September 1979 BYTE News column, I reported on 16-bit 8086 processor boards for S-100 systems. I regret that I omitted mention of a company that has been making such a board since December 1978. The company is Tecmar Inc, 23414 Greenlawn Ave, Cleveland OH 44122. They sell a complete line of S-100 boards to make up a complete system.

**RANDOM RUMORS:** Apple Computer will soon introduce the Apple III, and it is rumored that it will not use the 6502 microprocessor. Apple is keeping a tight lid on their plans (bit-slice, perhaps?) for this unit. . . Digital Research, the firm that developed CP/M, the most popular disk operating system for microcomputer systems, will soon announce a version of CP/M for the Intel 8086 16-bit microprocessor, which will include an assembler program. . . IMI (International Memories Inc) of Cupertino, California, the first company to ship 8-inch, Winchester-technology, hard disk drives, is rumored to be planning to show a 5¼-inch, 3-megabyte Winchester drive at the 1980 National Computer Conference in June. Rumor is that there will be at least one other such drive shown at the NCC. . . .

**MAIL:** I receive a large number of letters each month, as a result of this column. If you wish a response please include a stamped, self-addressed envelope.

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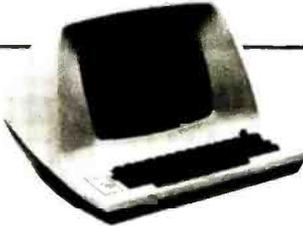


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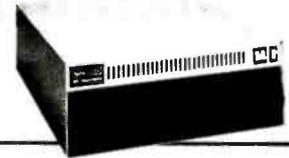
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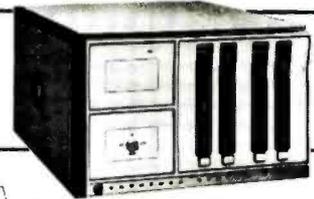
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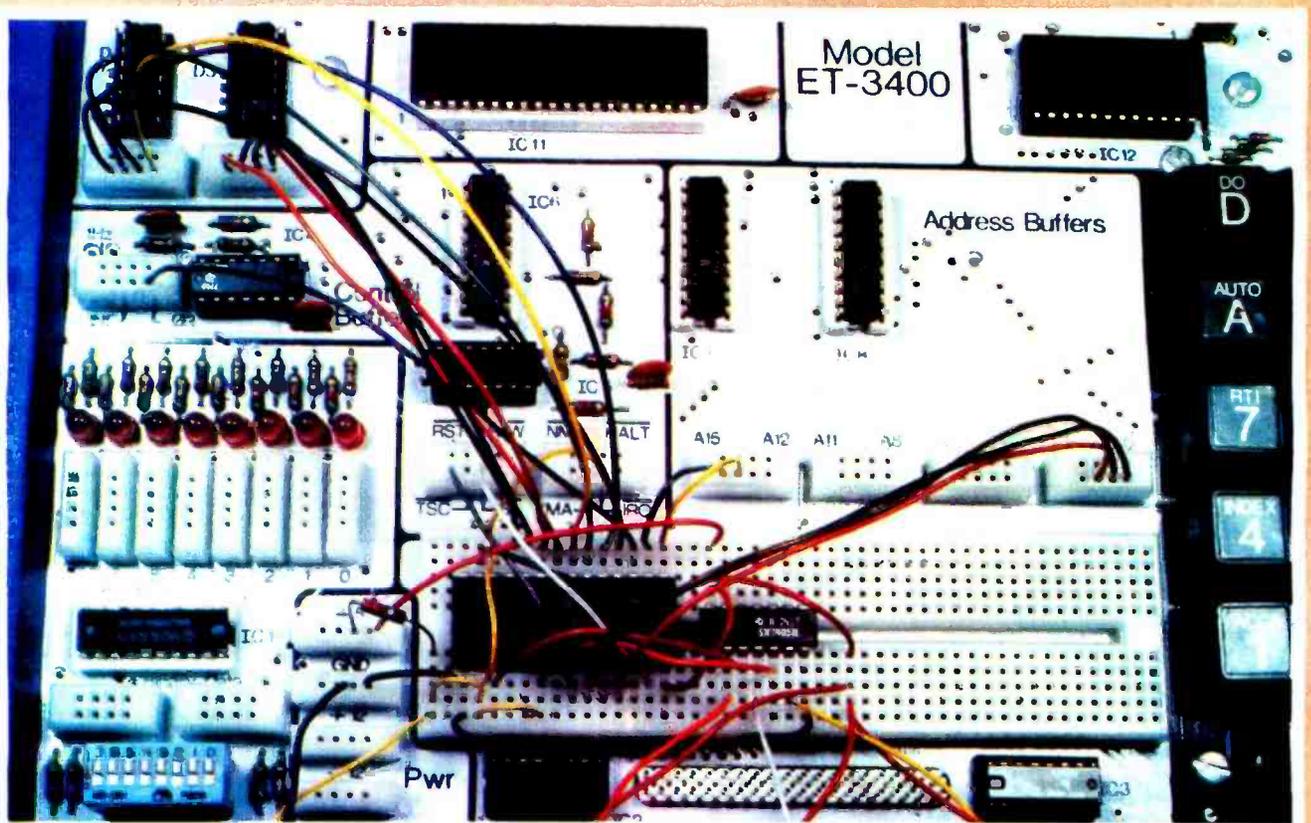
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# A Computer-Controlled Light Dimmer

## Part 2: Implementation

John H Gibson  
Physics Department  
Alma College  
Alma MI 48801



**Photo 3:** Close-up view of the Heathkit ET-3400 microprocessor trainer wired for use with the demonstration program. The ET-3400 programmable timing module is connected to the trainer's data bus via the eight wires from the left corner of the picture. The synchronizing signal is transmitted over the yellow-black twisted pair at the bottom of the picture. The red-orange, red-white, and red-yellow twisted pairs carry the output trigger pulses to the three AC phase controls.

The numbering of the photos, figures, and tables is continued from part 1 of this article, January 1980 BYTE, page 56.

In part 1 is an examination of the basic principles and techniques for achieving proportional AC phase control with a microcomputer and a programmable timer. I would now

like to present a completely worked-out demonstration program designed to run on a Heathkit ET-3400 microprocessor trainer. This demonstration program will operate three lamp circuits, giving you keyboard control over the lamps that are to be faded on and off.

In addition to the ET-3400 trainer, you will need an MC6840 programmable timer module, a 7405 hex in-

verter (open collector), a synchronizer (from figure 5 in part 1), and three AC phase controls (each from the circuit of figure 9 in part 1).

Here is a step-by-step procedure for making the demonstration program work:

- 1) Plug the MC6840 and the 7405 integrated circuits into the ET-3400 trainer's breadboard socket.

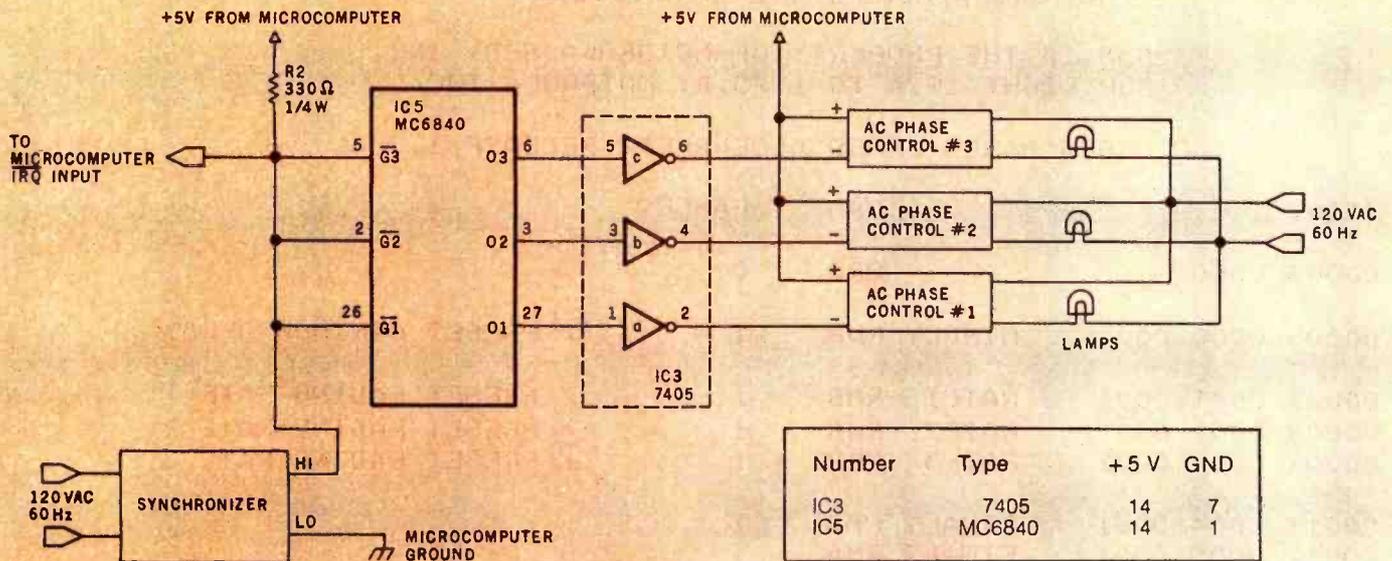


Figure 10: Wiring diagram for proportional power control of three AC lamp circuits. Connections between the MC6840 programmable timer and the ET-3400 microprocessor trainer have been omitted for clarity.

- 2) Make the connections between the MC6840 and the ET-3400 trainer as shown in table 2.
- 3) Wire the circuit shown in figure 10.
- 4) Load the FADER2 program in listing 1 beginning at location hexadecimal 0100.
- 5) Memory location 0000 stores a minimum delay number for all lamps. If you want the lamps to reach maximum brightness, it should be preset to 00.
- 6) Fading rates for the three lamps should be preset in memory locations 0001, 0002, and 0003. Setting each of these rate values to hexadecimal FF will cause each lamp to go from complete darkness to full brightness in about 2 seconds. At the opposite extreme, setting each rate value to 01 will cause this change to take 9 minutes.
- 7) Location hexadecimal 017F con-

tains the output-pulse-width value hexadecimal 1E that was computed in part 1 of this article. This pulse width was computed for a microprocessor clock frequency of 1 MHz. If your system's clock frequency is different, you will have to recompute this pulse width.

A pulse width that is too short will not permit the lamps to darken completely; a pulse width that is too long will cause the lamps to flicker or flash back on at full brightness just when you expect them to be completely dark.

- 8) The program (listing 1, p. 74) begins execution at location hexadecimal 0100, initializing all variable locations. With the program running, pushing keys 0 thru 7 will fade the lamps on and off in different combinations, according to the binary value of the keys pressed. The lamps' changing values will appear on the ET-3400's six seven-segment readouts.

- 9) You can stop the program without turning off the lamps by pushing the 9 (break) key. With the program stopped, you may examine and change registers, all without affecting the lamps. You may then restart the program at location

6840	6840 Pin Numbers	ET-3400
$V_{cc}$	1	GND
$V_{ee}$	14	+ 5 V
RESET	8	RST
IRQ	9	no connection
RS0	10	A0
RS1	11	A1
RS2	12	A2
R/W	13	R/W
CS0	15	A14
CS1	16	A15
Enable	17	$\phi 2$
D0	25	D0
D1	24	D1
D2	23	D2
D3	22	D3
D4	21	D4
D5	20	D5
D6	19	D6
D7	18	D7

Table 2: Connections to be made between the Heath ET-3400 microprocessor trainer and the MC6840 programmable timer.

hexadecimal 0110, which retains previous values in the variable locations.

This demonstration program should be enough to fire your imagination to think of your own applications for this lamp control technique. I will be interested in hearing about programs and applications developed by BYTE readers.

#### Author's Note

I am indebted to Professor Kameswara Rao, of National Semiconductor, Santa Clara CA, for his advice and technical support. This lamp control program was developed and tested in his electronics laboratory at Western Michigan University with the use of a Motorola M6800 cross-assembler resident on Western's PDP-10 computer.

Listing 1: FADER2, a program written in assembler language for the Motorola M6800 processor to control the light dimmer.

MOTOROLA M68SAM CROSS-ASSEMBLER

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MOTOROLA M6800 CROSS ASSEMBLER, RELEASE 1.2

```
00001          NAM      FADER2

00003 0000          ORG      0

00005 0000 0001    MINDLY RMB      1      / PRESET MINIMUM DELAY

00007 0001 0001    RATE1  RMB      1      / PRESET FADING RATE 1
00008 0002 0001    RATE2  RMB      1      / PRESET FADING RATE 2
00009 0003 0001    RATE3  RMB      1      / PRESET FADING RATE 3

00011 0004 0001    FINAL1 RMB      1
00012 0005 0001    FINAL2 RMB      1
00013 0006 0001    FINAL3 RMB      1

00015 0007 0001    DELAY1 RMB      1
00016 0008 0001    DELAY2 RMB      1
00017 0009 0001    DELAY3 RMB      1

00019 000A 0001    INTER1 RMB      1
00020 000B 0001    INTER2 RMB      1
00021 000C 0001    INTER3 RMB      1

00023          00F7    UIRQ   EQU     $00F7    / MONITOR VECTORS HERE ON IRQ

00025          * ADDRESSES IN PROGRAMMABLE TIMING MODULE

00027          8000    CR1   EQU     $8000
00028          8001    CR2   EQU     CR1+1
00029          8000    CR3   EQU     CR1

00031          8002    M1    EQU     CR1+2    / MSB OF LATCH 1
00032          8003    L1    EQU     CR1+3    / LSB OF LATCH 1

00034          8004    M2    EQU     CR1+4    / MSB OF LATCH 2
00035          8005    L2    EQU     CR1+5    / LSB OF LATCH 2

00037          8006    M3    EQU     CR1+6    / MSB OF LATCH 3
00038          8007    L3    EQU     CR1+7    / LSB OF LATCH 3

00040          * THESE ET-3400 MONITOR SUBROUTINES ARE USED

00042          FC00    RESET EQU     $FC00    / RETURN TO MONITOR
00043          FDF4    INCH  EQU     $FDF4    / INPUT CHAR FROM KEYBOARD
00044          FCBC    REDIS EQU     $FCBC    / RESET DISPLAY TO 1ST LED
00045          FD7B    DSPLY EQU     $FD7B    / DISPLAY ROUTINE

00047          * MAKE A COLD START FROM THIS ADDRESS - $0100
```

Listing 1 continued on page 76

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Listing 1 continued:

```
00049 0100                ORG      $100

00051                * INITIALIZE DELAYS SO ALL LAMPS ARE OFF

00053 0100 86 FF  CLDSTR LDA A  #$FF      / MAXIMUM DELAY VALUE
00054 0102 CE 0004          LDX    #FINAL1  / INITIALIZE POINTER

00056 0105 A7 00  INITIA STA A  0,X      / STORE #$FF HERE
00057 0107 08          INX          / POINT TO NEXT VARIABLE
00058 0108 8C 000D      CPX    #INTER3+1  / LAST VARIABLE?
00059 010B 26 F8          BNE    INITIA  / RETURN IF NOT DONE

00061 010D 01          NOP
00062 010E 01          NOP
00063 010F 01          NOP

00065                * MAKE A WARM START FROM THIS ADDRESS - $0110

00067 0110 0F          WRMSTR SEI          / MASK IRQ WHILE INITIALIZING

00069                * THESE STEPS CONFIGURE THE TIMERS FOR SINGLE-SHOT
00070                * OPERATION WITH TURN-ON DELAY M(L+1)T AND OUTPUT
00071                * PULSE WIDTH LT.

00073 0111 86 B6          LDA A  #$B6      / CONTROL WORD FOR CR3, CR1
00074 0113 C6 B7          LDA B  #$B7      / CONTROL WORD FOR CR2

00076 0115 B7 8000      STA A  CR3      / CONFIGURE TIMER 3
00077 0118 F7 8001      STA B  CR2      / CONFIGURE TIMER 2
00078 011B B7 8000      STA A  CR1      / CONFIGURE TIMER 1

00080                * ON IRQ, THE ET-3400 VECTORS TO LOCATION
00081                * UIRQ. WE MUST PROVIDE A JUMP INSTRUCTION
00082                * AND A VECTOR TO TRANSFER TO OUR PROGRAM'S
00083                * IRQ SERVICE ROUTINE AT LOCATION #CYCLE.

00085 011E 86 7E          LDA A  #$7E      / LDA A WITH JUMP COMMAND
00086 0120 97 F7          STA A  UIRQ      / STORE JUMP COMMAND AT UIRQ

00088 0122 CE 0137      LDX    #CYCLE  / JUMP TO THIS LOCATION
00089 0125 DF F8          STX    UIRQ+1  / STORE #CYCLE AT UIRQ VECTOR

00091 0127 0E          CLI          / CLEAR IRQ MASK

00093                * MAIN PROGRAM LOOP

00095 0128 BD FDF4 KEY   JSR    INCH      / GET HEX VALUE OF KEY PUSHED

00097 012B 81 09          CMP A  #$09      / IS IT "BREAK" KEY?
00098 012D 26 04          BNE    CONT      / BRANCH IF NOT "BREAK"

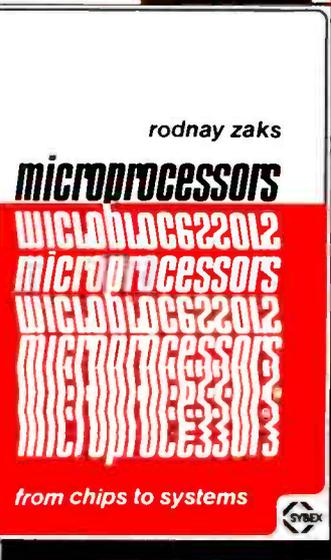
00100 012F 0F          SEI          / SET IRQ MASK
00101 0130 7E FC00      JMP    RESET    / GO TO ET-3400 MONITOR RESET
```

Listing 1 continued on page 78

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Listing 1 continued:

```

00103 0133 8D 09   CONT   BSR   NEWFN   / SET NEW FINAL VALUES
00104 0135 20 F1           BRA   KEY     / GET NEXT CLOSED KEY VALUE

00106                * IRQ INTERRUPT SUBROUTINE

00108 0137 8D 1E   CYCLE  BSR   CHANGE  / CHANGE DELAY VALUES
00109 0139 8D 3E           BSR   LOAD    / LOAD TIMERS WITH NEW DELAYS
00110 013B 8D 54           BSR   SHOW   / DISPLAY DELAY VALUES
00111 013D 3B           RTI

00113                * SUBROUTINE TO CHANGE FINAL VALUES

00115 013E 81 07   NEWFN  CMP A  #$07   / VALID HEX VALUE?
00116 0140 22 14           BHI   NEWFN4  / BRANCH IF NOT VALID

00118 0142 CE 0004           LDX   #FINAL1 / POINT TO FINAL1

00120 0145 46           NEWFN1 ROR A           / SHIFT LAMP(X) BIT INTO C
00121 0146 24 04           BCC   NEWFN2  / BRANCH TO DIM LAMP

00123 0148 D6 00           LDA B  MINDLY / LDA B WITH MIN DELAY
00124 014A 20 02           BRA   NEWFN3

00126 014C C6 FF   NEWFN2 LDA B  #$FF   / LDA B WITH MAX DELAY

00128 014E E7 00   NEWFN3 STA B  0,X    / STA B FINAL(X)

00130 0150 08           INX           / POINT TO NEXT LAMP
00131 0151 8C 0007           CPX   #FINAL3+1 / LAST LAMP DONE?
00132 0154 26 EF           BNE   NEWFN1  / RETURN IF NOT DONE

00134 0156 39           NEWFN4 RTS

00136                * ROUTINE FOR CHANGING DELAY NUMBERS

00138 0157 CE 0001 CHANGE LDX   #RATE1 / POINT TO LAMP 1

00140 015A E6 09   CHNG1  LDA B  9,X    / LDA B INTER(X)
00141 015C A6 06           LDA A  6,X    / LDA A DELAY(X)

00143 015E A1 03           CMP A  3,X    / CMP DELAY(X) WITH FINAL(X)
00144 0160 22 08           BHI   BRITER  / BRANCH IF DELAY(X)>FINAL(X)
00145 0162 27 0A           BEQ   RESTOR  / BRANCH IF DELAY(X)=FINAL(X)

00147 0164 EB 00   DIMMER ADD B  0,X    / B = INTER(X) + RATE(X)
00148 0166 89 00           ADC A  #$00   / A = DELAY(X) + CARRY
00149 0168 20 04           BRA   RESTOR

00151 016A E0 00   BRITER SUB B  0,X    / B = INTER(X) - RATE(X)
00152 016C 82 00           SBC A  #$00   / A = DELAY(X) - BORROW

00154 016E E7 09   RESTOR STA B  9,X    / STA B INTER(X)
00155 0170 A7 06           STA A  6,X    / STA A DELAY(X)

00157 0172 08           INX           / POINT TO NEXT LAMP
00158 0173 8C 0004           CPX   #RATE3+1 / DONE WITH ALL 3 LAMPS?

```

Listing 1 continued on page 80

# MicronET

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Access to the MicroNET service is available in 153 other cities for an additional charge of \$4.00 per hour.



*"... but the really impressive stuff is in the back room."*

Listing 1 continued:

```
00159 0176 26 E2          BNE    CHNG1    / RETURN TO DO NEXT LAMP
00161 0178 39            RTS

00163                    * THIS ROUTINE LOADS THE TIMER LATCHES

00165 0179 CE 8002 LOAD   LDX    #M1      / POINT TO M1

00167 017C 96 07          LDA    A    DELAY1
00168 017E C6 1E          LDA    B    #1E      / OUTPUT PULSE WIDTH
00169 0180 A7 00          STA    A    0,X     / LOAD M1 WITH DELAY1
00170 0182 E7 01          STA    B    1,X     / LOAD L1 WITH PULSE WIDTH

00172 0184 96 08          LDA    A    DELAY2
00173 0186 A7 02          STA    A    2,X     / LOAD M2 WITH DELAY2
00174 0188 E7 03          STA    B    3,X     / LOAD L2 WITH PULSE WIDTH

00176 018A 96 09          LDA    A    DELAY3
00177 018C A7 04          STA    A    4,X     / LOAD M3 WITH DELAY3
00178 018E E7 05          STA    B    5,X     / LOAD L3 WITH PULSE WIDTH

00180 0190 39            RTS

00182                    * THIS ROUTINE SHOWS THE THREE DELAY VALUES ON
00183                    * THE ET-3400'S SIX 7-SEGMENT READOUTS.

00185 0191 BD FCBC SHOW   JSR    REDIS    / RESET DISPLAY TO 1ST LED
00186 0194 CE 0007        LDX    #DELAY1  / START DISPLAY WITH DELAY1
00187 0197 C6 03          LDA    B    #03    / DISPLAY 3 BYTES
00188 0199 BD FD7B        JSR    DSPLAY   / DISPLAY DELAY1, 2 AND 3

00190 019C 39            RTS

00192                    END
```

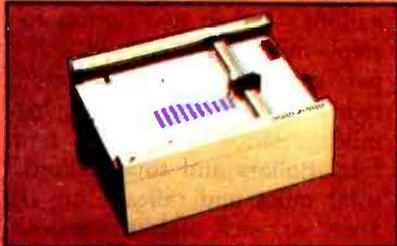
#### SYMBOL TABLE

MINDLY	0000	RATE1	0001	RATE2	0002	RATE3	0003	FINAL1	0004
FINAL2	0005	FINAL3	0006	DELAY1	0007	DELAY2	0008	DELAY3	0009
INTER1	000A	INTER2	000B	INTER3	000C	UIRQ	00F7	CR1	8000
CR2	8001	CR3	8000	M1	8002	L1	8003	M2	8004
L2	8005	M3	8006	L3	8007	RESET	FC00	INCH	FD74
REDIS	FCBC	DSPLAY	FD7B	CLDSTR	0100	INITIA	0105	WRMSTR	0110
KEY	0128	CONT	0133	CYCLE	0137	NEWFN	013E	NEWFN1	0145
NEWFN2	014C	NEWFN3	014E	NEWFN4	0156	CHANGE	0157	CHNG1	015A
DIMMER	0164	BRITER	016A	RESTOR	016E	LOAD	0179	SHOW	0191 ■

STOP --

# Now... You, the small systems user can enjoy the advantages of HI-performance *low cost* computer graphics

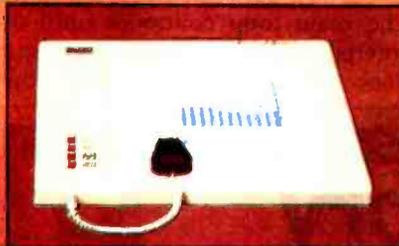
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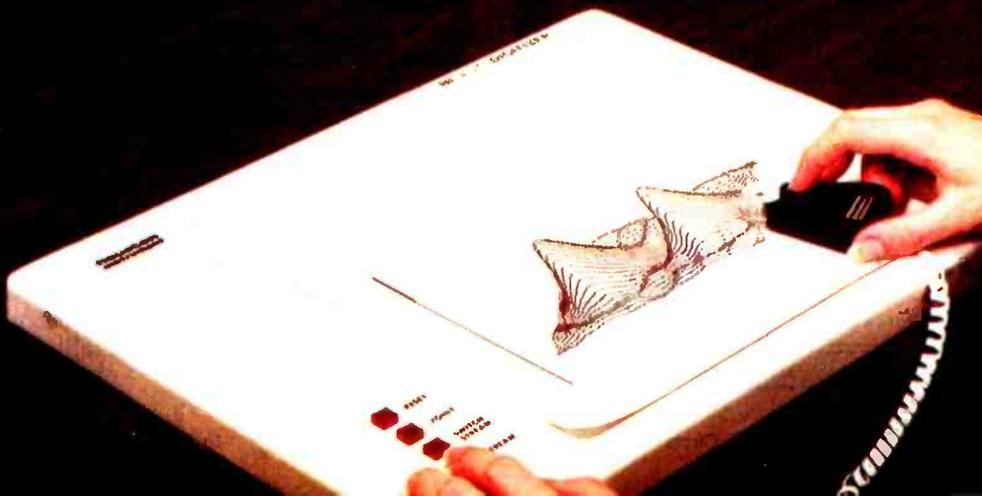
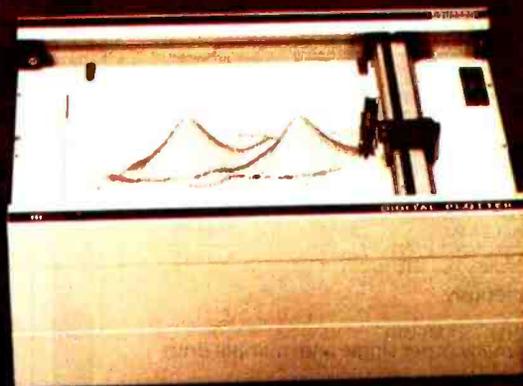
HIPLØT Circle Inquiry #222

HIPAD Circle Inquiry #223

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# Programming Quickies

## Gasuse

Mike R Firth, 4712 Northway Dr,  
Dallas TX 75106

Gasuse is a program I wrote to use facts I record in a notebook in my car to produce useful information. I note the mileage of my car, the cost of the gas, and usually the gallons and dollars of the purchase along with the

state of purchase and date (for tax purposes). Aside from the special features noted below, the program in listing 1 consists of the initialization routine (lines 1010 thru 1084), the main loop (1100 thru 1900), and routines to allow for missing information (2000 thru 2190) and printer output. The main loop continues until 0 is entered for the miles. The program does not permit entering a lower

mileage than the last mileage reading. The missing information section will permit computations if two of the three items— price, gallons, cost— are known.

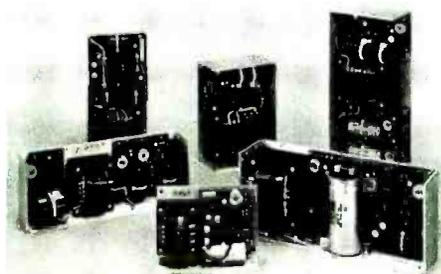
The information printed out includes the entered (or calculated) numbers—miles at purchase, dollars, gallons — then two figures for this step—miles since last fill and miles per gallon. Then there are total figures—miles since start of trip and mileage since the start in terms of total dollars and total gallons. The total miles and mileage are figured anew at each step to smooth out errors.

Notes on odd items: lines 40 and 50 save retyping the commands used on the Wang for disk storage. U\$ contains the character to move the cursor up one line. This results in the display being solid information, neatly arranged, with data entered on the bottom lines. The Select Print statements after line 8100 are the means of assigning the printed output. Only one device can be selected at a time, where 005 is the video terminal and 215 is the fast printer. Lines 9400 thru 9406 are special functions that relate to special keys on the terminal and permit controlled listing of the program. Wang uses % for image statements, where most BASICS use : in my experience.

Table 1 is an example output from listing 1. (See table 1 and listing 1 on page 124.) Please note that while two of the segment mileage figures vary considerably (17.9 and 40.1), the average mileage stays in the mid-twenties. One reason that segment mileage will vary is that the tank is not filled to the same point each time. If 10 gallons are used in 250 miles, but only 5 are purchased the program will give twice the mileage for that segment. However, when one has to fill-up with 10 gallons after only 125 miles, the mileage will drop.

Note that the totals are run up each time the program is run, which represent a page in your notebook—all the gas purchased on a trip or a month's driving. To add to a list, simply take the old list's starting mileage and the final totals as the first entry, (see table 1 for example).

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CP323 powers up to (4) drives simultaneously.

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+ 5V @ 2.5A	- 5V @ .5A	+ 24V @ 3A/3.4A PK	CP206	\$ 91.95
+ 5V @ 3A	- 5V @ .6A	+ 24V @ 5A/6A PK	CP162	\$120.00
+ 5V @ 1.7A/2.2A PK	- 5V @ .15A/.2A PK	+ 24V @ .2A/3A PK	CP272A	\$ 91.95
+ 5V @ 2A	+ 12V @ .4A	- 12V @ .4A	HTAA-16W	\$ 49.95

CP272A powers Percsi Drives (includes unregulated 7 - 10V @ 1.2A/10A PK). HTAA-16W powers Percsi controller.

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The CY500 executes 22 hi-level instructions, either in command mode or as a sequence of internally-stored commands, using single byte code such as 'P' for position, 'R' for rate, and 'S' for slope. Parameter values can be expressed in ASCII-decimal for keyboard programming or binary code from the host computer. Parallel or serial communication.

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Numerous input and output control lines allow synchronizing the CY500 with external events or devices and allow each step to be triggered. Stepping at rates up to 3500 steps/sec, the CY500 also provides ramp-up, slew, and ramp-down operation, all under software control. Two interrupt lines request the host's attention if needed.

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Listing 1: Gasuse program for determining mileage, gas efficiency, and keeping track of gas expenses.

```

10      REM PROGRAM GAS TO FIGURE MILEAGE
40      REM SCRATCH F "GASUSE"
50      REM SAVE DC F ("GASUSE") "GASUSE"
110     U$ = HEX(OC)
1010    PRINT " I COMPUTE AND DISPLAY GAS MILEAGE"
1020    PRINT "  ENTER ZERO FOR UNKNOWN FIGURES, I WILL TRY"
1030    PRINT "  ENTER ZERO FOR MILES TO STOP"
1032    PRINT
1035    PRINT "  ENTER  1. FOR SCREEN DISPLAY"
1037    PRINT "        2. FOR PRINTER OUTPUT"
1039    INPUT P9
1040    PRINT
1050    PRINT "STARTING MILES";
1060    INPUT M0
1070    M7 = M0
1075    IF P9 = 2 THEN 8100
1080    PRINTUSING 1081
1081    % COST DISTANCE TOTAL AVE TOTAL TOTAL
1082    PRINTUSING 1083
1083    %MILES GAL MILEAGE MILES MILEAGE COST GAL
1084    PRINT
1100    PRINT U$; "NEXT MILES";
1110    INPUT M1
1115    IF M1 = 0 THEN 1900
1120    IF M1 > M7 THEN 1130
1124    PRINT U$; " THIS MILES LESS THAN LAST, OR SAME"
1126    GOTO 1100
1130    PRINT U$; "  GALLONS";
1140    INPUT G1
1160    PRINT U1; "  DOLLARS";
1170    INPUT D1
1190    IF G1 = 0 THEN 2000
1195    IF D1 = 0 THEN 2100
1200    REM
1210    M8 = M1-M0
1220    D8 = D8 + D1
1230    G8 = G8 + G1
1245    IF P9 = 2 THEN 8150
1248    PRINT U$;
1250    PRINTUSING 1252,M1,D1,G1,M1-M7,(M1-M7)/G1,M1-M0;M8/G8,D8,G8
1252    %##### $###.## ##.# ### ##.# ##### ##.# $###.## ##.#
1255    PRINT
1260    M7 = M1
1290    GOTO 1100
1900    STOP
2000    PRINT U$; " GALLONS ENTERED AS ZERO, ENTER CENTS/GALLON";
2010    INPUT C1
2020    IF D1 = 0 THEN 2080
2030    G1 = D1/(C1/100)
2050    GOTO 1200
2080    PRINT U$; " DOLLARS ALSO ZERO, NO CALCULATION POSSIBLE";
2090    GOTO 1100
2100    PRINT U$; " DOLLARS ENTERED AS ZERO, ENTER CENTS/GALLON";
2110    INPUT C1
2120    D1 = G1*(C1/100)
2130    IF D1 = 0 THEN 2180
2150    GOTO 1200
2180    PRINT U$;" CALCULATION RESULT IS ZERO; REENTER "
2190    GOTO 1100
8100    SELECT PRINT 215(80)
8110    PRINTUSING 1081
8111    PRINTUSING 1083
8115    SELECT PRINT 005(64)
8120    GOTO 1084
8150    SELECT PRINT 215(84)
8160    PRINTUSING 1252,M1,D1,G1,M1-M7,(M1-M7)/G1,M1-M0;M8/G8,D8,G8
8170    SELECT PRINT 005(64)
8180    PRINT U$;TAB(64)
8190    GOTO 1260
9400    DEFFN'0 "LISTS"
9404    DEFFN'1 " ,9999"
9406    DEFFN'2 "'000,9999"

```

MILES	COST	GAL	DISTANCE	MILEAGE	TOTAL MILES	AVE MILEAGE	TOTAL COST	TOTAL GAL
1202	\$4.19	7.5	201	26.8	201	26.8	\$4.19	7.5
1453	\$5.75	10.1	251	24.8	452	25.6	\$9.94	17.6
1604	\$2.59	5.0	151	30.2	603	26.6	\$12.53	22.6
1715	\$3.45	6.2	111	17.9	714	24.7	\$15.98	28.8
1995	\$3.95	6.9	280	40.1	994	27.7	\$19.93	35.7

Table 1: Sample output from listing 1. To determine accurate gas usage take an average over several results.

Circle 52 on inquiry card.



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Stanley added loudly, "And that's versatility and efficiency I'd like to see more of around here."

"My COBOL-80 package from Microsoft includes the MACRO-80 assembler, LINK-80 linking loader and LIB-80 relocatable library manager. I can even call FORTRAN, BASIC, assembler and COBOL modules from a COBOL-80 program. It's perfect—a total software development package," exclaimed Stanley.

Microsoft's COBOL-80 is an ANSI-74 standard COBOL that supports such advanced data manipulation verbs as COMPUTE, INSPECT, STRING, UNSTRING AND SEARCH; three-dimensional arrays; full COPY facility; and com-

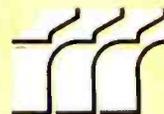
plete screen handling capability. The optional packed decimal format saves on mass storage by as much as 40%. And as Stanley puts it, "With my floppy disk system, that's a big plus."

Stanley can't say enough about his new addition to the office. "COBOL-80 supports indexed and relative files, including DYNAMIC access, FILE STATUS, START, READ NEXT, DELETE and REWRITE. Best of all, interactive ACCEPT/DISPLAY gives the most powerful screen handling capability possible.

"Frankly," says Stanley, "Microsoft COBOL-80's performance is so superior it's set a whole new standard of efficiency for my staff. My new motto? 'Shape up or ship out.' Thanks Microsoft, my office will never be the same."

The COBOL-80 package for the CP/M or ISIS-II operating system with documentation is \$750. Documentation may be purchased separately for \$20. Dealer purchases and OEM license agreements available on request.

# MICROSOFT



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Circle 53 on inquiry card.

## String Comparator for Horizon

Richard W Lindberg, 9302 Mayrene Dr,  
Garden Grove CA 92641

As a recent purchaser of a personal computer, and an even more recent subscriber to *BYTE*, I look for programming articles to help expand the horizon of my Horizon. I scanned the September 1979 issue as soon as it arrived, and was intrigued by the article "A Similarity Comparator for Strings," by T C O'Haver on page 58. Realizing changes would be necessary, I immediately set out to translate it to run in North Star BASIC.

The first change required was the replacement of the string operator `MID$(A$,I,1)` with `A$(I,I)` in statements 130, 140, 230, and 240. (Note that North Star also allows

*Listing 1: Similarity comparator program in North Star BASIC, adapted from the program by T C O'Haver.*

```

8      DIM A$(64),B$(64),Z$(64),A1$(64),B1$(64)
10     T=0
20     P=3
30     !"FIRST WORD",
40     INPUT A1$
50     A=LEN(A1$)
55     A$(1,A)=A1$
60     !"SECOND WORD",
70     INPUT B1$
75     IF A1$=B1$ THEN !"EXACT MATCH"
80     B=LEN(B1$)
85     B$(1,B)=B1$
90     IF A>B THEN B=A
100    FOR M=1 TO B
110      C=0
120      FOR I=1 TO M
130        K$=A$(B-M+I,B-M+I)
140        L$=B$(I,I)
150        IF K$=L$ THEN C=C+1
160      NEXT I
170      C=C*I
180      T=T+C
190    NEXT M
200    FOR M=B+1 TO 2*B-1
210      C=0
220      FOR I=1 TO 2*B-M
230        K$=A$(I,I)
240        L$=B$(M-B+I,M-B+I)
250        IF K$=L$ THEN C=C+1
260      NEXT I
270      C=C*I
280      T=T+C
290    NEXT M
300    S=100*T/B*I
310    !S,"% "
320    T=0
325    B$=Z$
330    GOTO 70
340    END

```

the implied LET and the use of ! for PRINT.) The next change was the addition of a DIMENSION statement to allow strings greater than 10 characters in length. Then when trying to compare two strings of different length, the computer threw me out! This necessitated having enough blanks in the shorter string to match the length of the longer one. To accomplish this, strings A\$ and B\$ were set to 64 blanks by the dimension statement, and temporary strings A1\$ and B1\$ were used to read in the input string data and compute the lengths A and B. A1\$ was then placed in the first A characters of A\$, and B1\$ in the first B characters of B\$, leaving the remaining characters blank. Blank string Z\$ is used to reset B\$ to blanks before testing a new string, otherwise there would be unwanted characters left in B\$ if the previous string were longer than the new string. This was noticed when I followed O'Haver's test sequence, and found that POO gave a 100% match with POOL, because the previous test string was COOL and the L was still there. So with the addition of line 325, I knocked the L out of it and had the program running. The address strings took many seconds to run.

Listing 1 gives the program as adapted to North Star BASIC Version 5.0, and listing 2 shows a sample run for comparison with the published run. Note that the agreement is quite good except for POOL ROOM, MAIL ROOM, and the long address strings. These differences are possibly due to the addition of the trailing blanks to fill the shorter string. A speedier version would be even more useful, and I am looking forward to the assembly language version — who would like to write it?

*Listing 2: Two sample executions of the program in listing 1.*

```

RUN
FIRST WORD ?POOL
SECOND WORD ?POOL
EXACT MATCH
103.125%
?POOR
45.3125%
?COOL
45.3125%
?POO
45.3125%
?POLO
28.125%
?LOOP
18.75%
?PAIL
12.5%
?POOL ROOM
20.164609%
?MAIL ROOM
3.0178326%
?PO/OL
14.4%
?OOOO
40.625%

RUN
FIRST WORD ?T.C. O'HAVER 710 HILLSBORO DR. SILVER
SPRING MD.
SECOND WORD ?TOM O'HAVER 710 HILLSBORO DR. SILVER
SPRING MD.
77.241074%
?R.D. O'HAVER 710 HILLSBOROUGH RD. SILVER SPRINGS FL.
14.492063% ■

```



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# Clubs and Newsletters

## Sorcerer User's Group in Ann Arbor MI

The Sorcerer User's Group and their newsletter, *The Sorcerer's Apprentice*, are based in Ann Arbor MI. The group meets once a month at the Newman Computer Exchange and the newsletter is printed every month and a half. The group's object is to spread Sorcerer-related information to all owners and to get as much out of the machine as possible. Contact Dave Bristol, 1530 Washtenaw, Ann Arbor MI 48104.

## Computer Group for Medicine and Science

Microcomputers in  
Medicine and the Sciences

Association is an organization devoted to aiding members of the medical and scientific communities gain working knowledge of computers and their uses in research and practical applications. Meetings are accredited seminars covering languages and applications of microcomputers. They meet in the Chemistry Building, Rm 105, University of South Florida, Tampa FL, on the fourth Thursday of the month at 7:30 PM. Their newsletter is called *MIMSA News*.

## Software World

Called the *Software World*, this quarterly publication from England contains programs, book

reviews, new products, and computer related business items. The subscription rate in the US is \$64 a year. The newsletter is one of a series of three software related publications from A P Publications Ltd, 322 St John St, London EC1V 4QH ENGLAND.

## Compucolor User's Group

The Canadian Compucolor User's Group meets on the second Wednesday of every month and invites users as well as interested onlookers to join and utilize the program library. For more information, contact House of Computers Inc, 368 Eglinton Ave W, Toronto, Ontario M5N 1A2 CANADA.

## Club 1802 Newsletter

*Club 1802* is a newsletter published for users of microcomputers which are based upon the 1802 processor. Programs, book and program reviews, want ads, items for sale and letters on related subjects are included. The newsletter is published twelve times a year and current rates are scheduled to be about \$10 a year. For more information, contact *Club 1802*, POB 985, Dickinson TX 77539.

## Apple Dayton

This Apple II users group alternates their meeting dates between the second Wednesday of odd numbered months and the second Thursday of even numbered months to allow different people to attend at least bi-monthly. Meetings are held at Computer Solutions, 1932 Brown St,

Dayton OH, at 7:30 PM. For more information, contact Apple Dayton, Robert W Rennard, 2281 Cobble Stone Ct, Dayton OH 45431.

## Sorcerer User's Group Newsletter

*The Exidy Monitor* is a monthly newsletter intended for users of Sorcerer microcomputers. The newsletter contains programs and other technical articles plus a software library buyer's guide for members and nonmembers. For information, write to *The Exidy Monitor*, c/o Computer Mart of Massachusetts, 1395 Main St, Waltham MA 02154.

## Computer Club in Central Nebraska

Compusers is a new club for anyone interested in computing, particularly owners or prospective owners of microcomputers of any make. Meetings are held on the third Monday of each month at 8 PM. Dues, by-laws, and permanent officers are not yet established. For more information, contact Rocky Friend, POB 2064, Hastings NE 68901. Their monthly newsletter is also available from the same address.

## West German Microcomputer Club for Radio Amateurs

The DAFG/GART German Amateur Radio Teleprinter Group has 1300 members who use SDK-85, KIM-1, PET 2001, TRS-80, Apple II, and other microcomputers for amateur radio operation in RTTY, FAX, SSTV, or CW. The membership fee is DM 35.00 annually. The newsletter, *RTTY*, is published six times a year. For more information, contact Manfred N May, Herrenstr.56, D 5014 Kerpen-Sndf. Or contact R F Matthaei, Beisserstr.45, D 2000 Hamburg-63, uC-Referat, WEST GERMANY.



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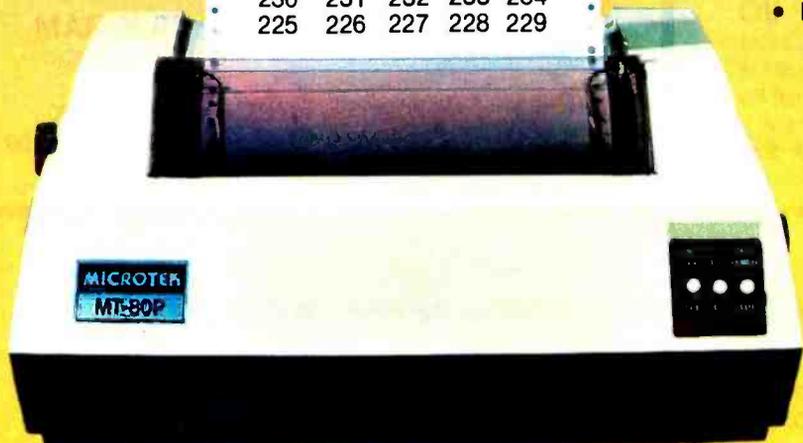
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### PAX (Program Analysis Exchange) Succeeds 52-Notes in a New Format

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currently on the public market for which good supporting documentation is not known to exist. Back issues of *PAX* and *52-Notes* are available for \$1 each. Write to Richard C Vanderburgh, 9459 Taylorsville Rd, Dayton OH 45424, to obtain information on contributing articles.

### Ontario Society for Microcomputers in Education

A group of seventy educators have started the Ontario Society of Microcomputers in Education in order to coordinate individual efforts and provide a clearinghouse for the exchange of information on equipment, curricular materials, and teaching methods. The group's aims are to promote the use of microcomputers in all aspects of education, share knowledge of hardware and software, develop strategies for demonstrating the uses

of microcomputers in the classroom, to assist in the development of software to meet specific curricular needs, and more. For more information, contact N Soltseff, Unit for Computer Science, McMaster University, Hamilton, Ontario, L8S 4K1 CANADA.

### International Computer Club

The International Society of Personal Computerists was organized to promote and advance personal computing on a world-wide basis. The society's services include free software, free consultation, custom programming, conversions from one BASIC system to another, and group discounts on software and hardware purchases. *Tid-Bits*, the newsletter, is of broad general interest to computer users and hobbyists. The society publishes several other newsletters

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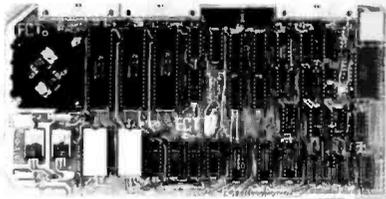
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The Southern New Hampshire Apple Core meets once a month. The group is dedicated to Apple users, and they currently have plans to give public demonstrations of computers. Their newsletter is entitled *SNAC Facts* and it contains information concerning the meetings, items of general interest, and short programs. The members are building a disk library and are interested in hearing from other Apple users. Dues are \$6 per year. For more information, contact SNAC, Computerland of Nashua, 419 Amherst St, Nashua NH 03060. ■

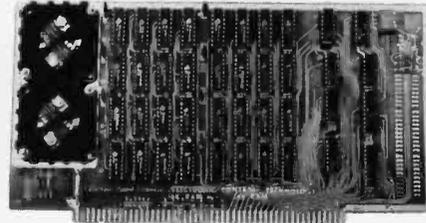
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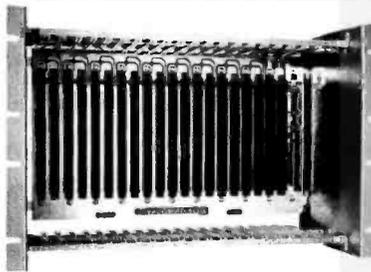
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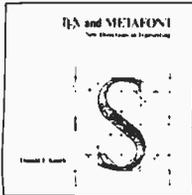
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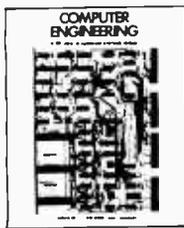
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# Implementing Dynamic Data Structures with BASIC Files

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In many computer applications where a large amount of information is to be stored, the need arises to sort, insert, and delete items efficiently using random-access tape or disk-based files. A common method of implementing a mailing list, for example, is to add new names to the end of the current file and to delete names by putting a blank field in place of the names to be deleted. This minimizes the number of time-consuming reads and writes to the file.

However, when this mailing list has to be printed in zip-code order, for example, the task becomes extremely slow as the number of names increases. This is because the number of file accesses increases exponentially with the number of items to be sorted. One possible solution is to actually sort the file so that it is always in order. This is impractical because it necessitates the same sort operation as before, plus a complete rewrite of the file.

With close examination of the problem, you might decide that the file should always be kept in order by inserting a new name in its proper place. This is a good idea, but requires that you must move, on the

average,  $N/2$  names (for a file of  $N$  names) to make room for the new names. Again, with large files, this may take an inordinately large amount of time.

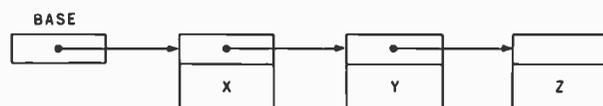
In order to solve these problems successfully and efficiently, you need a data structure that will permit an insertion and deletion of components without having to worry about where new components fit or what happens to the empty space left by deletion. The tool needed to create such a structure is called a *pointer*. This is simply a number that points to the location of a desired piece of data. Using disk files, for example, a pointer to a piece of data is its actual record number on the disk file. This takes advantage of the random access capabilities of a disk file so as to directly locate and read the data using the pointer value.

Using pointers, a *linked list*, the simplest type of dynamic data structure, can be built. In order to build the linked list, every data record must

be accompanied with a pointer to the next element in the linked list. Therefore, space must be reserved in the file for a pointer value within each data record.

A linked list is shown pictorially in figure 1. In a disk file, for example, you could store the base pointer value in the first record of the file. However, you need some way of knowing that the last data item  $Z$  does not point to anything. This can be accomplished by storing some special number not in the range of possible pointer values, such as zero, as the pointer value associated with the last data item. An important thing to realize is that records  $X$ ,  $Y$ , and  $Z$  can *physically* be in any order on the disk. However, they are *linked* in order and can be retrieved in order with absolutely no comparing or sorting.

Record insertion is also relatively simple. The ordered list is scanned until the element to be added is greater than or equal to the current



**Figure 1:** Example of a linked list. In this picture,  $X$ ,  $Y$ , and  $Z$  are records containing the information that is to be stored. The boxes on top represent a portion of memory connected with each record that contains the address of the next record in the list. These are called pointers. The first record in the file, called the base record, points to the first data record in the file but does not contain data itself. This is because the base record also contains a pointer (not shown) to the first available space for new records.

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## About the Author

Ted Carter is employed at the Texas Instruments Corporate Engineering Center. In 1978, he founded Software Industries, a custom software house. His interests include computer speech synthesis and computer automation.

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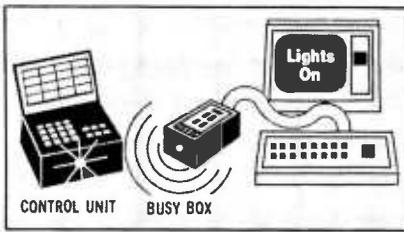


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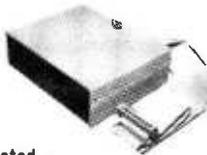
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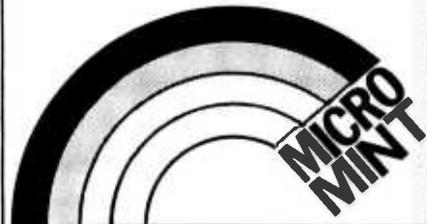
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The number of file accesses increases exponentially with the number of items to be sorted.

element and less than the next element in the list. The new element is then inserted between these two elements. For example, assume that Y2 is to be inserted before Z and after Y, as in figure 2a. This is achieved by placing Y2 physically in the first free position on the file, making Y2 point to where Y pointed, and making Y point to Y2, as in figure 2b.

The process of deleting an element is easier. Consider deleting Y2 from the list in figure 2b. By making Y point to where Y2 pointed before Y2 was deleted, the result is the list in figure 2a.

In some situations, an improvement on the linked-list data structure is the *doubly linked ring*, shown in figure 3. With this structure, you may

scan from either direction, often facilitating an insertion and deletion either before or after an element. For ease of explanation and understanding, a simple singly linked list as in figure 1 will be used in the examples given in this article.

## Implementing the Linked List

When implementing a linked list using random-access files, some additional problems must be solved. An element can be inserted in the linked list easily enough, but the computer must know where the first empty disk file is located. Secondly, when deleting an element, the disk file location of the deleted record should be recovered for later use.

These problems could be solved by marking the record to be deleted and later searching for the first empty or marked record when adding a new element. A much better solution is to create a linked list of free records. When adding a new element, a record is taken out of the linked list of free records and inserted in the ordered

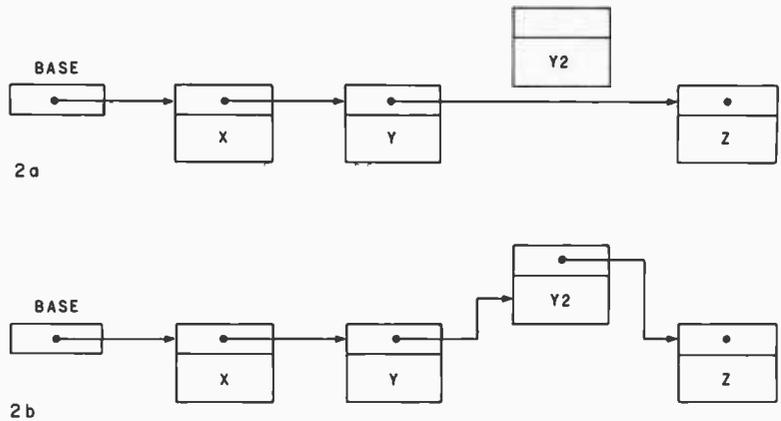


Figure 2: The process of insertion in a linked list. Figure 2a shows a new record, Y2 (probably physically located after nodes X, Y, and Z), before it is linked into its proper place in the list. To link it into the list, as in figure 2b, only the pointers in Y and Y2 must be changed.

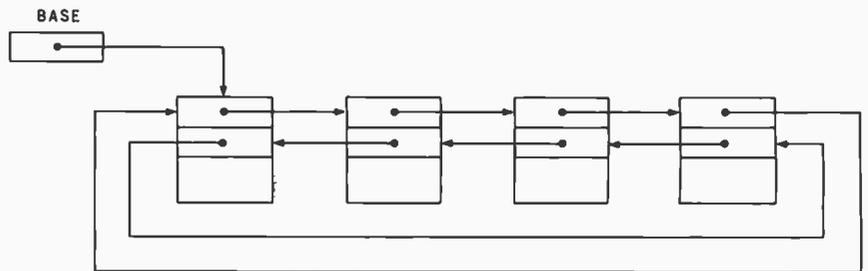
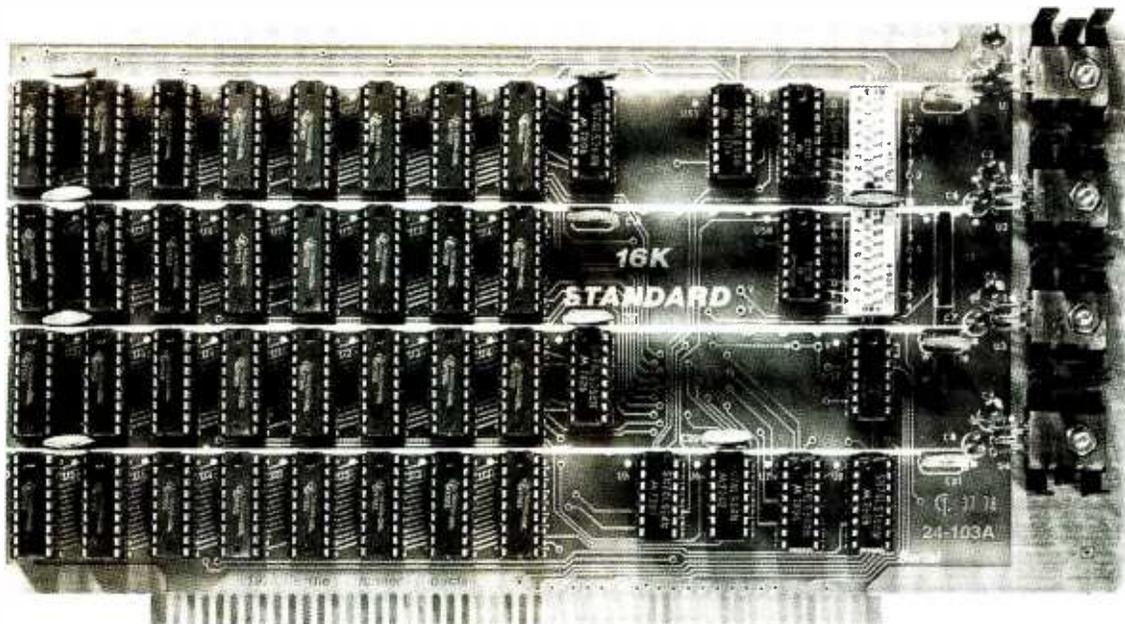


Figure 3: Example of a doubly linked ring. In this kind of linked list, each record contains a pointer to the previous as well as to the next record in the list. This has certain advantages in some applications, although it creates more memory overhead in each node. Doubly linked lists are not discussed in this article.



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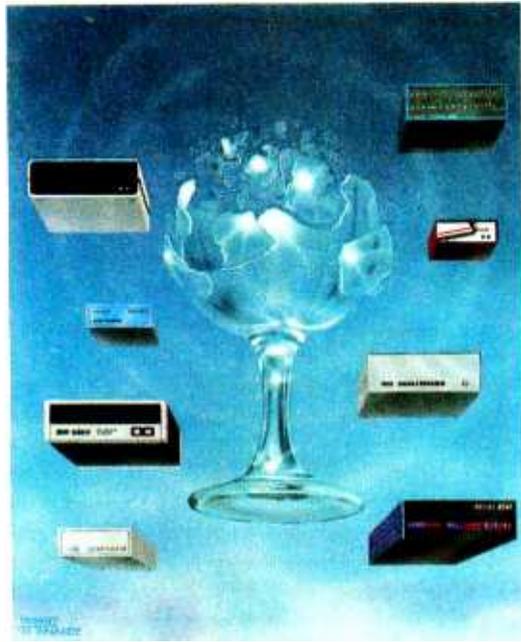
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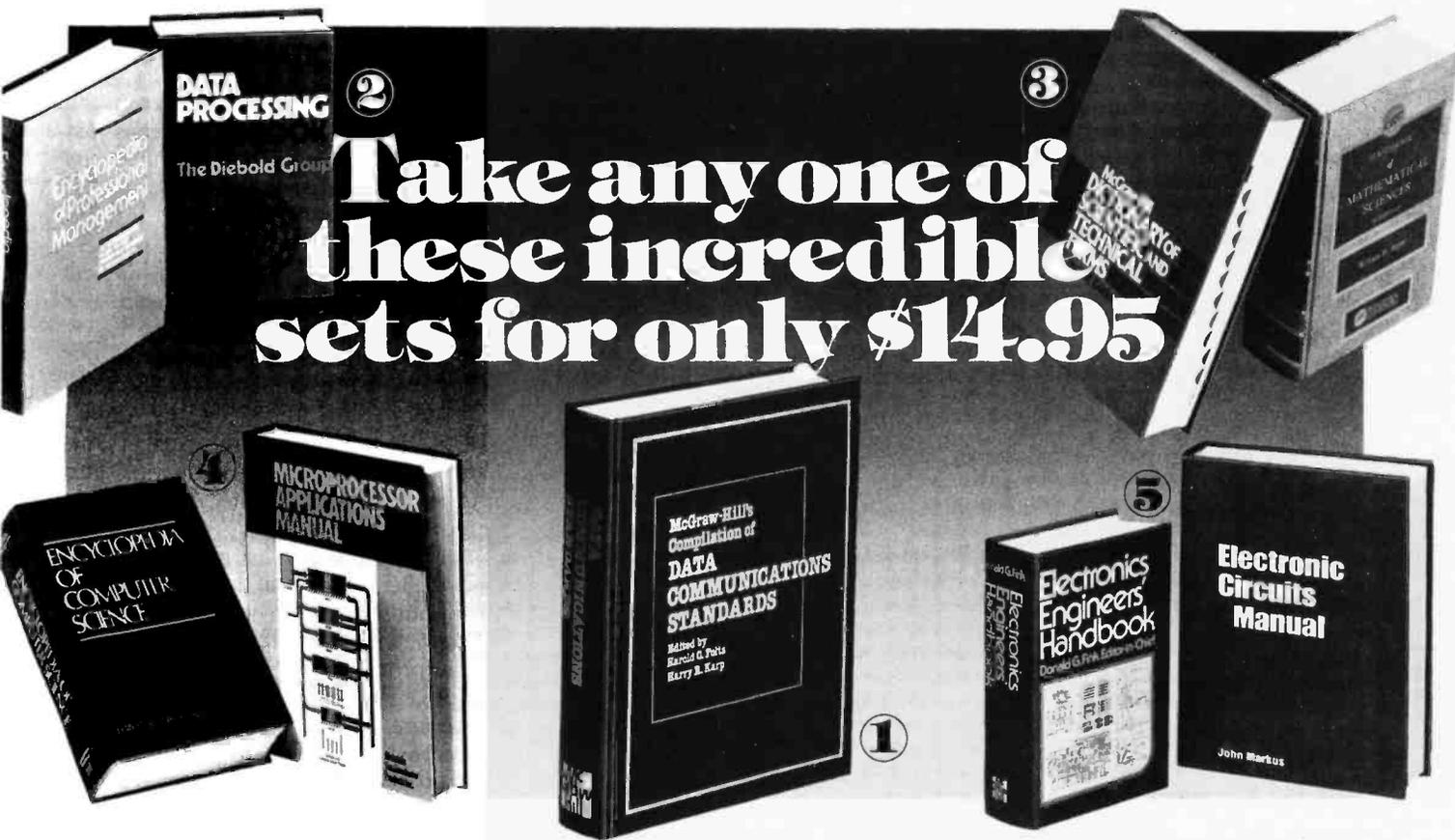
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**Listing 1:** Program to create a linked list file. This program, written in CBASIC, creates a small file that contains forward pointers to the next available record. The first record, which is initialized to "2,3", points to the first data record in the file (record 2) and to the first empty (available) record in the file (record 3). The second record, initialized in line 25, is a sentinel record that denotes the end of the file. It is always the last data record in the file and has a forward pointer of zero.

```

REM  CREATE A FILE WITH A LINKED LIST OF FREE RECORDS
REM  -----
REM
REM---There will be 10 free records in the sample file.
10   FILELENGTH=10
REM---Create the file with a record length of 22. Give
REM---it the file number of one.
15   CREATE "DATA.FIL" RECL 22 AS 1
REM---Put pointer in for the ordered linked data list
REM---and list of free records.
20   PRINT #1: 2,3
REM---Put sentinel with highest possible value at end
REM---of linked list of data.
25   PRINT #1: 0,"zzzzzzzzzzzzzzzz"
REM---Create the linked list of free records by making
REM---each one point to the next record.
30   FOR Z=4 TO FILELENGTH+2 : PRINT #1: Z,"" : NEXT Z
REM---Make the last free list record pointer equal
REM---zero to signify the end of the list.
35   PRINT #1: 0,""
40   CLOSE 1

```

**Listing 2:** Program to add a record to a linked list file. This program uses the forward pointers to chain through the linked list until the proper place for the new record is found. The only pointers that need to be changed are those on the record being added and the record immediately preceding it.

```

REM  THIS PROGRAM ADDS SOME ALPHANUMERIC DATA TO OUR FILE
REM  WHILE KEEPING IT IN ALPHABETICAL ORDER.
REM  -----
REM
REM---Open file #1 with record length of 22.
10   OPEN "DATA.FIL" RECL 22 AS 1
REM---Set pointers to start of linked lists.
15   READ #1,1: BASEPOINTER, NEXTFREE
20   IF NEXTFREE=0 THEN PRINT"File is full" : GOTO 90
REM---Get data to add.
25   INPUT"New data:";NEWDATA$
REM---Left justify data in a field of blanks.
30   NEWDATA$=LEFT$(NEWDATA$+ " ",14)
REM---Set pointers to start of list.
35   POINTER=BASEPOINTER : NEXTPOINTER=BASEPOINTER
REM---Search loop which traverses the linked list to
REM---find the proper place to insert the new data.
40   TRAILPOINTER=POINTER : PREVDATA$=DATA$
45   POINTER=NEXTPOINTER : READ #1,POINTER: NEXTPOINTER,DATA$
50   IF NEWDATA$>DATA$ THEN 40
REM---Insert our NEWDATA$ in the linked list
REM---after the element pointed to by TRAILPOINTER.
REM---Get the place to physically put the new record by
REM---taking a record out of the free linked list.
55   READ #1,NEXTFREE: NEXTRECORD
REM---If TRAILPOINTER=POINTER, then the base pointer must
REM---be modified in order to add at the beginning.
60   IF TRAILPOINTER<>POINTER THEN 75
65   PRINT #1,1: NEXTFREE, NEXTRECORD
70   PRINT #1,NEXTFREE: BASEPOINTER, NEWDATA$: GOTO 90
REM---Now take record out of free linked list.
75   PRINT #1,1: BASEPOINTER, NEXTRECORD
REM---Now make the new item point to where the record
REM---pointed to by TRAILPOINTER pointer, make the record
REM---pointed to by TRAILPOINTER point to new item.
80   PRINT #1,NEXTFREE: POINTER, NEWDATA$
85   PRINT #1,TRAILPOINTER: NEXTFREE, PREVDATA$
90   CLOSE 1

```

list. When deleting a record from the ordered list, the record that has just been removed is added to the linked list of free records so that it can be used the next time an element is to be added.

The following example uses linked lists and random-access files. For the sake of simplicity, assume that each record consists of one pointer to the next record in the list and one string of data. Since there are two linked lists, the first logical record will contain two pointers, one to the first data element, the second to the first free record.

The program of listing 1, written in CBASIC, creates a data file capable of holding ten data entries of fourteen characters each. The file created by this program is shown in listing 5a. Notice that data record number two, the first in the linked list of data, has a zero for its forward pointer and is filled with "z"s, the highest possible data going in alphabetical order. Such a dummy record, usually called a *sentinel*, will always be the last element of the linked list. The sentinel is also used to locate the end of the linked list when the linked list is traversed in ascending order. Although programs can be written without the sentinel record, the sentinel greatly simplifies them.

The program of listing 2 adds a record to the linked list. It gets the data to be added and scans the linked list (keeping a pointer to the previous record) until the record to be added is alphabetically less than the one being read. When this occurs, the new item should be added immediately before the one being read. This is accomplished by making the new record point to the record being read and making the previous record point to the new record. When inserting a new item at the very beginning of the linked list, a special case exists that must be accounted for, since the base pointer in the first record must be changed to point to the new record.

Listing 5b shows what the data looks like after adding a piece of data named "First item". Listing 5c and listing 5d show the contents of the file after the addition of several new entries to the file. Note that the path of the linked list is such that the data is always in alphabetical order.

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**Listing 3:** Program to list a linked-list file. This program uses the forward pointers to print out the records in the order in which they are encountered. This example corresponds to printing out the data fields in ascending alphabetic order.

```

REM THIS PROGRAM LISTS OUR ALREADY SORTED FILE.
REM -----
REM
REM--Open file #1 with record length of 22.
10 OPEN "DATA.FIL" RECL 22 AS 1
REM--Set pointer to start of linked list.
15 READ #1,1: POINTER
REM--Loop to traverse list and print data
REM--until POINTER is zero.
20 READ #1,POINTER: POINTER,DATA$
25 IF POINTER<>0 THEN PRINT DATA$: GOTO 20
30 CLOSE 1

```

**Listing 4:** Program to delete a record from a linked list file. This program deletes a given record by changing the pointer of its previous record. The pointers in record 1 and the deleted record are changed so that this record is the first record of the linked group of free (available) records.

```

REM DELETE A DATA ITEM FROM OUR MAIN LINKED LIST AND
REM ADD IT TO OUR LINKED LIST OF FREE RECORDS.
REM -----
REM
REM--Open file #1 with record length of 22.
10 OPEN "DATA.FIL" RECL 22 AS 1
15 INPUT"Data to delete:":DATA$
REM--Left justify data in a field of blanks.
20 DATA%=LEFT$(DATA$+" ",14)
REM--Set pointers to beginning of linked list.
25 READ #1,1: BASEPOINTER, NEXTFREE
30 POINTER=BASEPOINTER: NEXTPOINTER=BASEPOINTER
REM--Search loop traverses the linked list until it
REM--finds a match or runs out of data.
35 TRAILPOINTER=POINTER: PREVDATA%=DATAIN$
40 POINTER=NEXTPOINTER
45 READ #1,POINTER: NEXTPOINTER, DATAIN$
50 IF NEXTPOINTER=0 THEN PRINT"No match found.": GOTO 75
55 IF DATAIN$<>DATA$ THEN 35
REM--Delete the record pointed to by POINTER by making the
REM--record pointed to by TRAILPOINTER point to the record
REM--after the one pointed to by POINTER.
60 IF TRAILPOINTER=POINTER THEN BASEPOINTER=NEXTPOINTER \
ELSE PRINT #1,TRAILPOINTER: NEXTPOINTER, PREVDATA$
REM--Add the now unused record pointed to by pointer to the
REM--free linked list.
65 PRINT #1,POINTER: NEXTFREE,""
70 PRINT #1,1: BASEPOINTER, POINTER
75 CLOSE 1

```

The program of listing 3 and its output in listing 5e will clarify any confusion in following the list. This program traverses the linked list of data and prints each item out as it is read. It can be concluded, from the brevity of listing 3, that printing a sorted list is much easier with the use of a linked-list file organization.

Listing 4 shows the solution to the problem of deleting a given data item and placing the free space back into the linked list of free records. The program scans the linked list until it reaches the end of the file or finds the data to be deleted. When the data to be deleted has been found, the previous record is made to point to where the deleted record points. As in listing 2, deleting the first item in the linked list results in a special case, and the base pointer must be modified. The deleted record is then added to the linked list of free records. Listing 5f shows the data file after the "Fourth" data item has been deleted. Note the "6" in the first line of listing 5f, which points to the first free record, the record that has just been deleted.

Although the concept of the linked list may be difficult to understand, it is a very powerful tool. If, in the mailing list example, the information needs to be sorted by more than one field, it is simple to create a linked list for each field to be sorted and to make room for the additional pointers.

Other modifications are possible; for example, the linked list could spread over more than one file on a disk or over more than one disk by having the pointers preceded by a

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Listing 5: Examples of linked list files. The contents of the file created by listing 1 are shown in listings 5a, 5b, 5c, 5d, and 5f. In each case, the records are numbered 1 through 12, with record 1 at the top. Listing 5a shows the contents of the file just after it has been created by the program in listing 1. Listings 5b, 5c, and 5d show the file after one, two, and five records, respectively, have been added. Listing 5e shows the result of running the program of listing 3. The data appears listed in ascending alphabetic sequence. Listing 5f shows the file after the fourth node has been deleted. Note that the available record pointer in record 1 points to line 6, the location of the line that has just been deleted.

```
(5a)  2,3
0,"zzzzzzzzzzzzzzzz"
4,""
5,""
6,""
7,""
8,""
9,""
10,""
11,""
12,""
0,""
```

```
(5b)  3,4
0,"zzzzzzzzzzzzzzzz"
2,"First item  "
5,""
6,""
7,""
8,""
9,""
10,""
11,""
12,""
0,""
```

```
(5c)  3,5
0,"zzzzzzzzzzzzzzzz"
4,"First item  "
2,"Second item "
6,""
7,""
8,""
9,""
10,""
11,""
12,""
0,""
```

```
(5d)  7,8
0,"zzzzzzzzzzzzzzzz"
6,"First item  "
5,"Second item "
2,"Third      "
4,"Fourth     "
3,"Fifth      "
9,""
10,""
11,""
12,""
0,""
```

```
(5e)  ADR2 LIST
CRUN VER 2.04
Fifth
First item
Fourth
Second item
Third
```

```
(5f)  7,6
0,"zzzzzzzzzzzzzzzz"
4,"First item  "
5,"Second item "
2,"Third      "
8,""
3,"Fifth      "
9,""
10,""
11,""
12,""
0,""
```

digit specifying the file or disk-drive number. A slightly better solution for very large data bases is to use pointers to create a tree structure. However, operations involving trees are very involved, and a discussion of them is outside the scope of this article. Those interested in this subject are encouraged to read the book *Algorithms + Data Structures = Programs* by Niklaus Wirth, listed in the references.

### Uses of the Linked List

The concepts of linked lists and pointers can also be used to handle data that has a variable amount of additional information associated with it. One particular problem that is unmanageable without linked lists involves a theatre-booking program where you have a movie film and an unknown, highly variable number of dates for which it is scheduled to be used. Because of the uncertainty

.....  
The concepts of linked lists and pointers can also be used to handle data that has a variable amount of additional information associated with it.  
.....

involved with the scheduling process, it is usually unacceptable to either limit the number of dates that can be associated with a film or to reserve enough space per film to handle even the most heavily scheduled film.

One solution to this scheduling problem makes use of a linked list. A file containing the essential information for each film can also have, for each record describing a film, a pointer that points to a linked list of date records (each record containing a date and its associated information). Traversing the linked list of dates for any one film is both fast and easy, and each film takes up only as much space for date records as is needed.

The programs and ideas presented here can be converted to work in any programming language that allows some sort of random-access files. In cases where a linked list is applicable, necessity for the additional storage space for the pointers and the slightly increased program complexity are both far outweighed by the ability to directly access related data items with a minimum of searching and sorting.

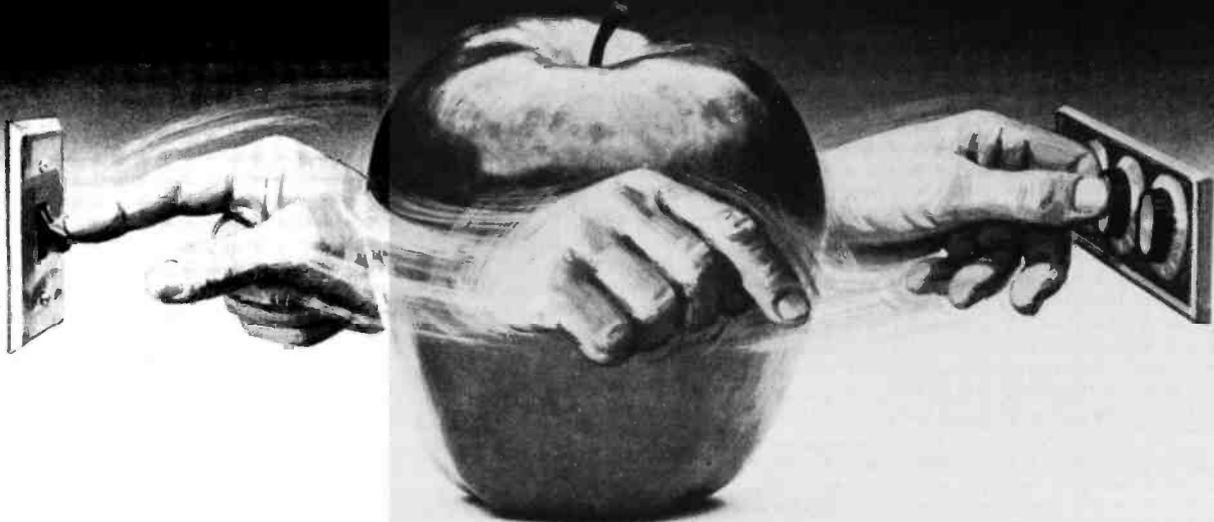
The difficulty arises in determining whether or not to use linked lists in a particular application. There are, unfortunately, no fixed criteria since the choice of a method will depend on such factors as the computer's disk capabilities, the number of data items, the length of the data items, how often the data will be sorted, and how often the data base will change. You should, however, plan the data base before doing any programming, taking into account the possible methods and the tradeoffs involved. ■

---

### REFERENCES

1. Grogono, Peter, *Programming in Pascal*, Addison-Wesley, Reading MA, 1973.
  2. Wirth, Niklaus, *Algorithms + Data Structures = Programs*, Prentice-Hall, Englewood Cliffs NJ, 1976.
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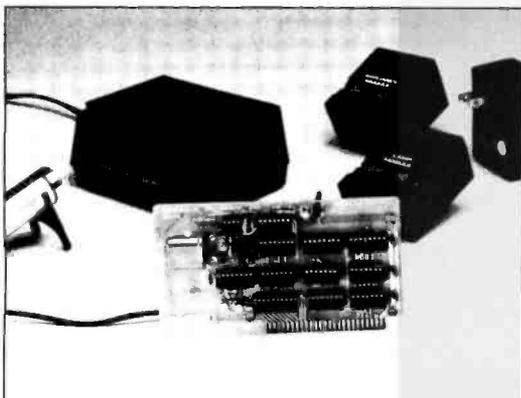
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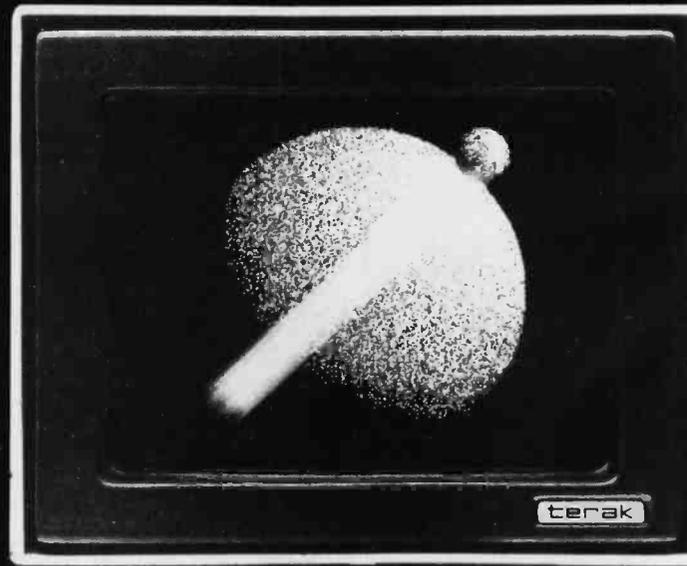
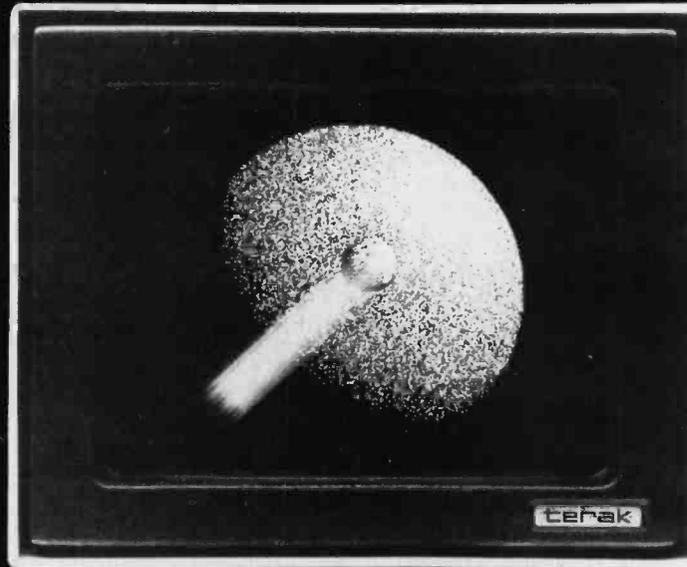
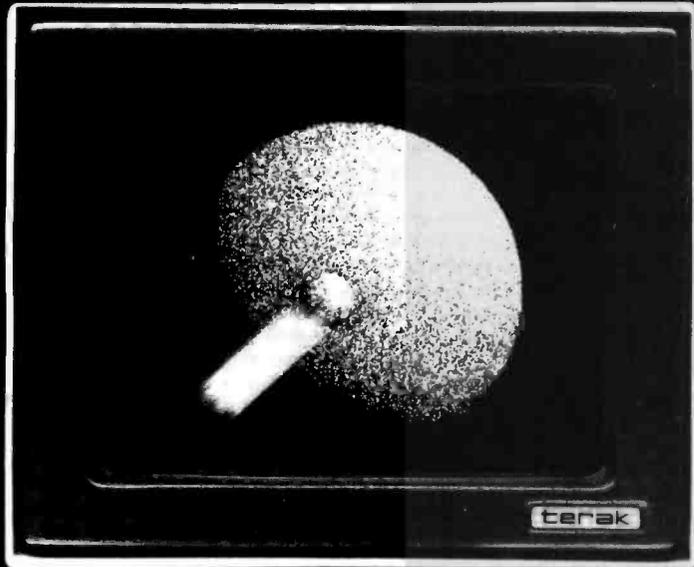
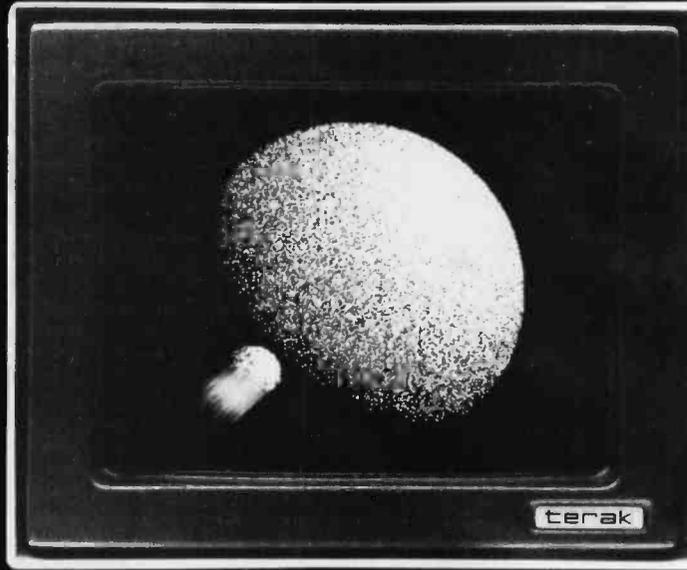
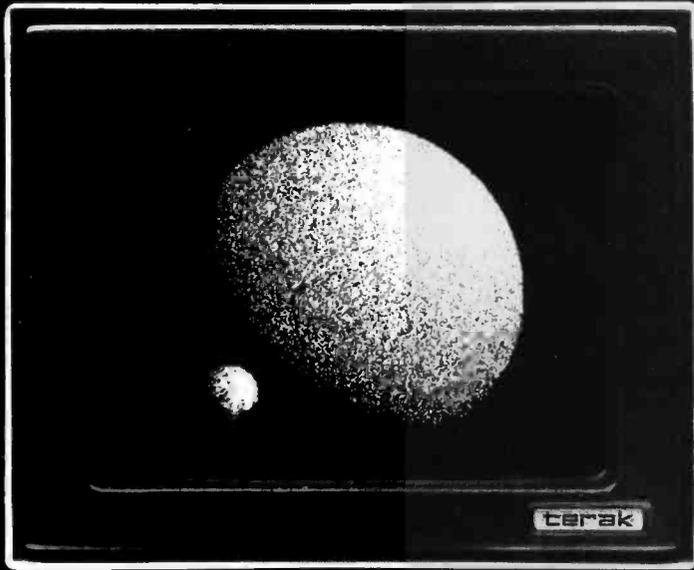
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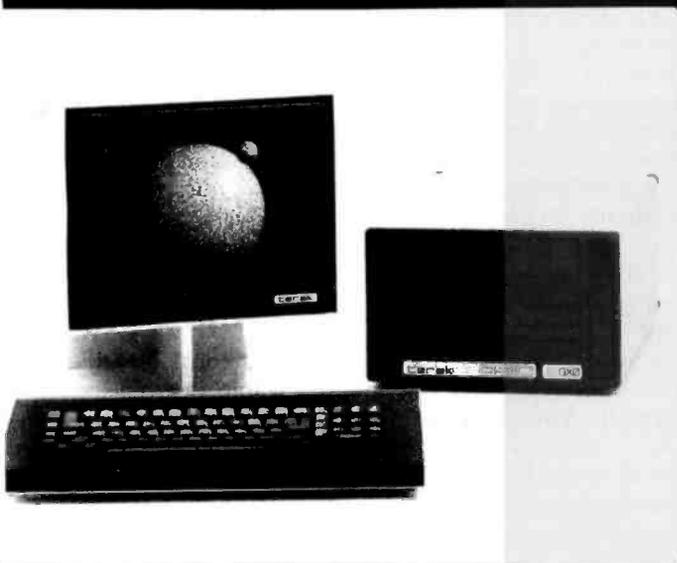
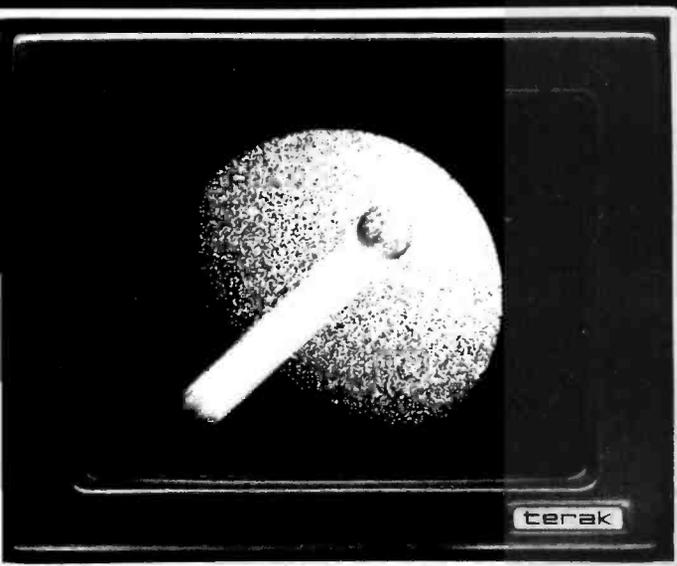
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# A Fast, Multibyte Binary to Binary-Coded-Decimal Conversion Routine

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A problem which has confronted users of small computer systems over the years has been the incompatibility of the number representation required by output devices and that used for internal processing. Output devices used by the small systems need to receive binary-coded-decimal (BCD) or ASCII (American Standard Code for Information Interchange) data representations, while the microprocessor is most efficient when handling a straight binary number. Several solutions to the problem exist, and as would be expected, each has its own advantages and disadvantages.

Some users choose to initially store all numbers in their binary-coded-decimal representation and do all subsequent processing in this format. This has the advantage of easy and quick conversion of the numbers into the required output format. At worst, the binary-coded-decimal represented number must be converted to an ASCII format. This requires attaching a fixed 4-bit prefix to each binary-coded-decimal digit.

A disadvantage associated with this approach is that arithmetic operations take longer to perform, since the results must be decimally adjusted after each operation. Also, more memory is required to store the binary-coded-decimal form of the number than is required for its straight binary equivalent. A direct result of this increased memory requirement is the need to perform more

memory-access operations to transfer the numbers into and out of the processor. Memory accesses are a very time-consuming operation.

For the users who choose a straight, binary-number representation for internal storage, the advantages of efficient memory utilization and straightforward arithmetic are gained. The question of how to convert the numbers to an acceptable output format for the display device still remains to be answered. This question basically reduces down to converting the binary numbers to binary-coded-decimal form.

## Methods of Conversion

There are three basic approaches in wide use. The first approach is to count the binary number down to 0 while incrementing its binary-coded-decimal counterpart up from 0 using modulo-10 counting. Modulo-10 counting performs a decimal-adjust operation after each incremental addition. This method is conceptually easy and requires a minimum of program code if the microprocessor has a decimal-adjust instruction. The counting method can, however, be very time-consuming if large numbers are being converted. For some applications this time penalty would be irrelevant (eg: if the output device is very slow when compared to the processor's cycle time). For a slow output device, any time savings realized by using a faster conversion routine usually has to be wasted in a wait loop.

The second approach is to use some form of table lookup routine. Assuming that the table is extensive enough, the lookup technique performs a very fast conversion. The drawback to this technique is that as the size of the numbers being handled gets larger, either a great deal of memory must be dedicated to the table, or some type of divide-with-remainder scheme must be imple-

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## About the Author

*Mike McQuade is currently working towards a PhD degree in the Computer Architecture Laboratory at the School of Electrical Engineering at the Georgia Institute of Technology. He has instructed computer courses there, and has taught short microprocessor courses for the Institute of Electrical and Electronics Engineers at both national and regional levels.*

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mented. The division scheme allows the table size to remain small, but it causes the conversion time to increase. As was pointed out earlier, this may not be important. If the processor being used does not have a decimal-adjust instruction and the numbers encountered are not too large, this second method is very popular.

The third approach in converting from straight binary to binary-coded decimal is to use an algorithm based on the structure of the binary number system. Given the binary number:

$$b_n b_{n-1} b_{n-2} \dots b_2 b_1 b_0$$

where each of the  $b$ s can represent either a 1 or a 0, and  $b_n$  is the most significant bit, it can be expanded as:

$$b_n \times 2^n + b_{n-1} \times 2^{n-1} + \dots + b_1 \times 2^1 + b_0 \times 2^0 \quad (\text{Form I}).$$

Form I is not conducive to an iterative-type binary to binary-coded decimal conversion routine, but can be rewritten as:

$$(\dots((b_n \times 2) + b_{n-1}) \times 2 + \dots + b_1) \times 2 + b_0 \quad (\text{Form II}).$$

Form II contains only the decimal numbers 0, 1, and 2, which have the same representations in either straight binary or binary-coded decimal. Straight binary and binary-coded-decimal representations of a number differ only for numbers greater than 9. While straight binary adheres strictly to position weighting in powers of 2, binary-coded decimal treats each decimal digit of the number *independently* and represents it as a 4-bit straight binary number.

If Form II is implemented using binary-coded-decimal arithmetic (performing a decimal adjust after each addition), the final result will be in binary-coded-decimal representation. Form II lends itself to an iterative-type implementation which allows it to be coded to easily accommodate any size number.

Carry	Auxiliary Carry	Correction Factor
0	0	10011010
0	1	10100000
1	0	11111010
1	1	00000000

Table 1: Correction factors in binary for the binary to binary-coded-decimal (BCD) conversion algorithm.

Much has been said about performing a decimal-adjust operation when operating on numbers in the binary-coded-decimal format. When two binary-coded-decimal numbers are added by the processor's straight binary-adding accumulator, the result is not in binary-coded-decimal form. It is necessary to perform one more operation after each addition to correct for the fact that the processor's arithmetic logic is designed to add straight binary numbers. This extra operation is the decimal adjust. Many of the microprocessors on the market today have the decimal-adjust operation contained in their instruction sets.

If the processor being used does not contain a decimal-adjust instruction, it is still possible to perform a decimal-adjust operation. What must be done is to allow for the fact that a binary-coded-decimal number uses only ten of the sixteen possible 4-bit combinations for each digit. If two binary-coded-decimal numbers are added together, and the least significant 4 bits of the result have a value greater than 9, then 6 must be added to the result. It is necessary to add 6 to skip over the six unallowed BCD bit combinations. The next 4 bits of the result are then tested, and 6 is added to them if necessary. This is repeated across the entire result.

### A Better Method

The above method works in theory but is rather awkward to program. Let us examine a method based on the above theory which lends itself to straightforward programming. The method will be for 8-bit processors,

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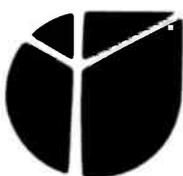
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**Listing 1: The multibyte binary to binary-coded-decimal (BCD) conversion algorithm coded as a subroutine for the 8080 microprocessor.**

```

; THE SUBROUTINES ALWAYS SAVE THE CONTENTS OF REGISTERS A
; D E H L AND THE STATUS FLAGS. IF THE CONTENTS OF REGISTERS
; B C NEED TO BE SAVED THE CALLING ROUTINE MUST EXPLICITLY DO IT.

;*****BINARY TO BCD CONVERSION SUBROUTINE*****

; THE SUBROUTINE CONVERTS A MULTI-BYTE BINARY NUMBER TO ITS EQUIVALENT
; MULTI-BYTE BINARY CODED DECIMAL (BCD) REPRESENTATION. THE BYTES
; OF BOTH NUMBERS ARE STORED IN MEMORY IN ASCENDING ORDER WITH
; THE LEAST SIGNIFICANT BYTE IN THE LOW END OF THE MEMORY STACK. THE
; REQUIRED PARAMETERS NEEDED TO BE PASSED ARE:

;           H L GETS ADDRESS OF LOW ORDER BYTE OF BINARY NUMBER
;           D GETS NUMBER OF BYTES IN BINARY NUMBER
;           E GETS NUMBER OF BYTES IN BCD RESULT AREA

; THE SUBROUTINE ASSUMES THAT THE BINARY NUMBER WILL FIT IN THE SUPPLIED
; NUMBER OF BCD BYTES. THE ROUTINE WILL FILL IN THE BCD BYTES WITH
; LEADING ZEROS IF NECESSARY.

0000 F5   DBBCD: PUSH   PSH           ;SAVE STATUS
0001 4B   MOV     C,E           ;COPY # OF BCD BYTES TO C
0002 E5   PUSH   H           ;SAVE ADDR OF BINARY # ON STACK
0003 216400 LXI   H,BCDNL          ;LOAD HL WITH ADDR OF BCD #
0005 3600   LAB16: MVI   M,0           ;ZERO OUT MEMORY LOCATION
0008 23   INX     H           ;INCREMENT HL
0009 0D   DCR     C           ;DECREMENT C
000A C20600 JNZ   LAB16          ;IF C=0 BRANCH FROM LOOP
000D 7A   MOV     A,D           ;PUT # OF BINARY BYTES IN A
000E 87   ADD     A           ;MULTIPLY BY 8 TO GET # OF BITS
000F 87   ADD     A
0010 87   ADD     A
0011 47   MOV     B,A           ;STORE # OF BITS IN B
0012 AF   XRA     A           ;SET CARRY TO ZERO
0013 4A   MLOOP: MOV    C,D           ;PUT # OF BINARY BYTES IN C

0014 E1   POP     H           ;RESTORE ADDR OF BINARY # TO HL
0015 3B   DCX   SP           ;LEAVE HL ON STACK
0016 3B   DCX   SP           ;PUT BINARY BYTE IN A
0017 7E   RLOOP: MOV   A,M           ;SHIFT BYTE LEFT & FILL WITH CARRY
0018 0F   ADC   A           ;REPLACE BYTE
0019 77   MOV   M,A           ;DECREMENT C
001A 0D   DCR   C           ;BRANCH FROM LOOP IF LAST BYTE
001B C22200 JZ    LAB17          ;INCREMENT HL
001E 23   INX   H           ;JUMP TO START OF ROTATE LOOP
001F C31700 JMP   RLOOP          ;RESTORE HL POINTER TO LOW ORDER BINARY BYTE
0022 E1   LAB17: POP    H
0023 3B   DCX   SP           ;LEAVE HL ON STACK
0024 3B   DCX   SP           ;SKIP FILL WITH ONE IF NO CARRY
0025 D22900 JNC   LAB18          ;FILL WITH ONE
0028 34   INR   M           ;PUT # OF BCD BYTE IN C
0029 4B   LAB18: MOV   C,E           ;LOAD HL WITH ADDR OF BCD
002A 216400 LXI   H,BCDNL          ;ZERO OUT A
002D 3E00   LAB20: MVI   A,0           ;ADD BCD BYTE TO A WITH CARRY
002F BE   ADC   M           ;CONVERT RESULT TO BCD
0030 27   DAA           ;SAVE NEW BCD BYTE
0031 77   MOV   M,A           ;SKIP REST IF NO CARRY
0032 D23A00 JNC   LAB19          ;POINT TO NEXT BCD BYTE
0035 23   INX   H           ;DECREMENT C
0036 0D   DCR   C           ;IF C=0 LEAVE LOOP
0037 C22D00 JNZ   LAB20          ;PUT # OF BCD BYTE IN C
003A 4B   LAB19: MOV   C,E           ;DECREMENT BIT COUNT
003B 05   DCR   B           ;EXIT MAIN LOOP IF COUNT = 0
003C C94E00 JZ    LAB40          ;LOAD HL WITH ADDR OF BCD
003F 216400 LXI   H,BCDNL          ;CARRY=0 ENTERING NEXT LOOP WHICH
;MULTIPLIES BCD # BY TWO
;PUT BCD BYTE IN A
;ADD BCD BYTE TO ITSELF WITH CARRY
;CONVERT RESULT TO BCD
;SAVE NEW BCD BYTE
;POINT TO NEXT BCD BYTE
;DECREMENT C
;IF C=0 LEAVE LOOP
;DO FOR ALL BITS OF BINARY #
;RESTORE HL
;RESTORE STATUS
;RETURN

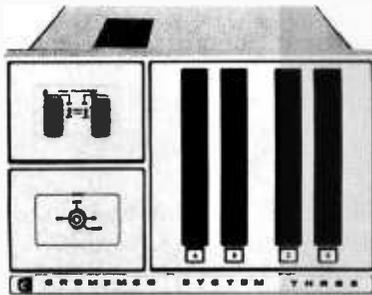
0042 7E   LAB21: MOV   A,M           ;ADD BCD BYTE TO ITSELF WITH CARRY
0043 0E   ADC   M           ;CONVERT RESULT TO BCD
0044 27   DAA           ;SAVE NEW BCD BYTE
0045 77   MOV   M,A           ;POINT TO NEXT BCD BYTE
0046 23   INX   H           ;DECREMENT C
0047 0D   DCR   C           ;IF C=0 LEAVE LOOP
0048 C24200 JNZ   LAB21          ;DO FOR ALL BITS OF BINARY #
004B C31300 JMP   MLOOP          ;RESTORE HL
004E E1   LAB40: POP    H           ;RESTORE STATUS
004F F1   POP    PSH          ;RESTORE STATUS
0050 C9   RET                    ;RETURN

```

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since they are the most popular. First it is necessary to keep track not only of the carry out of the eighth bit position, but also the carry from the fourth to fifth bit position. This second carry will be referred to as the *auxiliary carry*.

- (1) Add the binary number 01100110 to the first number.
- (2) Add the second number to the result generated in step 1. Keep track of both the carry and auxiliary carry from this addition. The carry generated here is the true carry to the next higher digit.
- (3) Based on the carry and auxiliary carry generated in step 2, add one of the correction factors shown in table 1 to the result of step 2.

The result has now been decimally adjusted.

The program shown in listing 1 and the flowchart shown in figure 1 provide an implementation of Form II using binary-coded-decimal arithmetic for the Intel 8080 microprocessor. It uses the decimal-adjust (DAA) instruction in the 8080's instruction set. A simple program shown in listing 2 converts data from binary-coded decimal to ASCII representation. The conversion from binary-coded-decimal to ASCII entails taking each of the two 4-bit, binary-coded-decimal digits, putting them in a byte, and appending the binary prefix 0011. Both programs are coded as subroutines, since these forms are usually more convenient to include in larger programs.

The binary-to-binary-coded-decimal subroutine of



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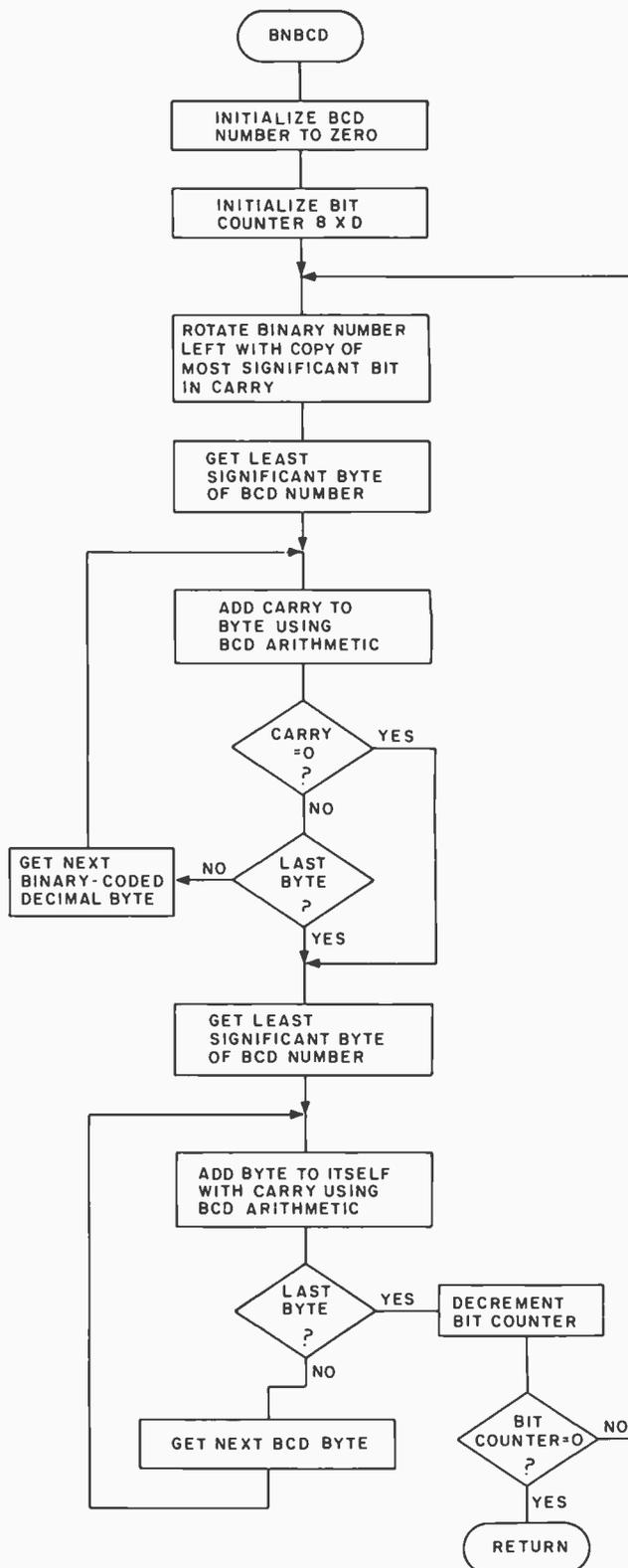


Figure 1: Flowchart of the algorithm for the binary to binary-coded-decimal (BCD) conversion subroutine.

listing 1 requires contiguous memory locations to hold the binary-coded-decimal result. The address of the memory location for the low-order byte of the binary-coded-decimal number has been labeled BCDNLC (binary-coded-decimal number location) in the subroutine. The

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**Listing 2:** A subroutine to convert a single-byte, 2-digit, binary-coded-decimal number to two single-byte ASCII characters, coded for the 8080 microprocessor.

```

;*****BCD TO ASCII SUBROUTINE*****
; THE SUBROUTINE TAKES A TWO DIGIT BCD NUMBER IN MEMORY POINTED TO BY
; HL AND CONVERTS IT TO ASCII. THE MOST SIGNIFICANT DIGIT IS PUT
; IN REGISTER B WHILE THE LEAST SIGNIFICANT DIGIT IS PUT IN REGISTER C.

0051 F5      ASCII: PUSH   PSH          ;SAVE STATUS
0052 3E0F    MVI     A,00001111B      ;PUT LEAST SIGNIFICANT DIGIT MASK IN A
0054 A6      ANA     M              ;MASK OFF LEAST SIGNIFICANT DIGIT
0055 F630    ORI     00110000B      ;CONVERT TO ASCII
0057 4F      MOV     C,A          ;PUT IN REG C
0058 3E08    MVI     A,11110000B    ;PUT MOST SIGNIFICANT DIGIT MASK IN A
005A A6      ANA     M              ;MASK OFF MOST SIGNIFICANT DIGIT
005B 0F      RRC
005C 0F      RRC
005D 0F      RRC
005E 0F      RRC                ;ROTATE RIGHT FOUR PLACES
005F F630    ORI     00110000B      ;CONVERT TO ASCII
0061 47      MOV     B,A          ;PUT IN REG B
0062 F1      POP     PSH          ;RESTORE STATUS
0063 C9      RET
0064          BCDNL: DS     31      ;START OF BCD NUMBER
0066          END

```

number is ordered upwards in memory. Register E must contain the number of bytes in the binary-coded-decimal number when the subroutine is called. If more bytes are specified than are needed, the extra will be filled with leading zeros.

The other parameters which must be passed to the subroutine are the number of bytes in the binary number and the address of the low-order byte of the binary

number. The number of bytes in the binary number is to be in register D, while the address of the low-order byte is in register pair HL. The binary number is assumed to be stored in memory using the same convention as the binary-coded-decimal number. The more significant bytes are found at increasing memory addresses.

By having register pair HL point to the binary number, the routine can be used to convert all binary numbers required by the user's program without moving them to a specific location. All results are put in the same location, since this is temporary storage needed only until the number is sent to the display device.

The binary to binary-coded-decimal conversion subroutine provided can handle binary numbers of any length up to and including 31 bytes. This corresponds to a decimal number in excess of  $4.5 \times 10^{74}$  with a full 75 significant digits. This should be adequate to handle any physical quantity encountered. To establish a reference, it is only about  $1.5 \times 10^{21}$  angstroms from the earth to the sun. (An angstrom is one ten-billionth of a meter, that is  $1/10^9$ , and is normally used to measure the wavelength of light.)

The routines provided have been tested using a high-speed line printer as an output device. The routines were fast enough to allow the line printer not to wait when being sent a stream of 6-digit numbers. While the routines have been tested and were fast enough for the desired applications, an extensive effort was not made to eliminate every unneeded processor cycle. The object code provided in listings 1 and 2 will also execute on an Intel 8085 or a Zilog Z80 microprocessor. ■

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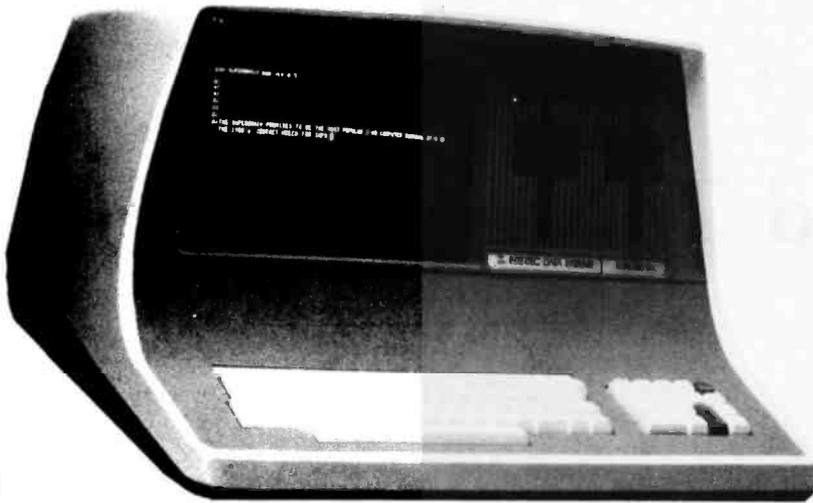
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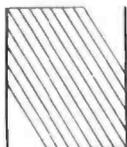
\*Superbrain is a registered trademark of Intertec Data Systems.

### System Specifications

<b>CPU</b>	
Microprocessors	Twin Z80A's with 4MHz Clock Frequency. One Z80A (the host processor) performs all processor and screen related functions. The second Z80A is "down-loaded" by the host to execute disk I/O. When not processing disk data, the second Z80 may be programmed by the host for other processor related functions.
Word Size	8 bits
Execution Time	1.0 microseconds register to register
Machine Instructions	158
Interrupt Mode	All interrupts are vectored
<b>Floppy Disk</b>	
Storage Capacity	320K total bytes formatted on two double density drives. Optional external 10-300 megabyte hard disk storage is available using optional S-100 bus adaptor
Data Transfer Rate	250K bits/second
Average Access Time	250 milliseconds .35 milliseconds track-to-track
Media	5 1/4 inch mini-disk
Disk Rotation	300 RPM
<b>Internal Memory</b>	
Dynamic RAM	64K bytes dynamic RAM
Static RAM	256 bytes of static RAM is provided in addition to the main processor RAM. This memory is used for program and/or data storage for the auxiliary processor
ROM Storage	1K bytes standard. Allows ROM "bootstrapping" of system at power-on. ROM storage is 2708 compatible and may be reprogrammed by the user for custom applications
<b>CRT</b>	
Display Size	12-inch, dynamically focused P4 phosphor
Display Format	25 lines x 80 characters per line
Character Font	8 x 8 character matrix on a 8 x 12 character field
Line Drawing Characters	Eleven special graphics symbols used for form generation
Display Presentation	Light characters on a dark background. Reversible through keyboard/program selection.
Bandwidth	20 MHz
Cursor	Reversed image (block cursor)
<b>Communications</b>	
Screen Data Transfer	Memory mapped at 38 kilobaud. Serial transmission of data at rates up to 9600 bps.
Auxiliary Interface	Universal RS 232 asynchronous. Synchronous interface optional.
Parallel Interface	Radio Shack TRS 80 compatible
S-100 Bus	Printed circuit edge connector provided for connection of optional S-100 bus adaptor.
Transparent Mode	Enables display of all incoming and outgoing control codes
Parity	Choice of even, odd, marking, or spacing
Transmission Mode	Half or Full Duplex. One or two stop bits
Addressable Cursor	Direct positioning by either discrete or absolute addressing
<b>System Utilities</b>	
Disk Operating System	CP/M
DOS Software	An 8080 disk assembler, debugger, text editor and file handling utilities.
<b>Optional Software</b>	
FORTRAN	ANSI standard. Relocatable, random and sequential disk access
COBOL	ANSI standard. Relocatable, sequential, relative and indexed disk access
BASIC	Sequential and random disk access. Full string manipulation, interpreter
Application Packages	Extensive software development tools are available including software for the following applications: Payroll, Accounts Receivable, Accounts Payable, Inventory Control, General Ledger and Word Processing
<b>Keyboard</b>	
Alphanumeric Character	Generates all 128 upper and lower case ASCII characters
Special Features	N-Key Rollover. Automatic repeat (at 15 CPS). Keyboard lock/unlock
Numeric Pad	0-9, decimal point, comma, minus and four user-programmable function keys.
Special Functions Keys	Up to 64 user-defined two-key function sequences
Cursor Control	Up, down, forward, backward, and home
<b>Internal Construction</b>	
Cabinetry	Structural foam
Component Layout	Two board modular design. All processor related functions and hardware are on a single printed circuit board. All video and power related circuits on a separate single board. These two boards are interconnected via a single 22-pin ribbon cable.
Mounting	CRT and two circuit boards mounted to base. CRT in a rigid steel frame. Disk Drive assembly mounted into upper cover for ease of servicing.
<b>Environment</b>	
Weight	Approximately 45 pounds
Physical Dimensions	14 1/4" (H) x 21 1/4" (W) x 23 1/4" (D)
Environment	Operating: 0° to 50° C Storage: 0° to 85° C. 10 to 95% rel. humidity, non condensing
Power Requirements	115 VAC, 60 HZ, 1 AMP (optional 230VAC/50HZ mode) available

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# A Quad Terminal Interface

Stephen A Alpert  
11 Ridgewood Dr  
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Every now and then, a micro or mini-computer owner may be fortunate enough to have more than one terminal and probably a modem or two. Unfortunately, there never seem to be enough interfaces to the computer system to connect all these

devices into the system at the same time. This article chronicles my local solution to the problem.

Through luck and a lot of hard work, my computer system consists of a Digital Equipment Corporation PDP-11/10 processor, a video monitor, a teleprinter, a modem and only one terminal interface. Conveniently, the video monitor, which serves as the main console, is driven directly off the processor. This still meant that there was a deficiency of one terminal interface.

After reviewing the schematic for the interface that I had, I started a design to essentially duplicate that board. A friend jokingly suggested that a design should be generated to drive several terminals at once. Taking that thought seriously, my course of action had been charted.

The creation of this quad terminal interface involves ideas applicable to almost any sort of processor that uses memory addressed IO. That is, the processor contains no special IO instructions, but instead addresses specific memory addresses to communicate with the status registers and buffers of the peripheral devices. This trade-off means that the devices look like memory and the processor can therefore be equipped with additional instructions at the loss of memory space.

In the case of the PDP-11 series, the processor has a 16 bit data bus and an 18 bit address bus. In this byte addressable machine, the maximum user address space is 32 K words. However, the processor automatically takes all addresses in the range of 160000 to 177777 octal and maps them to 760000 to 777777 octal. (Digital Equipment Corporation uses octal notation in all software.) That means the user memory space is limited to 28 K words with the addresses generated by the processor for 124 K to 128 K specified for the IO page.

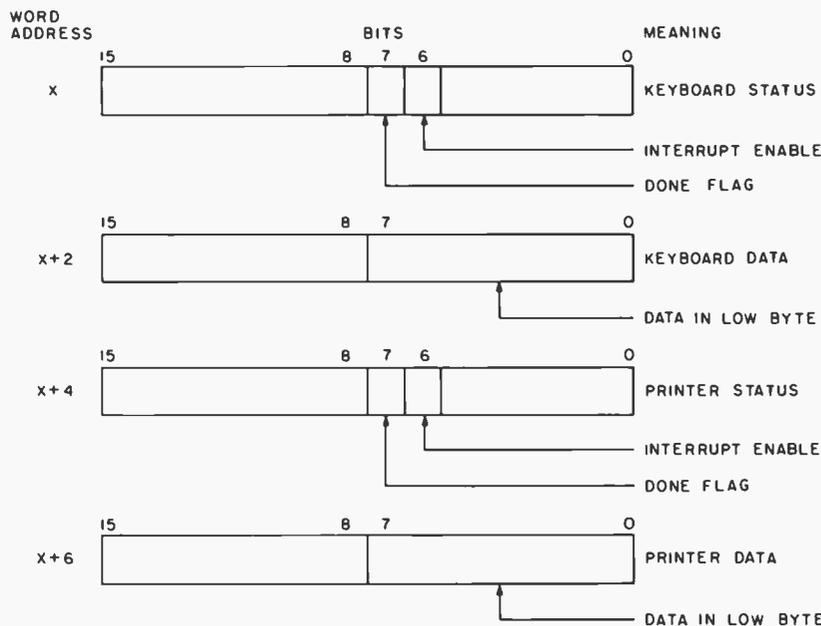


Figure 1: Addresses required for a single terminal are the low bytes of four consecutive words.

- Each terminal requires four words of 16 bits each. The bits in a word are numbered 0 to 15 from right to left. Hence, the low byte in a word contains bits 7 thru 0 and the high byte contains bits 15 thru 8.
- The first word contains only two bits of interest. Bit 7, the most significant bit in the low byte, is the keyboard *done* flag. It is set when a byte is received as input. It is cleared by a bus initialization (BUS INIT) or a processor read of the data. Bit 6 is an interrupt enable bit for the keyboard. When set, an incoming character will cause an automatic vectored interrupt through the processor.
- The low byte of the second word contains the keyboard data.
- The third word is arranged like the first word but is used for the printer side of the terminal. Bit 7 is set by a bus initialization signal (BUS INIT) or when the interface can accept another byte from the computer and is cleared when a byte is sent to the terminal.
- The low byte of the fourth word is the data buffer for the printer.

Table 1: Device addressing organization for interface configuration shown in figure 1.

### About the Author

*Stephen Alpert is an associate professor of computer science at Worcester MA Polytechnic Institute. He was the first vice chairman of the ACM's special interest group for minicomputers (SIGMINI) and is a software consultant to Digital Equipment Corporation through Hias Inc. He has owned a mini-computer since 1973.*

*Stephen wishes to thank R Hully, the president of Hias Inc, for the use of personnel during construction of this equipment.*

The organization for the device addressing used on the interface in figure 1 is summarized in table 1. This structure is imposed primarily by the requirement to maintain compatibility with the interfaces supported by the existing software. Essentially, the interface should look to the software exactly like four separate terminal interfaces. A microprocessor could easily utilize this memory layout in consecutive bytes in page zero.

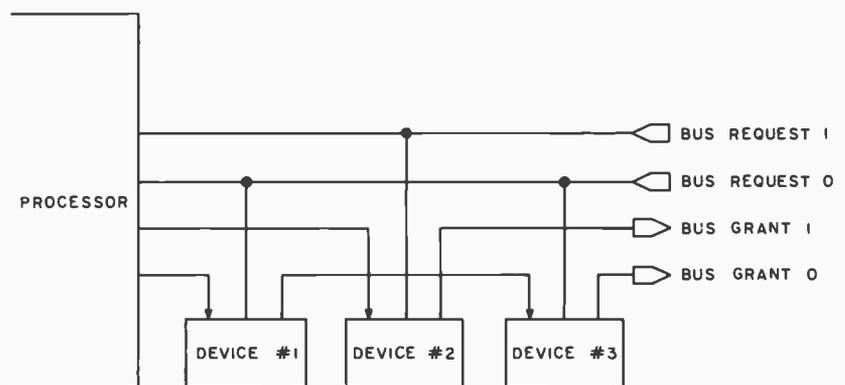
Without the interrupt enable (IE) bit set, the keyboard status register must be constantly checked by the program for the presence of a byte of data. This overhead is wasteful and serves no utility except in the case where the processor has nothing else to do. The processor can acknowledge an interrupt by automatically jumping to a special location in page zero whenever an interrupt occurs. A routine must either poll the individual devices or, via some kind of acknowledge instruction, get information off the bus pertaining to an address of the desired routine or identification of the device requesting the interrupt. This software overhead in a minicomputer makes for very inefficient performance. Also, what happens when more than one device requests service simultaneously? Interrupt masking of some sort is needed. What about a possible priority based on the requests?

The PDP-11 processor eliminates these problems by utilizing hardware priority arbitration and vectored interrupt logic. The processor allows four levels of interrupt requests and a nonprocessor request mode for direct memory access (DMA). Once the processor decides to allow an interrupt request, it issues a BUS GRANT on one of the four lines corresponding to the different interrupt levels. This grant line is fed in sequence from one device to the next. Each device that does not want the grant is responsible for passing it along to the next device as shown in figure 2. In this way, the device closest to the processor always

gets the grant first in the case of simultaneous requests on the same line. After the grant has been received by the requesting device, that device is responsible for asserting an interrupt service request and simultaneously asserting a 9 bit address on the data lines of the processor's single bus. The processor will accept this address not as an address of a routine, but rather as a pointer to a pair of words. The first word contains the address of the interrupt service routine and the second word contains a new processor status word. The old program counter and processor status word are saved on the processor's stack. This complete sequencing requires approximately 7  $\mu$ s in the PDP 11/10.

From the previous discussion, it is apparent that the interface must properly decode 16 distinct word addresses, four for each terminal, along with the proper read or write lines. Furthermore, to eliminate redundant hardware, and save space on an interface board, the logic must do some of its own decoding and encoding of addresses and data. The program counter and

*Text continued on page 120*



*Figure 2: Typical bus request and grant arrangement with two levels. Requests are asserted on a particular request line of the processor. Grants are generated from the processor and daisy chained through the devices associated with that level.*

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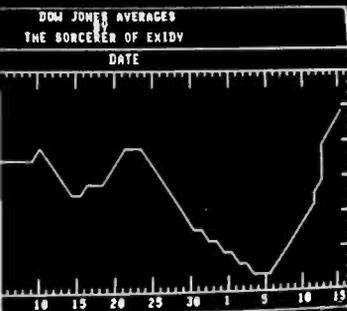
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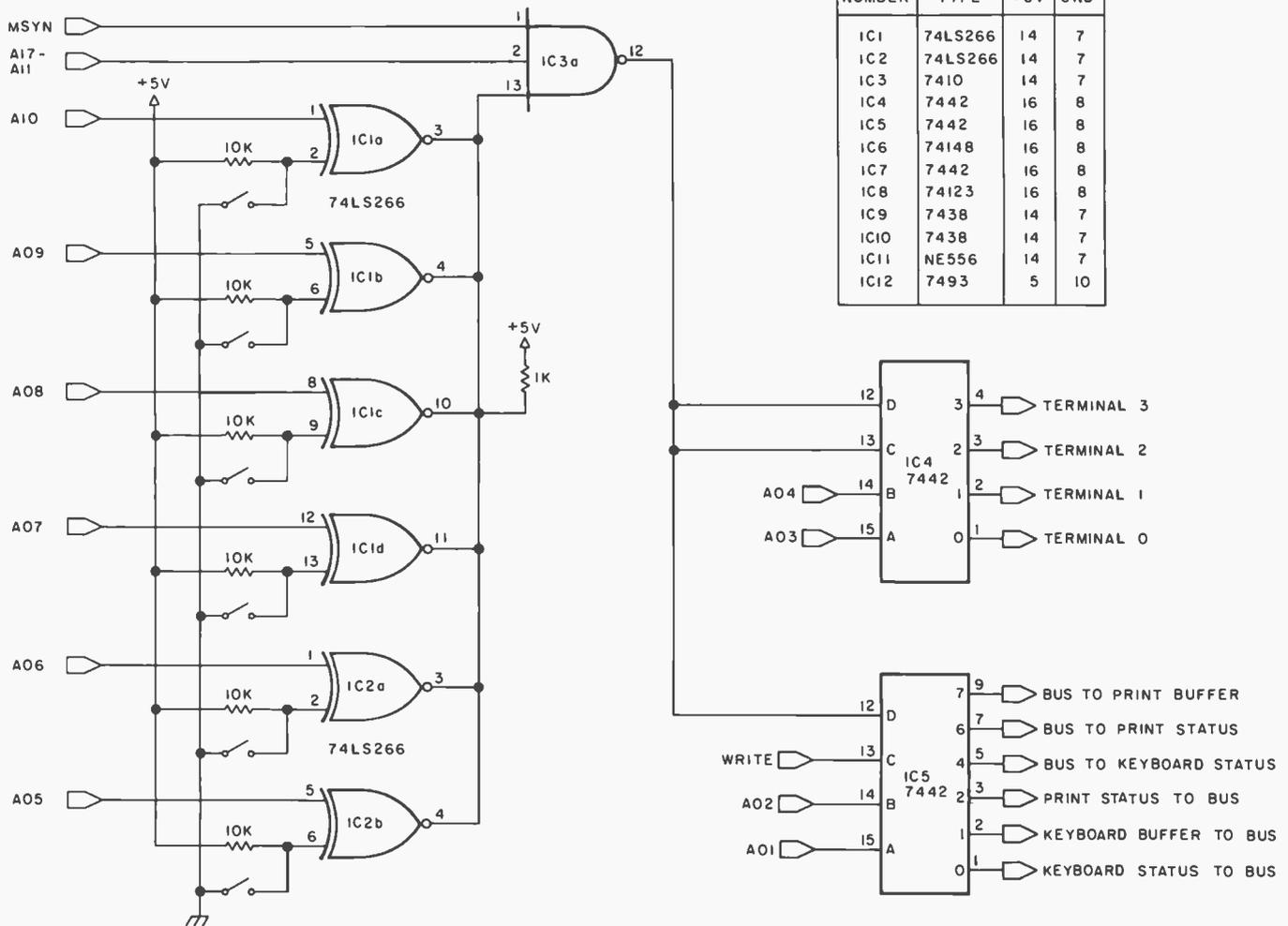


Figure 3: Address decoding circuitry.

Text continued from page 117: processor status word for the service routines are placed in low memory of addresses less than octal 776 by the software and not by the hardware.

The memory words necessary for this interface will consist of D type flip flops for the status registers since only two bits are needed per word. The input and output data buffers may be hooked directly to the UARTs. UART is, of course, an abbreviation for the Universal Asynchronous Receiver Transmitter, a device which converts parallel bytes of data into a serial stream of bits in an industry standard, time ordered format. The specific UART used in this design is the General Instruments part numbered AY-5-1013.

The address decoding circuitry is shown in figure 3. All signals are conditioned by bus receivers and are not considered valid until the processor asserts a master synchronization signal (MSYN). The 74LS266 is a 4 bit digital comparator with open collector outputs that are "wire ORed" to detect the

proper setting of six address lines. The address may be selected by the adjustment of the switches. A pair of 7485 magnitude comparators could have been used in series since they only require a 48 ns delay to compare six bits. The MSYN signal is not asserted until at least 75 ns after the address lines have been activated. Notice the use of two 7442s, binary coded decimal decoders. Since all addresses are in consecutive words, given a base address, say X, the first terminal will use addresses X to X+6, the second terminal will use addresses X+10 to X+16, and so on. IC4 will only assert one of its lower four output lines if the address is in the range for that terminal. IC5 is used with the low address bits and the read or write control lines to indicate which action must be done for the specified terminal. Note that the keyboard data buffer is a "read only" memory and the printer data buffer is a "write only" memory.

The UARTs used in this interface require a transistor-transistor logic load

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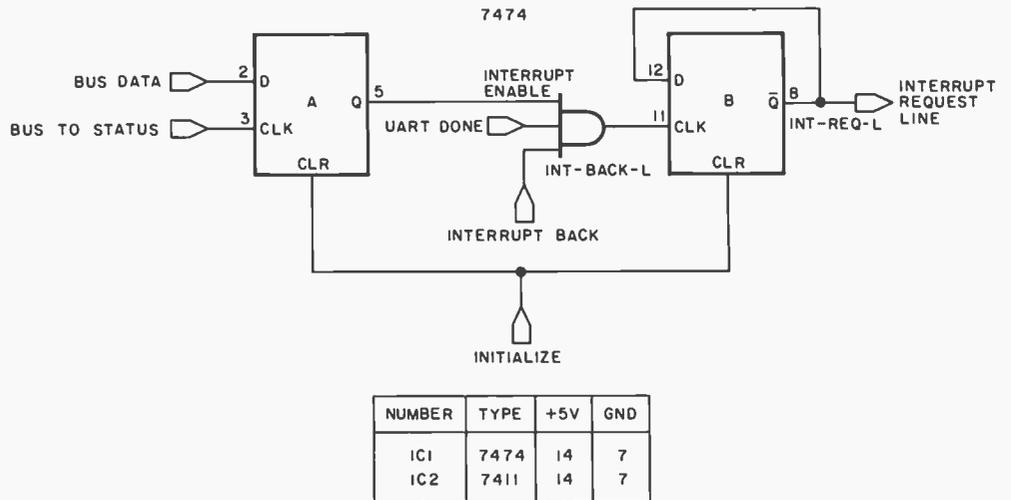


Figure 4: The interrupt logic for each UART consists of a pair of these circuits: one for transmit and one for receive. For the complete interface, eight copies of this circuit are required, so the sections of the 7474 circuits are referenced in text by A and B.

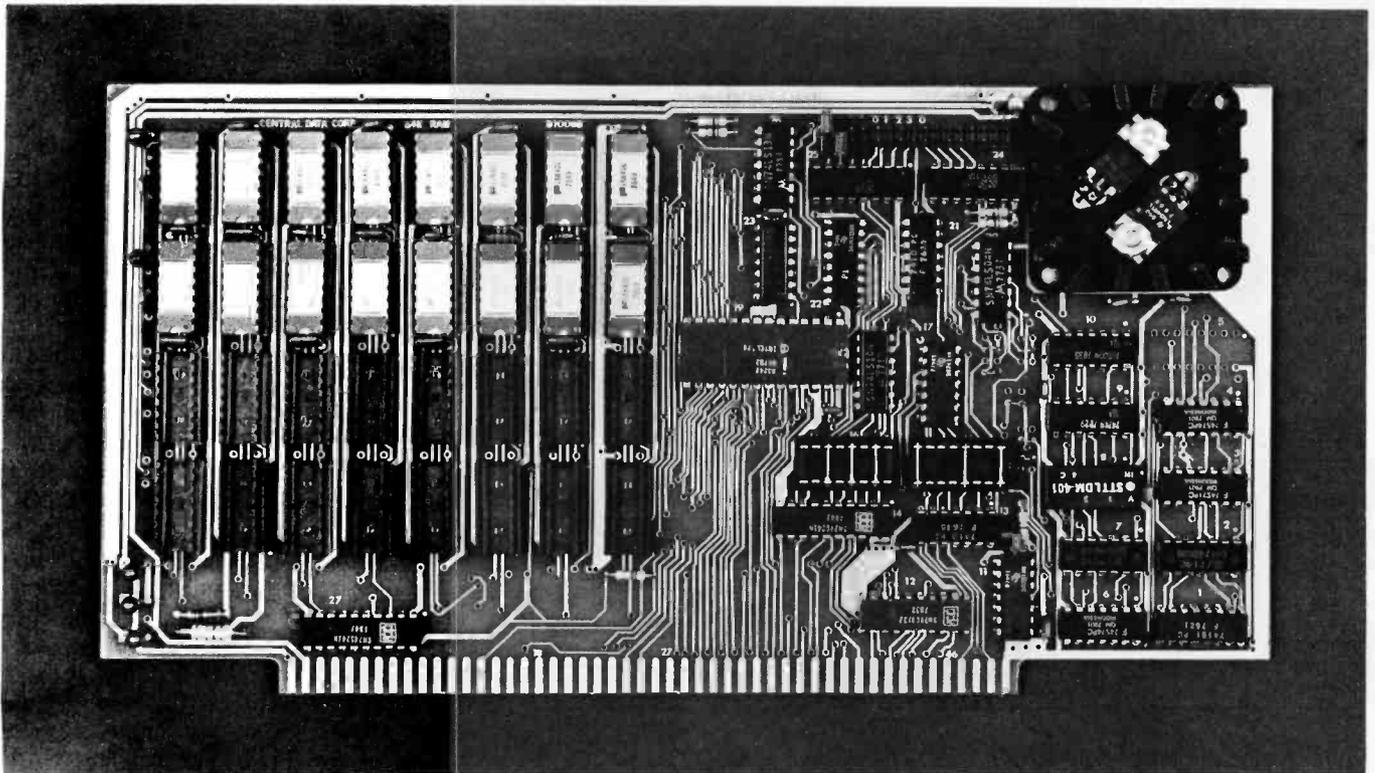
(1.6 mA) for the data inputs and have three state data outputs capable of driving one transistor-transistor logic load. Since the data ports had to be buffered to correctly interface to the processor bus, all input data ports could be wired in parallel and the same for the output data ports. All individual signals to and from each UART must be conditioned via AND or NAND gates to insure communication with the correct terminal unit.

The most difficult task remained: designing the necessary interrupt logic. It was desirable to make the priority of all keyboards higher than any of the printers. This way, no characters would be lost. The inclusion of four terminal drivers on a single board forces a significant increase in the complexity of the interrupt logic.

The interrupt logic consists of two related sections. The first section required properly generating an interrupt from either the input or output side of the UART. Figure 4 shows the circuit for one side of a UART. This circuit appears eight times in the completed board. The interrupt enable bit must have been set through a 7474 flip flop section labeled A in figure 4. Initially, the B section of the 7474 is off so the interrupt request line (INT REQ L) is high and not asserted. Likewise, the interrupt back line (INT BACK L) is high and not asserted. When a character is received (in the case of the receiver side of the UART), UART DONE causes a low to high level transition on the clock input of the B section of the flip flop. Since  $\bar{Q}$  was high,

D is high and Q is then asserted, making the interrupt request line ( $\bar{Q}$ ) active. This signal then serves as input to the interrupt arbitration logic. The interrupt back line (INT BACK L) will remain high until the actual vectoring takes place. After that, a low to high transition on the interrupt back line will cause the B section of the 7474 to shut off and stay off until either the interrupt enable or the UART done line is cleared and set again. As a convenience, any processor write operation to the status register will also reset the UART making the UART done line wait for the next character to be received.

The interrupt arbitration logic is in figure 5. Interrupt requests are arbitrated by the 74148 8 line to 3 line priority encoder. With the enable input (EI) line normally low, the gate status (GS) output will go low when at least one of the inputs is low, signaling an interrupt request had been posted. The outputs of IC6 will be a binary encoding of the one's complement of the highest priority input signal that is asserted low. When the processor acknowledges the request, the proper vector information, which is made up of a combination of switch settings and 74148 outputs, will be put onto the bus through the 7438 bus drivers. See table 2 for an enumeration of the vectoring. Observe that the bus is at ground potential for an address bit of 1. At the same time, the D3 input to IC7 will go low asserting an output line corresponding to the interrupt. When the interrupt sequence is done, the D3 input goes high and the cor-



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responding interrupt back line goes high clearing its respective D flip flop from figure 4. Simultaneously, IC8 is triggered to time out the gate status output of IC6. This is necessary because the remainder of the interrupt logic requires the gate status line to go high before it can be asserted to request another interrupt.

Unfortunately, there is a period of about

50 to 100 ns when the bus drivers are active that a higher priority interrupt could perhaps sneak through IC6 and deskew the correct data. This problem could probably be eliminated by giving the higher communication rate terminals a higher priority or by using an extra set of latches.

If all the UARTs were driven off the same clock source, the interrupts could only occur simultaneously (in which case the arbitration works correctly) or at least spread apart by an interval equal in length to 16 times the transmission rate. This would be 26  $\mu$ s at 2400 bps. Feeling that the odds of two people typing two keys within 100  $\mu$ s of each other is quite small, the circuit remains as presented. The interrupt enable bits and the done flags are reported back to the user through 74153s, dual 4 line to 1 line data selectors. The input to these chips comes from the interrupt enable signals of the 7474s and from the UARTs directly.

Interrupt	74148 Output			Octal to 7442	Vector Offset
	A2	A1	A0		
KBD 0	L	L	L	0	+ 0
KBD 1	L	L	H	1	+10
KBD 2	L	H	L	2	+20
KBD 3	L	H	H	3	+30
PRINT 0	H	L	L	4	+ 4
PRINT 1	H	L	H	5	+14
PRINT 2	H	H	L	6	+24
PRINT 3	H	H	H	7	+34

Table 2: Vector table generated by the 74148 and 7442 (IC1 and IC2 in figure 5) combination through the bus drivers.

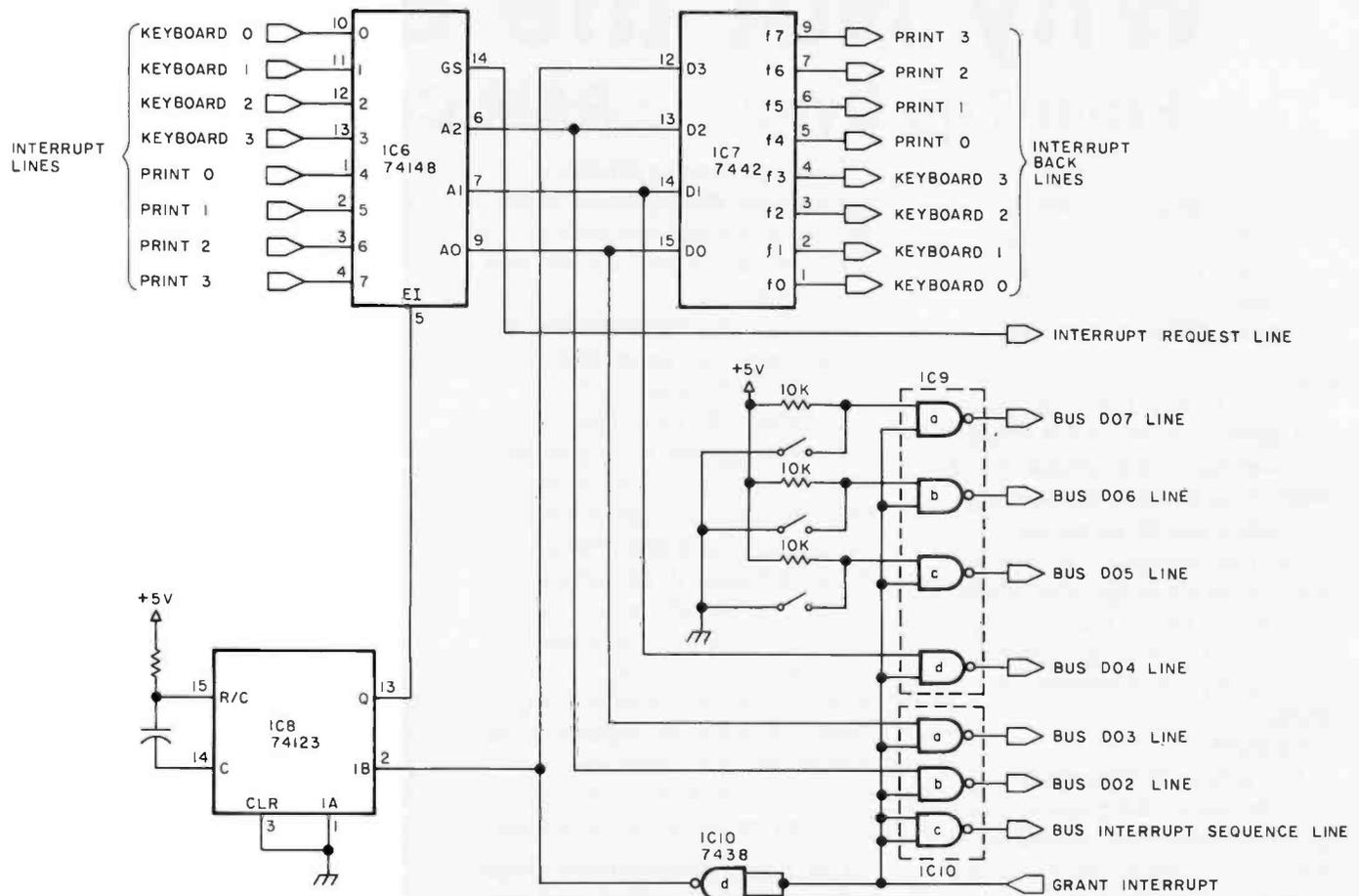


Figure 5: The interrupt arbitration logic interfaces the requests from the UARTs to the remainder of the bus interrupt sequence logic. Note that the 74148s can be wired in serial to control even more requests.

An additional item: in trying to keep my costs to a minimum, my clock driver consisted of an NE556 dual timer and a 7493 divide by 16 counter instead of a MC14411 bit rate generator. Luckily, the NE556 was the only part not in my rather well stocked junk box at the start of this effort. The clock circuit is shown in figure 6. Current market price for four terminal interface boards for the PDP-11 is about \$1600. This interface required some four months of spare time to design and debug. The time has been well worth the effort. My 20 mA teleprinter, operating at 110 bps, and my EIA modem, operating at 300 bps, are currently attached to this interface with two ports still open. Now I have a single terminal interface left over with no use for it. I guess I will have to find another terminal. ■

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2. *Signetics Logic Data Manual*, Signetics Corp, Sunnyvale CA, published yearly.

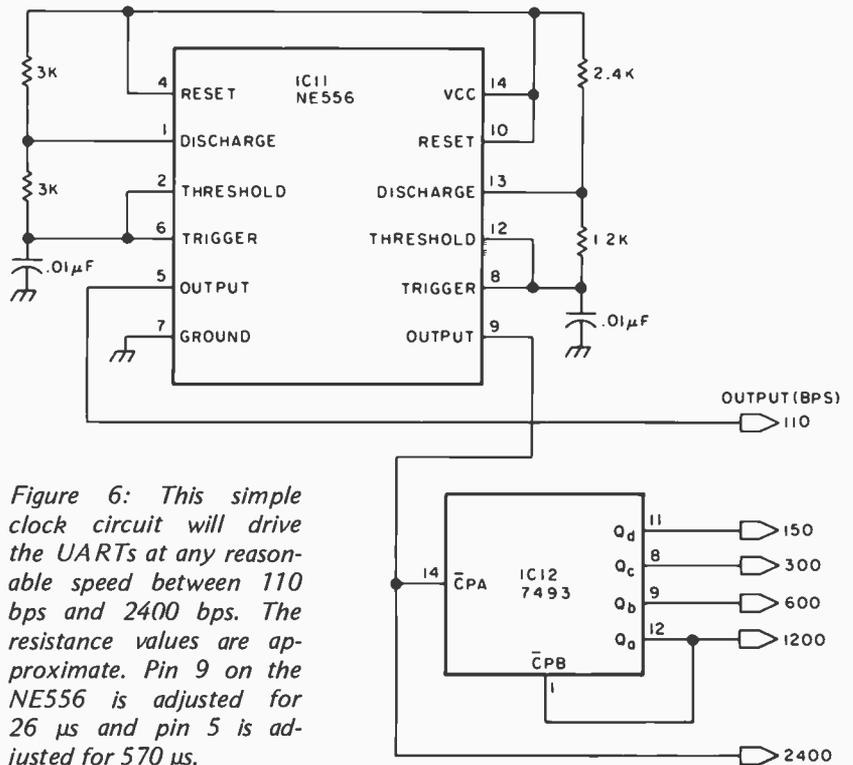


Figure 6: This simple clock circuit will drive the UARTs at any reasonable speed between 110 bps and 2400 bps. The resistance values are approximate. Pin 9 on the NE556 is adjusted for 26 µs and pin 5 is adjusted for 570 µs.

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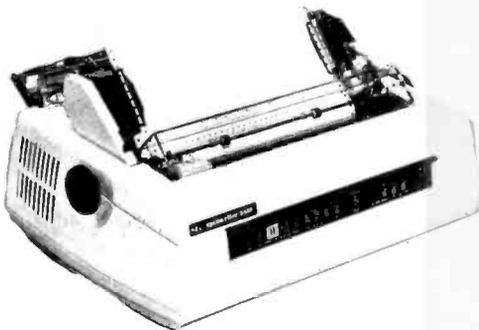
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# Comparison of Some High-Level Languages

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Different languages are appropriate for different tasks: multilingual ability is as useful in the computer world as it is in the human world.

The time is not far off when microprocessor users will begin the serious use of high level languages other than the BASIC supplied for many current machines. There are many projects hither and yon to implement contemporary languages in microcomputer form, and the emergence of 16 bit processors will probably accelerate this trend. Indeed, even now microcomputer users have a practical way to use high level languages: using the personal computer as an intelligent interactive editing terminal and sending source code over telephone lines to be compiled and executed by a large remote time-sharing computer. For many such tasks, the connection time (the charge levied by the big computer operators for merely listening to your terminal) is a substantial fraction of the total cost. But this time is short compared to the data entry time, which will be entirely on the user's own system.

Unfortunately, most information about languages is gleaned from people who have a stake in a particular language due to a greater familiarity with it. Different languages are appropriate for different tasks. Multilingual ability is as useful in the computer world as it is in the human world. To this end I would like to describe the differences and similarities between major general purpose programming languages, and offer opinions about how these differences might affect your choice of a high level language.

A number of the conclusions I draw can be attributed to questions of style, and many whose personal programming styles are different might take issue or even umbrage at what I offer. Nevertheless, I claim the critical reviewer's prerogative to offer opinion, and hope only that it is clearly identified. One precaution to the novice and to the initiate: In comparing programming languages, I assume that the specific choices are equally well implemented. Unquestionably the worst

version of language A may be far harder to use than the best version of language B, even if in principle the opposite is the case.

My own particular bias is that I am not interested in "number crunching": that is, the use of the computer for scientific or statistical calculations which are complex, lengthy (in terms of machine time), and which often run repeatedly with different data. For such so called *production* programs the programming expense is usually small compared with the computing expense, and there is a premium on efficient programs. Suppose one writes a program to solve a system of linear equations by Gauss' method with the principal intention of understanding that method. It then becomes irrelevant that an additional 10 hours of programming effort can produce a 50 percent increase in running speed. The program will run only a few times for a few seconds.

Finally, I admit I am a mathematician. Mathematicians think in unusual ways, especially about computers. I once baffled a computer professional when I told him that most of the programs I write, once written and correct, never needed to be run. Programming as a logical and esthetic discipline is not a very comfortable idea to many professionals. In any case, writing a program in order to understand an algorithm, instead of vice versa, is a commendable use of computers and one which colors my own thinking.

In many organizations some system of phantom money is in effect for computer use. The users and their departments often have budgets but do not spend any money. Rather they simply have some restriction put on their use if this budget is expended. Indeed it has been argued that certain computer use, like library use, should be completely without accounting. Nevertheless, it is common to talk of one or another solution being expensive, and this is to

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be understood as being a vague and relative term, taking into account such factors as computing charges, programmer's time and storage charges for data and programs in or outside the machine.

I will discuss essentially three languages: BASIC, FORTRAN, and ALGOL (together with PL/I). I'll also take a cursory look at Pascal and give a brief description of APL together with the reasons for not including it in this survey. These languages are fairly standardized so that if one has learned them on one machine, there is very little relearning necessary for another. Indeed, aside from minor punctuation differences, one rarely encounters machine dependent features of these languages except for input and output (IO). Thus it is often practical to transport programs from one machine to another with very little rewriting except for the IO, but in some circumstances this can be substantial.

Many BYTE readers know BASIC already, but I will describe it so that a broader audience might be reached. In some of the following examples I have abused programming language punctuation in the interest of comprehensibility.

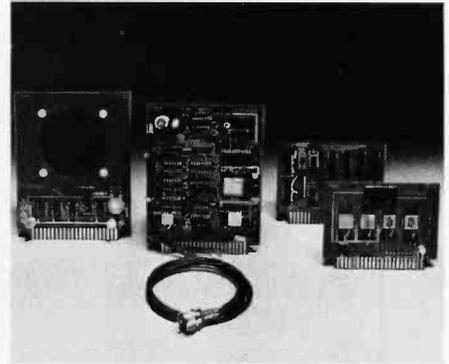
## BASIC

BASIC is an acronym for Beginner's All-purpose Symbolic Instruction Code. It was developed originally at Dartmouth University and designed as a conversational interactive language, meaning that the user is essentially in immediate and constant contact with the computer. A good BASIC translator will give some diagnostic messages even as the user types in the program. In any case the system will attempt to indicate to the user the point at which a linguistic error occurs. This is true for most high level languages whether conversational or not, but the conversational feature and the similarity of BASIC to ordinary mathematical notation make it a particularly easy language to learn and use. In fact, it is the language of choice when the program to be written is short, say 20 commands or less, and the manipulation no more than high school algebra. BASIC is typically available on the interactive minicomputers used in many high schools. It looks like this:

```
100 LET X=Y=3
200 LET Z=5
300 LET W=3*(X+(Y/2))
400 PRINT W
500 END
```

BASIC is an inherently expensive language in terms of time, because it is interpreted rather than compiled. This means that the program is translated into machine

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language each time it is executed, rather than translated once and stored in machine form. The technical differences between interpreters and compilers are not otherwise relevant here. Roughly speaking, with an interpreter one does much less cajoling of the computer to get it to pay attention to one's program.

BASIC programs are easy to alter. To change a line, simply retype the offending line number followed by the new text, then a carriage return. The new line replaces the old and one can try to execute again. Thus, getting a program working right can involve very little waiting.

Many large computers operate in *batch* mode. This means that the user submits the program to the operator, typically on punched cards, and waits for it to be processed in turn. In such an environment the interactive feature is of no use. Although some batch systems have BASIC processors, it seems pointless to use the language this way.

For complicated problems, especially of a mathematical nature, BASIC has some severe deficiencies, even though it is probably the best first language to learn where it is available. One of the biggest of these is the difficulty of writing a BASIC program in pieces. "Passing parameters" can be a very messy business in BASIC and it is usually important to make sure that there is no confusion over the names of the variables. Generally, different variables must have different names, and the same variables the same name throughout a program. Fully-implemented FORTRAN avoids these pitfalls (in a somewhat unnatural fashion), and in ALGOL and PL/I they cannot arise at all. The mathematician's penchant for calling all independent variables *t* or *x* may be freely indulged in ALGOL, cautiously so in FORTRAN, and not at all in BASIC. This is particularly important when one is writing general routines to be plugged into several programs which may not have even been conceived yet.

### FORTRAN

FORTRAN looks like this:

```
I=2
J=3
K=I+J
WRITE(6,10) K
10 FORMAT(I1)
```

The WRITE statement, if mysterious, is at least formal and standard. It instructs the machine to write on output unit 6, probably a printer or the user's terminal, according to format statement 10, the present value of the variable K.

Respectable modern FORTRAN compilers allow the programmer the option of ignoring the format and outputting the results in some standard fashion.

FORTRAN stands for FORMula TRANslator. It is the oldest and most widely used language for scientific computing. FORTRAN compilers for most machines produce extremely efficient machine language programs because demand is so great and the language has such a long history. For this reason, also, there are many compilers with excellent diagnostic features, such as the University of Waterloo's WATFOR and WATFIV systems available for large IBM machines and even optimizing compilers which attempt to improve on the programmer's efforts.

However, as we shall see, some of the classic features of FORTRAN are the very ones that should make people shun it. But because it is so familiar, it is difficult to convince FORTRAN adherents that the language is detrimental to their efforts. Of course, for production programs, efficiency is a legitimate reason to use it. Writers of more ephemeral programs should be aware of the extent to which the other languages around them are being improved and be sure the sacrifices are needed. There are two major objections to FORTRAN: it is difficult to write readable programs; and it is difficult to structure programs in a logical way that reflects the programmer's mathematical ideas for the solution of the given problem. I do not claim that these tasks are impossible. But it is widely agreed that typical FORTRAN programs are unreadable. This is often caused by bad habits encouraged by the language. A common experience with large FORTRAN programs is that some months after writing one, even the programmer's writer must study it at length to find out how it works. For another reader, this job may be immense.

One of the main reasons for this is the way in which logical alternatives are considered and acted upon in FORTRAN (and BASIC, for that matter). One of the principal powers of a computer is its ability to alter its course of action according to conditions that may not be known at the time the program is written, but which may be known only when it is executed. In FORTRAN and BASIC the alternative course of action is numbered (in BASIC all statements are numbered) and a program may contain a statement such as IF (condition to be tested) THEN GO TO 55. If the condition is not met, the computer executes the next instruction, but if it is met it executes the series of instructions which begins with

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statement number 55. However, people never think in this way even if the alternative courses of action are too complicated to remember in detail. Instead of bearing in mind *where* the alternatives may be found, one always keeps in mind *what* they are, perhaps in some brief mnemonic form. Thus the ALGOL statement:

```
IF GCD(A,B)≠1 THEN
P:=SMALLEST.COMMON.PRIME.DIVISOR(A,B)
ELSE
P:=MIN(A,B)
```

is surely more informative than the FORTRAN version:

```
IF (GCD(A,B).NE.1) THEN GO TO 55
P=MIN(A,B)
GO TO 65
55 . . .code describing how to find smallest
common prime
65 continuation of program
```

I am not suggesting that ALGOL knows how to find the smallest common prime. Of course, the words SMALLEST.COMMON.PRIME.DIVISOR(A,B) must also be defined in the program, just as they would at line 55 in the FORTRAN program. But the FORTRAN programmer, in the interest of intelligibility, must add comments, both at line 55 and at the appeal to it, telling the reader what is going on. The necessity of adding comments (words which explain the program to the reader but which are ignored by the computer) is a sign that the conventions of human thought have been sacrificed to the conventions of the programming language. This is a common occurrence in FORTRAN and almost impossible to avoid with the use of GO TO statements (see reference 6 for an exposition of this point and its history).

The second mathematical objection to FORTRAN is that dummy variables are somewhat restricted. They occur automatically in subprograms (small portions of a program which are executed repeatedly but each time with different values assigned to their parameters), but otherwise are essentially absent. This means that some care must be taken in writing complicated programs so that variable names are not confused. Because of this it is difficult to transport pieces from one program to another. A skilled FORTRAN programmer told me that his biggest headache is having to constantly rewrite the same algorithm. That favorite phrase of mathematicians "we are done because we are reduced to a previously solved case" is very difficult to put in practice in FORTRAN and BASIC but quite easy in ALGOL and PL/I. FORTRAN subprograms are not recursive.

That is, unlike their ALGOL counterparts, they cannot appeal to themselves in their own definition. This subtle difference can have extreme consequences in nonnumeric calculations, but this is beyond our scope.

### ALGOL-like Languages

ALGOL is the ALGOritmic Language developed around 1960 (a standard and quite commonly available version is called ALGOL 60). Originally intended as a language for specifying algorithms for publication, it is now widely implemented and used in scientific environments, especially in Europe. A portion of the language PL/I is similar to ALGOL, and the remarks below generally apply to it. Since PL/I is supported by IBM for its machines far more than is ALGOL, users of IBM equipment may prefer to keep it in mind. Pascal is a kind of second generation ALGOL 60 to which most of the comments in this section apply.

Simple ALGOL appears much like BASIC:

```
BEGIN
INTEGER X,Y,Z;
X:=3; Y:=2; Z:=X+Y; PRINT(Z);
END.
```

This program does what the BASIC example does. The differences are in punctuation. ALGOL commands are separated by semicolons, whereas BASIC requires each to have a line number. ALGOL uses the symbol := to assign a value to a variable while BASIC requires the theme LET x=3 (though some versions make LET optional).

Most notable is that the *type* of each variable must be specified; in this example each variable is declared to be an integer. In BASIC no distinction is made between integers and real numbers, while in FORTRAN, if a variable name begins with (usually) I,J,K,L,M or N it is understood to be an integer. Otherwise it is a real variable with some understood accuracy convention (complex variables are also allowed in FORTRAN and most ALGOL implementations). These conventions can be overridden by the programmer, and readability need not be sacrificed in FORTRAN.

One main feature of ALGOL which makes it attractive for mathematical and logical problems is that it is a *block structured* language. By definition a block is a piece of code that begins with BEGIN and ends with END. There may be blocks within blocks nested as deeply as physical limits imposed by the actual computer will allow. Within each block one may declare the names of variables which are to exist only within that block. These variables do not have any existence outside that block and indeed,

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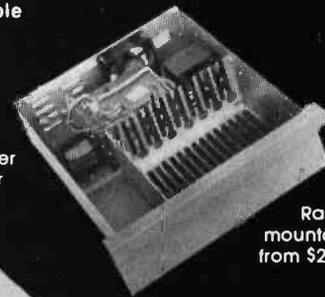
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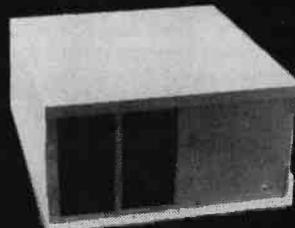
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outside the block there may be other variables with the same name and they will not be confused. Consider the following program:

```
BEGIN
  INTEGER X,Y;
  X:=3;Y:=2;
  BEGIN
    INTEGER X,Z;
    X:=6;Z:=X+Y; PRINT(X);PRINT(Z);
  END;
  PRINT(X);
END.
```

The variable X in the inner block bears no relation to the X in the outer block and references to it in the inner block behave as though there were no X in the outer block. The Y in the inner block, however, has not been declared there, so *it* refers to the next most global occurrence of Y: namely that in the outer block. This program will output:

6 8 3

The first two numbers are produced by the print statements in the inner block, the last by that in the outer block.

This example is a trivial illustration, but the reader will appreciate that no care whatsoever need be taken with the naming of those variables whose existence is not needed outside the algorithm of which they are part. For this reason, algorithms are easily transported from one program to another. The possible sources of confusion arising from these so called *local variables* are approximately the same as those arising in ordinary mathematical discourse: "the variable x here is not the same as the variable x in the previous section."

Another feature of ALGOL and PL/I that adds to the ease of structuring programs is the existence of condition testing phrases other than IF. For example, one may use the sequence WHILE... condition to be tested... DO... something. Not only is this close to our way of thinking, but it has surprising implications for the programming solutions which are naturally suggested by the language. Such structures have been urged for FORTRAN and may well be included in future versions. They are beginning to appear in nonstandard versions of FORTRAN already.

What are the disadvantages of ALGOL? Foremost is that even the most commonly used mathematical procedures are often not preprogrammed into the system as they are in BASIC and FORTRAN. Thus, although arrays are a standard data type in ALGOL, there are no matrix manipulation functions such as BASIC's LET MAT A = B + C. The programmer is responsible for adding the routines to perform these operations. Because of the transportability we have

discussed, this is not particularly difficult. In many systems, these routines could be stored on a high speed storage device such as a magnetic disk, easing the task even further. Thus, each programmer or group may have to build a library of standard routines, whereas in BASIC and FORTRAN large libraries are usually already provided.

These functions often include many transcendental functions and sophisticated procedures, but ALGOL libraries may contain little more than elementary functions. This is largely a historical development and may be expected to change as ALGOL becomes more widely used. This drawback is of little consequence if one's application is nonnumeric. At this writing I am programming procedures in ALGOL to calculate with polynomials over finite fields. Since it is too much to expect any library to have a routine to calculate the zeta function of a curve, I am not terribly restricted by the skimpy offerings of ALGOL libraries.

Even more consequential, because of its limited libraries, is the fact that ALGOL tends to require more programming effort for IO than FORTRAN or BASIC. Simply getting numbers in and out is generally easy, but adjusting format or IO of text may be a complicated task. IO is at least standardized, if cumbersome, in FORTRAN and BASIC. However, IO is not part of the official definition of ALGOL, which burdens it with machine dependent features.

#### Pascal

Pascal is a modern language derived from ALGOL 60 that addresses itself to a very important issue we have not dealt with so far in this elementary exposition: data structures.

Pascal allows the user to define and manipulate new types of data beyond the fundamental types (integers, reals, arrays, strings) which appear in the older languages. Further, it does so in a completely recursive fashion, which adds considerable power to this feature. These matters are beyond the scope of this article, but, as designed, Pascal is easy to learn, powerful and very much like ALGOL in nature.

#### APL

APL stands for A Programming Language. It is a high powered language designed to make the handling of matrices and vectors particularly easy, and as such it is very successful. Its adherents tend to be emphatic about its value as a general purpose language. My own view is that its array orientation is a disadvantage for structuring complicated



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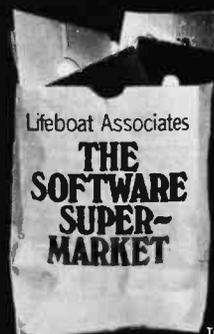
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programs unrelated to array handling. The language does not encourage the writing of readable programs. It is easy and tempting to write very compact, cryptic programs (however, this is a human decision and not really forced by the language). The present view of programming languages is that the elementary data and control structures of the language shape the programmer's way of thinking about solutions. Because of its underlying array orientation, I prefer to put APL with special purpose languages and omit it from this discussion, even though it is so widely used that it can not be regarded as an exotic language.

### Exotic Languages

A number of special purpose languages and systems have arisen as the result of research in computer languages. An annual survey of languages is published by the Association for Computing Machinery.

Some of these special purpose languages, like the algebraic manipulation systems, may be particularly complex or difficult to use, although appealing to the mathematically

inclined. Others, while exciting in prospect, are only beginning to be implemented. Anyone wishing to explore these languages should first gain some traditional programming skill and establish a close relationship with the professionals at the computer center where you are using them, because the exotic products do not always behave as promised and sometimes need a little coaxing from the systems programmers.

### Acknowledgements

None of the ideas expressed here is original. They have been percolating in the computer field for a few years, but apparently are still regarded by some as controversial. The names often associated with them are Dijkstra, Wirth, Knuth and Hoare, whose works set them out in detail. I thank Richard Palais for nudging me toward ALGOL and thence to a consideration of these ideas. I wrote this article using a computerized text formatter adapted from the RATFORMATter of Kernighan and Plaugher (see bibliography) who were the first to insist that there is such a thing as literacy in programming.

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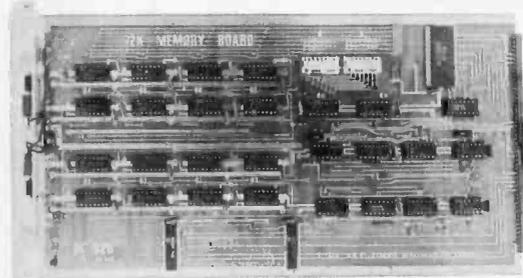
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## Getting Started

The bibliography which follows contains my own favorite introductory texts. Consult local opinion also, because personal explanation is one of the most useful tools in learning programming. If a particular book is highly regarded by people around you, your questions may be more easily answered by others familiar with it. Two other warnings are necessary: you cannot understand programming without writing and running programs; and be wary of the machine manufacturer's language manuals — they are often written for someone who already knows the language or some other high level language. But check them for minor differences with your text. With ALGOL you will probably have to learn the IO from the manual.■

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9. McCracken, D D, *A Guide to FORTRAN IV Programming*, Wiley, 1972. A widely used text. Included are excellent discussions on points of style and efficiency, and an appendix on the WATFOR and WATFIV compiler. They are often used at universities running IBM systems. They will ease the learning of FORTRAN, as will this book.
10. Weinberg, G M, *PL/I Programming: A Manual of Style*, McGraw Hill, New York, 1970. Yet another beginning.
11. Wirth, N, *Systematic Programming: An Introduction*, Prentice-Hall, Englewood Cliffs NJ, 1973.

Also see *Communications of the ACM*, volume 19, number 12, 1976.

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## Some Example Plots

David Dameron 402 E O'Keefe St, Apt 27, E Palo Alto CA 94303

I have been reading BYTE since it was first published in 1975 and have enjoyed its articles, especially those on plotting graphics. My computer is a Cromemco Z80 with 48 K bytes of programmable memory and a 5-inch disk drive. This configuration gives about 20 K bytes of available user memory with 16 K BASIC. My plotter is a Sylvanhills DFT-2, run from a parallel port. I modified the plotter to use stepping-motor X,Y movements, under computer control after reading "Taking the First Step" (February 1978 BYTE, page 35). It now has 300 points per inch of resolution using 15-degree stepping motors.

After the basic vector control software was completed, one of the first routines I entered was a character generator: "A Plot is Incomplete Without Characters" (July 1976 BYTE, page 64). Inspired by "Venus de Plotto"

(February 1977 BYTE, cover), I entered various three-dimensional routines, for example: "Hidden Line Subroutines for Three-Dimensional Plotting" (May 1978 BYTE, page 49). You can see that BYTE has greatly contributed to this plotting system.

The three-dimensional plot "Waves" (figure 1) is an example of the hidden line routines. There are 141 points in the X direction and 156 in the Y direction. It is the sum of four radially-damped sinusoidal waves rotated in three dimensions. The program took about 10 hours to run with a 4 MHz clock, divided evenly between point calculation and the actual plotting, which was done concurrently. Listing 1 is a *chord* program which produces the output in figure 2 (page 144).

This sample output took about 90 minutes to plot; a

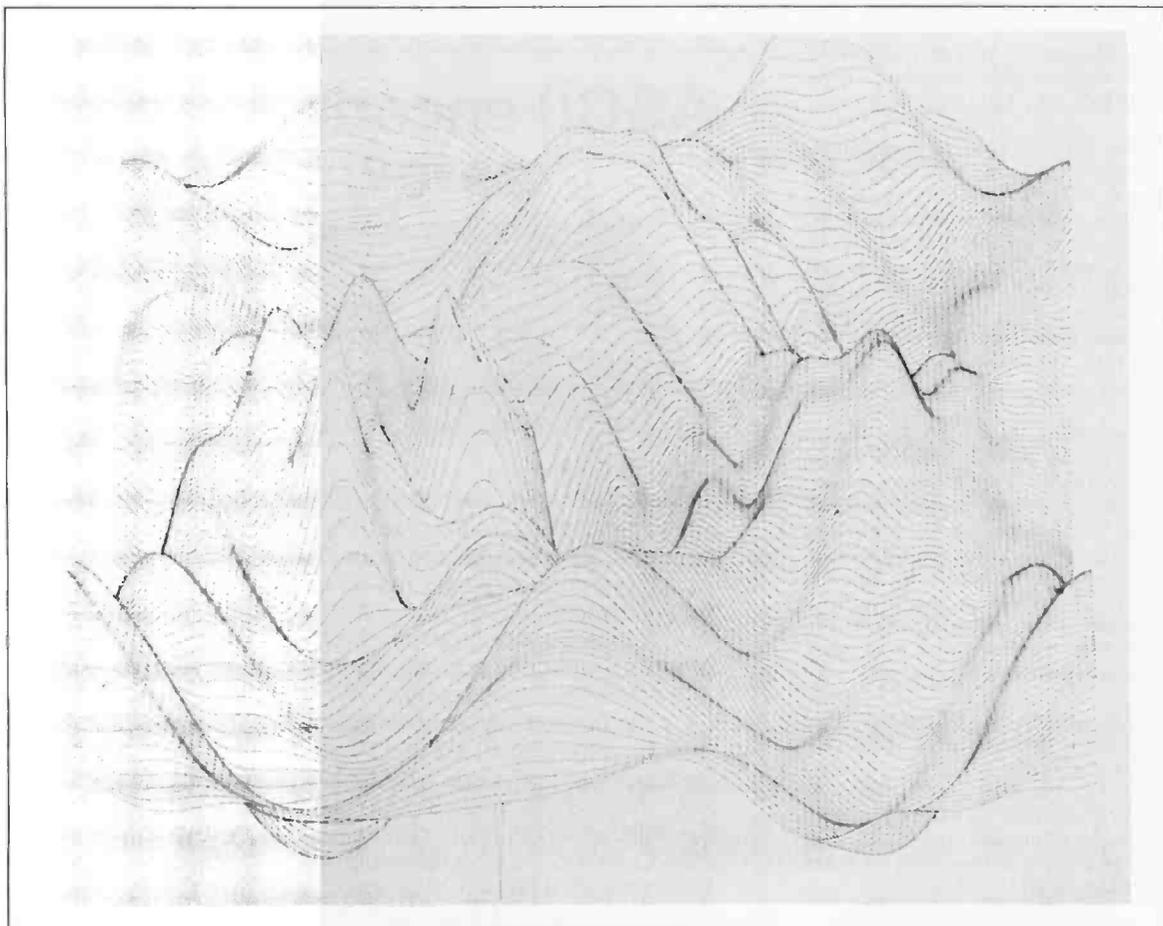
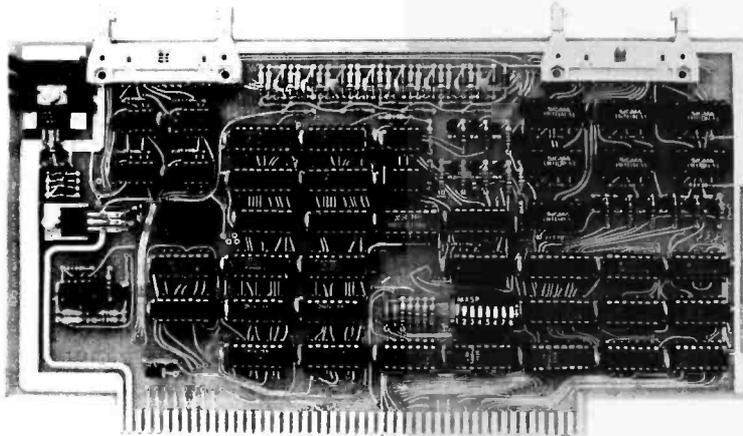


Figure 1: Three-dimensional wave program output which took 10 hours to produce.

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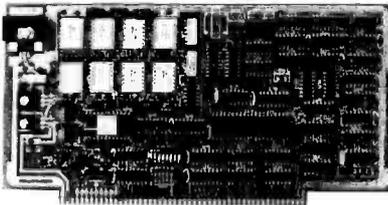
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```

10 REM DRAWS ALL CHORDS WITHIN AN N-GON 7/16/78 240 J2=1 : F=1
20 REM USES DIMENSIONS IN PLOTTER RASTERS 250 N1=N
30 REM WRITTEN BY DAVID H. DAMERON 260 IF I=N/2 THEN N1=I
40 REM INITIALIZE PLOTTER HERE. 270 REM J1=FROM, J2=TO POINT
50 INPUT*NUMBER OF SIDES? *,N 280 REM MAKE J1=PREVIOUS J2 UNLESS TAKEN (H(J1)=1)
60 DIM B(N),C(N) 290 REM IF TAKEN INCREMENT J1 TILL I FOUND, LIFT PEN
70 INTEGER I,J,H(N) 300 FOR J=1 TO N1
80 INPUT*RADIUS OF PLOT? *,R 310 J1=J2
90 P1=6.2831853/N 320 IF H(J1)=0 THEN 360
100 FOR I=1 TO N 330 J1=J1+1 : IF J1>N THEN J1=J1-N
110 B(I)=R+10*R*COS((I-1)*P1) 340 F=1
120 C(I)=R+10*R*SIN((I-1)*P1) 350 GOTO 320
130 NEXT I 360 J2=J1+I
140 FOR I=1 TO INT(N/2) 370 IF J2>N THEN J2=J2-N
150 REM DRAW LINES TO I'TH NEIGHBOR 380 H(J1)=1
160 FOR J=1 TO N 390 REM F=1 IS A FLAG TO LIFT THE PEN
170 H(J)=0 400 REM IF F=1 THEN MOVE TO B(J1),C(J1) WITH PEN LIFTED
180 NEXT J 410 REM CALL VECTOR ROUTINE HERE.
190 IF I<>N/2 THEN 240 420 F=0
200 REM DRAW ONLY 1/2 LINES IF DIAMETERS 430 REM DRAW TO B(J2),C(J2) HERE. INSERT VECTOR ROUTINE HERE.
210 FOR J=N/2+1 TO N 440 NEXT J
220 H(J)=1 450 NEXT I
230 NEXT J 460 STOP

```

**Listing 1:** Program Chord produces a series of chords for a given circle. The sample output is shown in figure 2 (page 144). This listing was made by the author's system using a plotter.

little backlash can be seen at the vertices of the 29-sided polygon. The listing was plotted on this system with characters four times the minimum size. This routine was written to remove some of the unnecessary plotter X,Y motion from that of just cycling through all the vertices for both the starting and ending points. Plotter routines should be inserted at lines 390 and 430 to suit a particular system. At 390, move to B(J1), C(J1) with the pen lifted. At 430, draw a line to B(J2), C(J2) with the pen down.

I use the system in my work plotting graphs and other

forms of data, and I hope to eventually sell some of the computer graphics I have produced. It is stimulating and fun to create various plot outputs on the spot, now that the hardware has been debugged and is running. The plotter output is not limited to ink drawings on paper. A needle or other engraving point may be mounted in the pen holder (a small clamp) for drawing etching lines in a zinc plate through a thin layer of an acid resisting substance. The plots can then be etched by dumping the plate in an acid bath for an appropriate time period.

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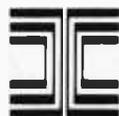
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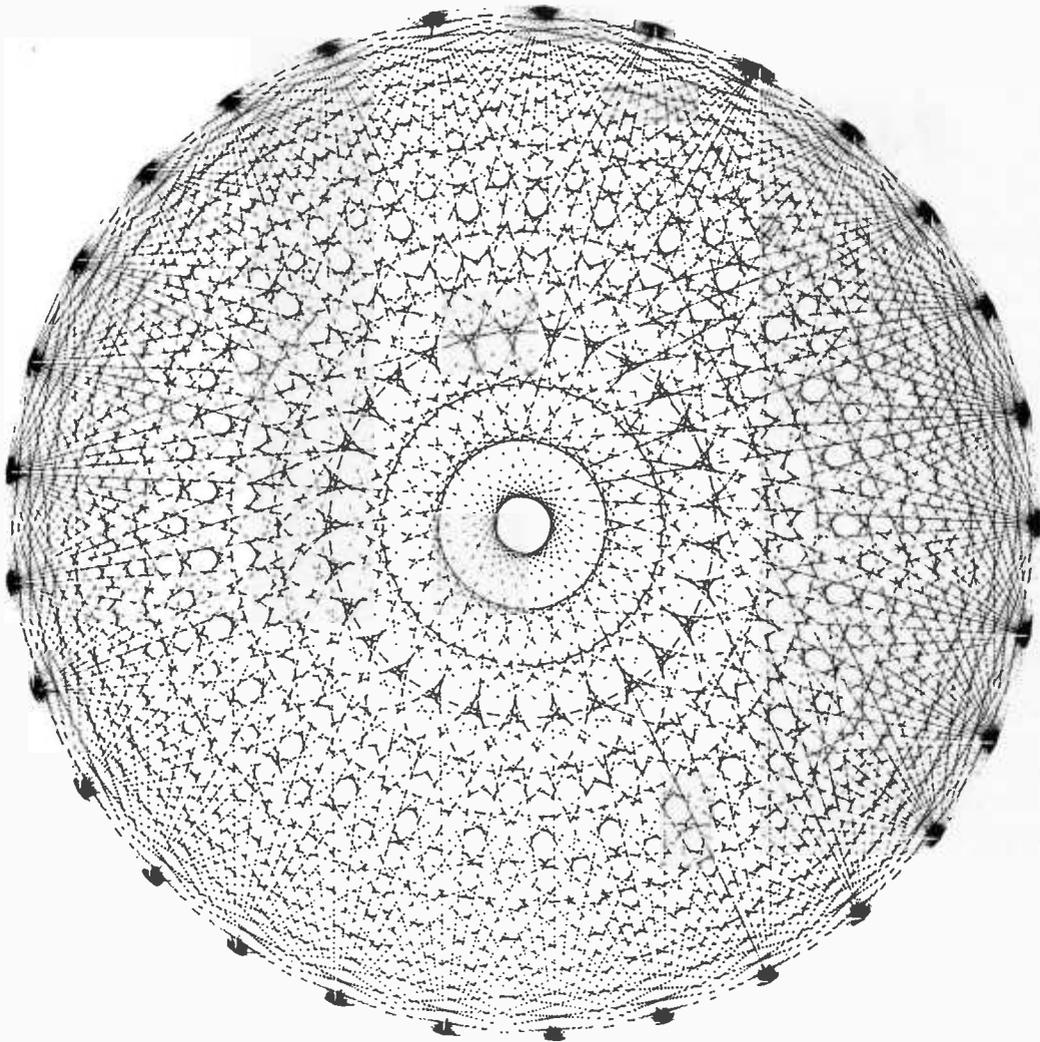


Figure 2: Sample output of the Chord program written in BASIC. This figure took 90 minutes to produce. ■

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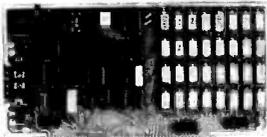
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# Technical Forum

## Introduction to Code Tightening

Geoffrey Gass, 5240 SW Dosch Rd, Portland OR 97201

"Why should a programmer be so obsessed with pinching and scraping to save a few bytes of code?" asks the representative from Behemoth Computers Inc. In his part of the universe, whether a program takes 110,000 bytes or 120,000 bytes is of no particular moment.

"What a damned tangle!" echoes one of his customers. "Haven't they ever heard of top down programming?" His part of the computer universe is concerned with programs written and understandable by interchangeable programmers, so any new job applicant capable of peeling his own bananas can pick up where the last programmer left off at the time of his unfortunate starvation.

In a smaller part of the universe occupied by minicomputer users and programmers, "tightening up the code" very early became a necessary practice to get useful programs into more confined memory spaces.

An even cozier corner, of course, is that of the personal computer programmer, who may have to spend many hours in tightening, trimming and squeezing to get a couple of quarts of program into his one-quart memory.

The tightest quarters of all (they might be described as "two-by-two by you") are those occupied by the microprocessor programmer fitting useful programs and modules into read-only memories (ROMs) for dedicated systems or monitors. Read-only memories come in relatively small, fixed sizes. The first estimate of what can be done in a given size read-only memory is always excessive of course, but in any typical project the absolute hardware limits are set very early, and it's up to the programmer to get as many as possible of the originally promised features into the fixed module size.

If by chance there are a couple of no-operation instructions (NOPs) in the final coding, then there is immediate pressure to do some tightening and squeezing to add another feature or two. If, as is more probably the case, the first coding runs long, then there is more intense pressure to squeeze, pare, tighten and rewrite every conceivable way to get the program genie into the bottle. (Even if the hardware decision is reversed and the read-only memory space doubled, program expectations will be increased until they again overflow the assigned space. This is a corollary of Parkinson's law; it is amply verified.)

The successful programmer in this environment is the one who gets the job done. It takes a substantial repertoire of techniques and a good eye for spotting loose coding and redundant logic to do a successful job of fitting the required functions into a fixed domain of memory. Though he may earn the scorn of the Behemoth man

("cheese-parer!") and the bitter enmity of the user who wants to reach in and borrow some of his subroutines, he wins in the marketplace when his product does more for less money, weight, power or space (or simply gets to the market sooner because of fewer hardware redesigns in the development cycle).

The object of this discussion is to present some of the tricks of the programmer's trade by which redundant logic and loose code can be tightened up to get maximum function into minimum memory space. But please heed the warning note at the end, lest you get yourself into a cleverness box from which there's no escape!

Redundant logic can be illustrated by the following sequence:

CMPA	#20	Compare ACCA to the value 20.
BMI	CODIN	Less than 20? Go to CODIN.
BEQ	DELIM	Equal to 20? Go to DELIM routine.
BGT	TEXTIN	Over 20? Treat as text input.

Obviously, the last instruction is redundant. If the accumulator is not less than or equal to 20, it must be more than 20, and the third test is unnecessary. Frequently, the redundancy is more subtle, being determined by external parameters which make certain conditions impossible, and therefore unnecessary to test for.

Loose coding may be illustrated by this nice, straightforward top down subroutine for a 6800 string print operation:

PDATA	LDAA	0,X	Get data byte per index register.
	CMPA	#04	Check for EOT (string terminator).
	BEQ	EXIT	If EOT, return to calling program.
	JSR	OUTEEE	Not EOT. Output this character.
	INX		Step index register to next location.
	BRA	PDATA	Go back for next byte.
EXIT	RTS		Return to calling program.

The routine uses 13 bytes. The sharp programmer notes immediately that it has two branches in it, one of them unconditional. An unconditional branch is always somewhat suspect in itself; in a short routine already containing a conditional branch, it's doubly suspect.

Here's how Wiles and Felix optimized the routine in Motorola's MIKBUG read-only memory. By moving the entry point to the middle of the routine, the unconditional branch can be thrown out and the loop closed by the conditional branch alone:

PDATA2	JSR	OUTEEE	Output the character.
	INX		Step to next location.
PDATA1	LDAA	0,X	Enter here. Get character per XR.
	CMPA	#04	Check for EOT.
	BNE	PDATA2	If not EOT, output the character.
	RTS		Was EOT. Return to calling program.

Now we are down to 11 bytes. To save even more, the system could be changed to use 00 (NUL) rather than 04 (EOT) as the string terminator symbol. Because the N and Z bits of the condition code register in the Motorola 6800 respond automatically to a LOAD operation (this is not true of the 8080 and some other processors; you have to know the fine print to do a good job of code tightening), the comparison can be thrown out:

PDATA2	JSR	OUTEEE	Output the character.
	INX		Step to next.
PDATA1	LDAA	0,X	Enter here. Get character per XR.

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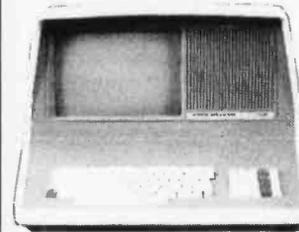
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BNE PDATA2 Not 00? Output it and get next.  
RTS Was 00. Return.

Now, the job is all done in nine bytes, a 30 percent saving in code. (This trick could not be used in MIKBUG, since some of the strings contained NULs.)

For the read-only memory programmer, that could mean the difference between fitting and not fitting the allocated hardware. For the home hacker who hand-assembles his code it could be the difference between rewriting these few bytes and rewriting several pages of code (and risking a blowup if an address or offset is overlooked). It's not hard to guess which approach is best!

**A Word of Warning**

Here's a word of warning though: if you learn a lot of tricks and start applying them all in your original coding, there will be nowhere to tighten up if you run over. Your coding will also be much harder to understand later when you want to do something slightly different with it.

It's a little pathetic to see a routine loaded with twists, kinks, and convoluted logic, followed by a string of NOPs, revealing that the programmer was just performing logical games for his or her own amusement, or else swiped the routine from someone else without understanding it!

So, the best programming practice is to go with relatively loose and straightforward top down programming in the initial approach to a problem, and to save the tricks until you really need them. ■

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A typical skip chain might look like this (coding is for the Motorola 6800, but the process is essentially the same for all machines):

CTRL1	CMPA	#\$18	Check for CANcel.
	BNE	CTRL2	Not CAN? Skip next.
	LDX	BUFAD	Was CAN. Get start point.
	STX	BUFLOC	Reset "current" location.
	BRA	BUFIN	Go get revised data.
CTRL2	CMPA	#\$0F	Check for CTRL/0 (backspace).
	BNE	CTRL3	Not CTRL/0? Skip the following.
	CPX	BUFAD	Was CTRL/0. Check current position in buffer.
	BEQ	BUFIN	At start? Can't backspace. Forget it.

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	DEX		OK for backspace. Step back 1.
	STX	BUFLOC	New "current position."
	BRA	BUFIN	Go get corrected input.
CTRL3	CMPA	#\$12	Check for CTRL/R (restart).
	BEQ	LININ	CTRL/R? Start all over.
	BRA	BUFIN	All others, back to BUFIN.

There is nothing seriously wrong with the routine as shown, but it uses up 29 bytes in making three comparisons, and all of the operations but one end up by branching to BUFIN. Two of the BRA BUFIN instructions are unnecessary. Since all of the tests are for equality, the quantity in A is obviously going to match at only one test. So why bother jumping out early to avoid the other tests?

Another redundancy in this particular instance is not quite so obvious unless you see the rest of the routine. Note that in the CTRL2 sequence, a backspace is performed by decrementing the index register and putting the index register value into BUFLOC. Evidently, the index register carries the "current position" and is equal to BUFLOC when first entering the routine. There are two STX BUFLOC instructions in the routine. Could they be consolidated? The answer is yes, if we do not mind stuffing the index register into BUFLOC for all incoming codes. Try this:

CTRL1	CMPA	#\$18	Check for CAN.
	BNE	CTRL2	Not CAN? Skip.
	LDX	BUFAD	Was CAN. Change XR content.
CTRL2	CMPA	#\$0F	Check for CTRL/0 (backspace).

	BNE	CTRL3	Not CTRL/0. Park XR and check for CTRL/R.
	CPX	BUFAD	Check position.
	BEQ	CTRL3	At start? No backspace. Drop on through.
	DEX		Step back 1.
CTRL3	STX	BUFLOC	New or old XR value.
	CMPA	#\$12	Final test, for CTRL/R.
	BEQ	LININ	If CAN or CTRL/0, will fall through.
	BRA	BUFIN	All except CTRL/R, back to BUFIN.

Now the routine is down to 23 bytes: possibly a significant saving in a program being squeezed for memory space.

Note that what we are doing here is to trade redundant code for redundant operations, a frequently encountered tradeoff. To save a few bytes of code we have stretched execution time significantly. For keyboard interactive routines (as in the example), the execution time is unimportant. In a much used mathematics subroutine on the other hand (eg: multiple precision add or multiply), execution time will be much more important, since the subroutine may be called thousands of times in one calculation, and an optimum tradeoff would be more likely in the direction of code redundancy to gain speed of execution (counting machine cycles, not bytes of memory).

The next time you are squeezed for space, and speed is not critical, take a look at your skip chains: they may be able to furnish all the bytes you need, with a little refining. ■

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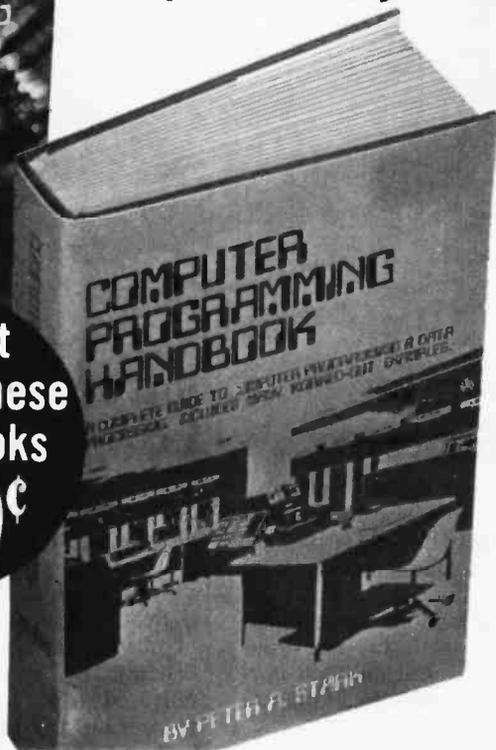
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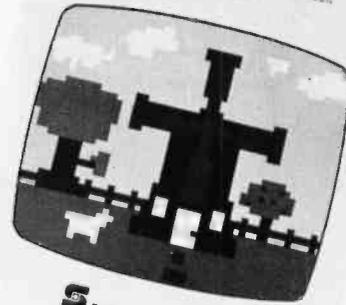
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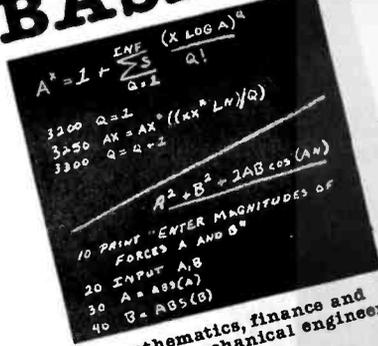
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# Event Queue

FEBRUARY 1980

February 6

**Invitational Computer Conference, Ft Lauderdale FL.** This conference is directed to the quantity buyer and will feature the newest developments in computer and peripheral technology. Contact B J Johnson and Associates, 2503 Eastbluff Dr, Suite 203, Newport Beach CA 92660.

February 12-14

**Data Communications Conference and Exhibition, Harbour Castle Hilton, Toronto Ontario, Canada.**

Panel sessions, presentations, workshops, and technical sessions related to the field of data communications will be featured. Network control, management,

performance and architecture; communications hardware and software; fiber optics; distributed data processing; and international communications policies are some of the subject areas that will be discussed.

The exhibition at the convention center will feature over 100 exhibitors.

For more information, contact Whitsted Publishing Ltd, Suite 2504, 2 Bloor St W, Toronto, Ontario M4W 3E2 CANADA.

February 11-13

**Programming the 6502 in Machine and Assembly Language, George**

Washington University, Washington DC. This course is aimed at engineers, scientists, mathematicians and students who need to learn

how to develop special-purpose microcomputer systems for their own use. Familiarity with FORTRAN or BASIC will be helpful. For more information, contact Director of Continuing Engineering Education, George Washington University, Washington DC 20052, (202) 676-6106.

February 11-13

**Configuration Management, George Washington University Washington DC.** The objectives of this course are to review the impact of latest Department of Defense directives and instructions in the configuration management (CM) area; explain policy for practical applications; and clarify the role of CM in meeting program/project objectives. Engineers, program managers, production, quality control, and purchasing people are invited to attend. Familiarity with the contents of MIL-STD-480 is a prerequisite. Contact the Director, Continuing Engineering Education, George Washington University, Washington DC 20052, (202) 676-6106.

February 13-15

**The IEEE International Solid State Circuits Conference, San Francisco CA.** This conference is a forum for the presentation of advancements in every aspect of solid state circuits. It will cover design, performance, fabrication, testing, and applications in digital, analog, microwave, and other areas of new solid state circuits,

device structures, phenomena and systems. For more information, contact Lewis Winner, 301 Almeria Ave, POB 343788, Coral Gables FL 33134.

February 18-21

**European Information Management Exhibition and Conference, Wembley Conference Centre, London England.** This show will exhibit microcomputer systems and peripheral items with demonstrations and applications focused on problem solving for the management executive. Contact Expoconsul, 420 Lexington Ave, New York NY 10017.

February 22-23

**Louisiana Computer Exposition, University of Southwestern Louisiana, Lafayette LA.** This conference is entitled "Distributed Systems Based on Mini and Micro Computers." It will cover programming languages, operating systems, evaluation of distributed systems, design criteria for distributed systems, and other related topics. There will be exhibitions of equipment and papers will be read and discussed. For more information, contact the Computer Science Dept, University of Southwestern Louisiana, POB 44330, Lafayette LA 70504.

February 25-27

**Communication Networks '80, Shoreham Americana Hotel, Washington DC.** This conference and exposition

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will cover business communications. For program information, contact the Director of Program Development, The Conference Company, 60 Austin St, Newton MA 02160. For exhibit information, contact the national sales manager, Communications Networks '80, POB 96, Haddon Heights NJ 08035.

February 25-27

**3rd International Learning Technology Congress and Exposition, Sheraton**

Washington Hotel, Washington DC. Applications and technologies for the use of microcomputers and video disks as well as traditional technological issues in education and training will be discussed. In addition to the technical sessions, exhibits will range from video disk and media-based systems to computer-based instruction systems. Contact the Society for Applied Learning Technology, 50 Culpeper St, Warrenton VA 22186, (703) 347-0055.

February 25-27

**Microprocessor Peripherals Workshop, Montgomery AL.** This hands-on workshop includes 27 hours of instruction, with a take-home option and one microcomputer station for every two participants. Contact Paul A Willis, POB 29, Arlington VA 22210.

February 25-28

**Compcon '80, Jack Tar Hotel, San Francisco CA.** The conference theme is "VLSI: New Architectural

Horizons." It will be devoted to developing advanced technologies for computers. Contact Compcon Spring '80, POB 639, Silver Spring MD 20901.

February 26-28

**Nepcon West '80, Anaheim Convention Center, Anaheim CA.** The conference and exhibit will deal with the latest advances in electronics by covering such topics as wave soldering, etching, automated assembly, die attaching, hybrid circuit packaging, photo lithography, precious metal recovery, laser annealing, and much more. For further information, contact ISCM Inc, 222 W Adams St, Chicago IL 60606.

February 26-29

**Office/Korea/80, Korea Exhibition Center, Seoul Korea.** Exhibits at this exposition will include the range of products needed in offices from computers, word processing equipment and software to stationery, supplies, furniture and services. Information about the show may be obtained from Expoconsul, a division of Clapp and Poliak, 420 Lexington Ave, New York NY 10017.

February - August

**Microprocessor Design Courses.** The course is aimed at professional design engineers and covers fundamentals of microprocessor operations, programming, architecture and input/output integration. It will also cover Z80 and 8085 processors, working with the STD BUS and the designing and documenting of software. Tuition for the course is \$400. The courses will be held in major cities throughout the US. Contact Elma Barnes, PRO-LOG, 2411 Garden Rd, Monterey CA 93940, or phone (408) 328-4745.



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Albion College, Albion MI. This fair will feature exhibits and seminars on microcomputers and their applications in business, education, and the home. Contact D W Kammer, Dept of Physics, Albion College, Albion MI 49224.

March 3-5

Office Automation Conference, Georgia World Congress Center, Atlanta GA. A combination conference and exhibition of office computer systems has

been developed to help management understand the growing technology of business computer systems. For more information, contact H A Bruno and Associates Inc, 78 E 56th St, New York NY 10022.

March 4 and 5

8th Annual Midwest Digital Equipment Exhibit and Seminar, Thunderbird Motel Minneapolis MN. Manufacturers of computer terminals, data communication equipment, peripherals, data

acquisition systems and digital test instruments will display their products. Seminars will be held both days. For further information, contact John Bastys Countryman Associates Co, 1821 University Ave, St Paul MN 55104.

March 6-8

Microprocessor Peripherals Workshop, Chattanooga TN. See February 25-27 for details.

March 10-12

1980 National Office Exhibi-

tion and Conference, Automotive Building, Exhibition Pl, Toronto Canada. Subject areas of the conference will include energy conservation, small business computers, micrographics, word processing, telecommunications, copiers, office landscaping, and many others. There will be approximately 100 exhibitors presenting their products and giving demonstrations.

For more information, contact Whitsed Publishing Ltd, Suite 2504, 2 Bloor St W, Toronto, Ontario M4W 3E2 CANADA.

March 14-16

West Coast Computer Faire, Civic Auditorium and Brooks Hall, San Francisco CA. An expected 15,000 attendees, over 340 exhibits, and more than 100 conference speakers will highlight this year's program. Exhibitor and speaker information may be requested from the Computer Faire, 333 Swett Rd, Woodside CA 94062.

March 17-20

Interface '80, Miami Beach Convention Center, Miami Beach FL. This conference and exposition is devoted to data communications, distributed data processing, and networking. Approximately 1000 exhibitors are anticipated and attendance is expected to exceed 12,000. For information, contact Interface '80, 160 Speen St, Framingham MA 01701.

March 17-21

Applied Time Series Analysis, University of California at Los Angeles CA. This course is designed for engineers, scientists, programmers, economists and other users of digital time series who require modern methods of data analysis using the fast Fourier transform (FFT), digital filtering, power spectral densities and correlation functions. The lectures cover topics relating to the Fourier transform, sampling linear systems, convolution, covariance, digital filtering,

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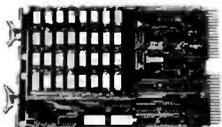
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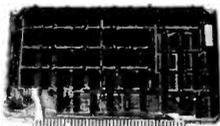
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*March 20*

**Electronic Road Shows,** Castaways Restaurant, Burbank CA. This traveling exhibition of components, materials, and instruments is being produced by the Electronic Representatives Association (ERA). Over eighty ERA member firms will participate, and products from over 700 electronic companies will be displayed. For more information, contact the Southern California ERA office 20969 Ventura Blvd, Suite 9, Woodland Hills CA 91364.

*March 24-26*

**Data Entry Management and Supervision Seminar,** Cherry Hill NJ. This course deals with the practical aspects of data entry, and the problems encountered that are common to supervisors and managers. Concepts, techniques, motivation, training, and productivity will be covered. The fee is \$415 for subscribers of MIC publications and \$445 for non-subscribers. For more information, contact MIC, 140 Barclay Ctr, Cherry Hill NJ 08034.

*March 24-28*

**Fourth European Conference on Electrotechnics,** Stuttgart. This conference will review recent developments, trends, and applications in the field of microelectronics. Microprocessors, computer communication, industrial electronics applications of microelectronics in the automobile and in medicine, and other topics will be covered. The conference language will be English. Contact Professor Dr W E Proebster, IBM Deutschland

GmbH, Postfach 80 08 80, D-7000 Stuttgart 80 GERMANY (BRD).

*March 26-28*

**Viewdata '80,** Wembley Conference Centre, London England. Viewdata 80 is an international exhibition and conference on video-based systems and microcomputer industries. The British Post Office is presenting the Prestel Show which is about electronic mail services.

Contact TMAC, 680 Beach St, Suite 428, San Francisco CA 94109.

*March 30*

**Greater Baltimore Hamboree and Computerfest,** Maryland State Fairgrounds, Timonium MD. Personal, dealer, and small business computer displays and exhibits will be featured. Space is available outside for tailgate sales and swaps. For more information, contact Joseph Lochte Jr, 2136 Pine Valley Dr, Timonium MD 21093.

*March - June*

**Computer and Office Systems Expo and Conference.** This is an exposition for marketers of office systems equipment. The show and conference will focus on the local problems and opportunities of each region. The exposition and conference will be held in major cities around the nation. Contact The Conference Co, 60 Austin St, Newton MA 02160, or phone (617) 964-4550.

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## APRIL 1980

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*April 1 and 2*

**Southeast Printed Circuits and Microelectronics Exposition,** Sheraton-Twin Towers Convention Center, Orlando FL. This show is a specialized event devoted entirely to the packaging, production and testing of printed circuits, multilayers, semiconductor devices, and hybrids

in the Southeast. Conferences are aimed at electronics specialists. Contact ISCM, 222 W Adams St, Chicago IL 60606.

*April 9-11*

**The Practical APL Conference,** Washington DC. This conference is addressed to business executives and systems designers. For more information, contact Joan Gurgold, STSC, 7 Holland Ave, White Plains NY 10603.

*April 9-11*

**International Conference on Acoustics, Speech and Signal Processing,** Fairmont Hotel, Denver CO.

The IEEE Acoustics, Speech and Signal Processing Society is sponsoring this conference devoted to experimental and theoretical aspects of signal processing, speech, and acoustics. For more information, contact IEEE, 1100 14th St, Denver CO 80202.

*April 11-12*

**10th Annual Virginia Computer Users Conference.** This conference is sponsored by the Virginia Tech ACM student chapter. The topics of discussion will be programming languages and system and personnel management. For more information, contact VCUC10, 562 McBryde Hall, VPI&SU, Blacksburg VA 24061.

*April 13-16*

**A Gateway to the Use of Computers in Education,** Chase Park Plaza Hotel, St Louis MO. The purpose of this convention is to provide a forum for the exchange of information and ideas between individuals, to inform educators of developments in computer technology, and to expose participants to innovations in computing which can be utilized in the field of education.

Educators are encouraged to exhibit and make presentations of instructional microprocessor materials

during the convention. Contact the Association for Educational Data Systems (AEDS), POB 951, Rolla MO 65401.

*April 14-18*

**High-Speed Computer Organization,** 6266 Boelter Hall, UCLA Extension, Los Angeles CA. This course is for computer designers, system architects, project leaders and managers. The course provides an understanding of the principles of high-speed computer organization and their use in cost-effective systems. Several commercial and paper high-speed computers are presented and compared.

For more information, contact UCLA Extension at POB 24901, Dept K, UCLA Extension, Los Angeles CA 90024.

*April 21-25*

**National Micrographics Association 29th Annual Conference and Exposition,** Sheraton Center Hotel and Coliseum, New York NY. The theme for the show is "Focus on Productivity in Office Management." Highlighting the conference and exposition will be presentations and talks concerning the use in offices for computer systems and related items.

For more information, contact the Conference Dept, National Micrographics Association, 8719 Colesville Rd, Silver Spring MD 20910.

*April 23-25*

**International DP Training Conference,** Hyatt Regency, Chicago IL. The theme for this event will be "The 1980s: The Information Decade." The conference is a symposium for data processing experts and corporate training executives. For information, contact Deltak Inc, 1220 Kensington Rd, Oak Brook IL 60521. ■

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**Microsoft Level III BASIC.** Upgrade your Level II TRS-80 and increase your programming efficiency without additional hardware. Microsoft Level III loads from cassette tape on top of the Level II ROM. It gives you every feature of Disk BASIC except disk file commands. But that's not all—Level III's high-speed graphics turn your TRS-80\* into a virtual electronic drawing board. And there's program renumbering, long error messages, quick shift-key entries, time-limit INPUT statements and many more features. System requirements: Level II BASIC and 16K. Occupies 5.2K RAM. Priced at \$49.95.

**Where To Buy.** Microsoft Consumer Products are sold by computer retailers nationwide. If your local computer store doesn't have them, call us. Phone (206) 454-1315. Or write Microsoft Consumer Products, 10800 Northeast Eighth, Suite 819, Bellevue, WA 98004.

\*TRS-80 is a trademark of Radio Shack Corp. \*\*Apple II is a trademark of Apple Computer, Inc.™ Editor/Assembler-Plus and Z-Bug are trademarks of Microsoft. TRM is a trademark of The Image Producers, Inc.



Ken Bowles'  
Current Activities:  
Training in Pascal...  
*notes by C Helmers*

In the last year or so, we have been placing much emphasis on the computer language Pascal, with particular attention to the University of California at San Diego (UCSD) system which, by being available, has become a de facto standard for small-computer, Pascal-oriented systems software. Dr Kenneth Bowles of UCSD was the originator of the project which generated the UCSD system, and he is its prime mover.

As a professor of Computer Science and Electrical Engineering at UCSD, Dr Bowles has been instrumental in the implementation of Pascal on small computers, starting with the LSI-11-based Terak machine, and now including all the major 8-bit microprocessor designs. Since its inception in 1974, UCSD Pascal has been licensed to more than 1000 individuals and organizations. With the recent availability on the Apple II, North Star Horizon, and other major personal computer systems, the UCSD software has become a major, machine-independent, industry-wide standard for an operating system and compiler. Due to the nonprofit status of the University of California, the system has been recently spun off to an independent software company, Softech Micro Systems of San Diego, California.

Dr Bowles' purposes in developing the UCSD Pascal system included the desire to make widely available a convenient and machine-independent structured programming language and operating system. The non-



Photo 1: The hands-on aspect of Ken's Integrated Computer Systems continuing education course on Pascal is provided by use of a number of portable computers such as the Apple II Pascal system. Ken is shown here demonstrating a point to some students.

commercial intellectual success of the Bell Laboratories UNIX operating system, with its language C, was doubtlessly an inspiration for the UCSD concept of a machine-independent operating system and language. As a teaching device in schools and universities, the intellectual popularity of the Pascal language was part of the reason for choosing it as a suitable vehicle for widespread teaching of programming concepts and convenient application programming. Also key to the choice of Pascal as a language to

pursue was the fact that its originators, Niklaus Wirth and Kathleen Jensen, had designed a concise but robust high-level language which was first (and most typically) implemented through the highly machine-independent technique of simulating a virtual "P-machine" on conventional machines. The rest is history. An operating system with many interactive features, editors and file management programs was written in Pascal along with the compiler; the code was made available and when the response got too large

for the university's "non-profit" political environment, the system's marketing and maintenance operations were assigned to a commercial company.

Ken is now participating in the continuing education programs of a company called Integrated Computer Systems Inc. This company specializes in intensive training courses given in major cities, as a sort of traveling road show intended for potential users of high-technology tools such as the Pascal language. Ken's course is designed for engineers, scientists and programmer/analysts who plan to use Pascal for the development of software systems. The class features exercises involving text processing, interactive data collection, dynamic graphic display and real-time control applications. Class sizes are strictly limited to (typically) 36 students in order to provide maximum hands-on activity.

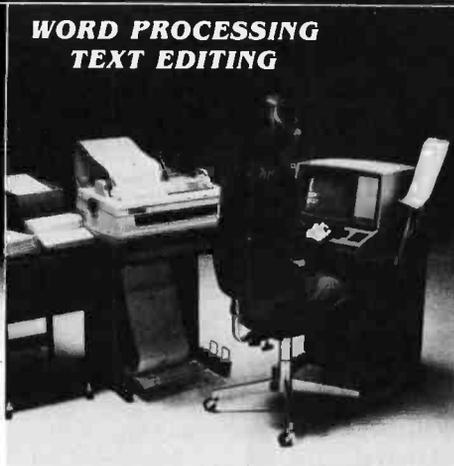
The course is operated for four days (Tuesday thru Friday). Each attendee receives a diploma and one Continuing Education Unit for each 10 hours of participation. The Continuing Education Unit is a nationally recognized credit awarded by universities and educational organizations for participation in such programs. (Scheduled time each day of the four-day schedule is from 9 AM to 6 PM, so in principle one could obtain 3.6 such units from the course given attendance of the full four-day schedule.) The price is \$795 including all materials, luncheons and coffee breaks. The following dates are presently scheduled:

San Francisco CA:  
February 12-15, 1980

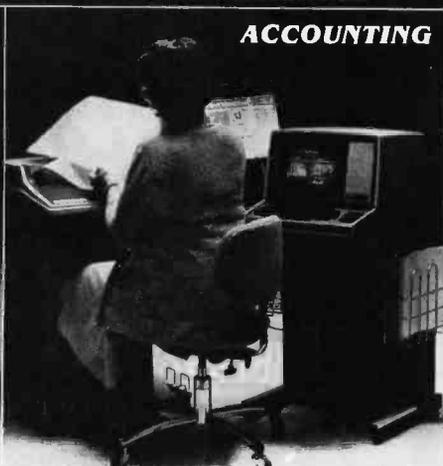
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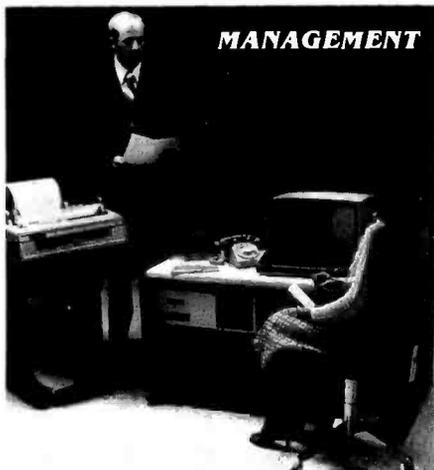
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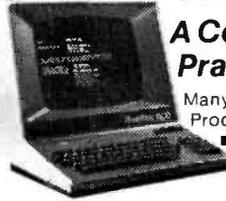
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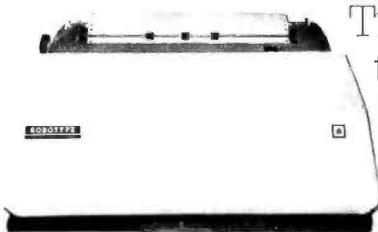
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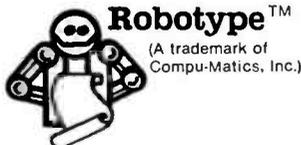
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 May 6-9, 1980

For further information and enrollment forms, contact Integrated Computer Systems Inc, 3304 Pico Blvd, Santa Monica CA 90405, or phone (213) 450-2060.

### Call for Papers—1980 LISP Conference

A call for papers has been announced for the August 24 thru August 27 LISP Conference at Stanford University. The topics should cover languages and theory, programming aspects, architecture, and applications of LISP. Other related items are welcome. Authors are requested to send four copies of a full draft paper not exceeding 4500 words, and a one-page abstract, by March 14, 1980 to the Conference Head. The abstract should provide sufficient detail to allow the committee to apply uniform criteria for acceptance. Authors will be notified of acceptance or rejection by May 16, 1980. For inclusion in the proceedings, final papers are due by June 27, 1980. Send papers to John R Allen, Stanford Artificial Intelligence Lab, Stanford University, Stanford CA 94305, or phone (415) 497-4971 for further details.

### Bulletin Board Notes

A computerized bulletin board system (CBBS) is now in operation in Cambridge Massachusetts, thanks to the diligent labors of David Mitton and other members of

the New England Computer Society. Running the CBBS code written by Ward Christensen and Randy Suess on a Processor Technology Sol-20, the system is available around the clock. Two data rates are supported, 110 and 300 bits per second (bps). The telephone number to access the system is (617) 864-3819.

A description of a CBBS appeared in the article "Hobbyist Computerized Bulletin Board," by Christensen and Suess, in the November 1978 BYTE, page 150.

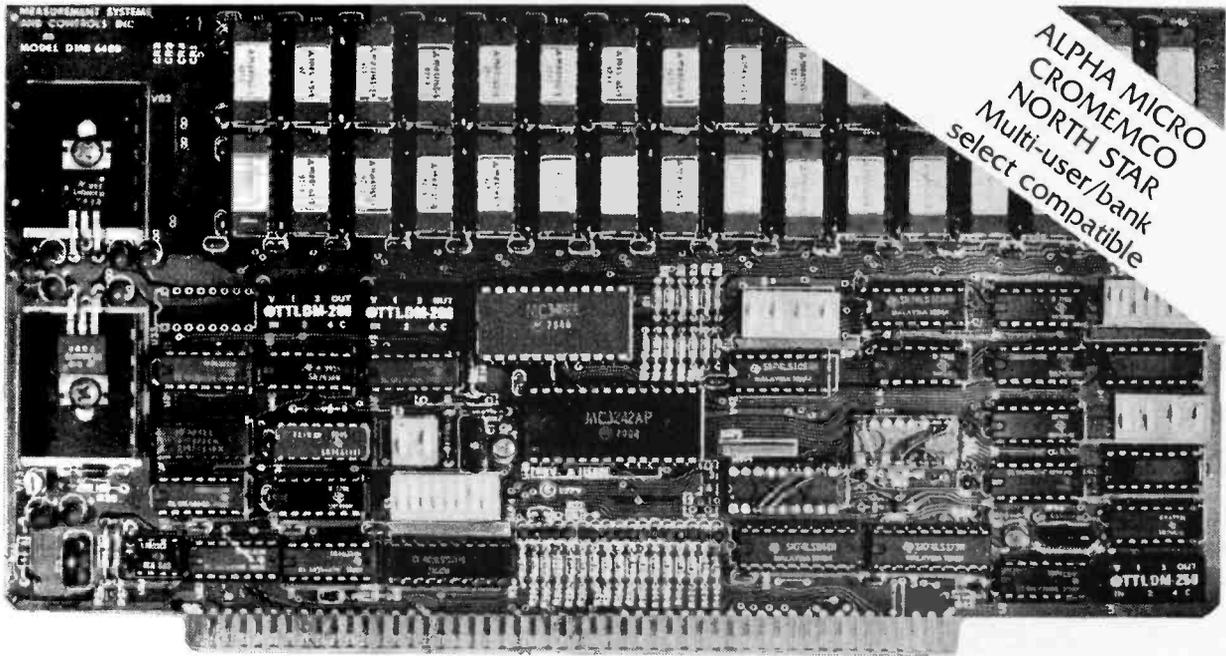
### Call a Computer for Computers

If you want to purchase computer equipment, software, terminals, supplies, or any other related equipment, call (813) 885-4811 and talk to a computer. There is no charge but calls are limited to 3 minutes; however, if necessary, you can call again. There should be a listing of the items needed. To access the system: set your terminal for 300 bps operation, set the modem for full duplex originate operation, call (813) 885-4811, after the terminal is on-line enter any character and a carriage return. The system will respond "PLEASE LOG IN", then enter the string "HELLO-Z999," (only the characters underlined), then follow the directions on the terminal to search the file.

To place a listing with the service, contact Basic Online Software Systems Corp, POB 22412, Tampa FL 33622.

### Cafeteria Chain Pioneers Computerized Cost Control of Recipes

A chain of cafeterias serving the Los Angeles public has developed a restaurant menu-planning system to minimize the effects of rapid inflation and skittish agricultural commodity prices.



**Model DMB-6400 Series dynamic 64k byte RAMS incorporate the features which are standard in the DM-6400 Series and adds bank select for multi-user-timesharing applications.**

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The CS/40 system has reduced the menu recost time from 9 months to 6 hours and could save the cafeteria chain about \$50,000 annually. In addition to the food purchasing and recipe maintenance, the system can handle the

payroll for 600 employees and do accounts payable, a general ledger and a cash journal. The system includes a printer, four video terminals, a magnetic tape drive and a potential 250 K bytes of memory storage on the disk drives.

The CS/40 business system has reduced errors, provided current information, and has allowed for more interesting and more varied menus.

Contact the P R Dept, Data General Corp, Rt 9,

Westboro MA 01581, for more information.

### Chicago Library Offers Public Computers and a Computerized Reference Service

To permit the public to experience computer-assisted instruction (CAI), to perform basic computer routines and to gain experience in programming, microcomputers have been installed in the Business/-

Science/Technology Division of the Central Library, the Popular Library in the Cultural Center, the Woodson Regional Library, and the Lincoln Park Branch, all agencies of the Chicago Public Library.

The system includes video displays, software, training manuals, but no printers. It runs on BASIC, and has 8 K bytes of programmable memory. Engineers, businessmen, students developing chess skills, and people balancing their checkbooks have been using the devices. If usage increases substantially, the Library will consider the purchase of additional units for other branches in the library system.

Their other service provides millions of references to books, periodicals, reports, all on a wide range of subjects. Where manual research can take hours or even days, the computerized service can reduce to only a few minutes the time usually required for a thorough research study. For this service, the first 5 minutes of computer time are free and each additional minute costs \$1.50. Contact the Business/Science/Tech- nology Division in the Central Library at 425 N Michigan Ave, Chicago IL 60611, or call (312) 269-2915.

### Apple Education Foundation Advances Learning Methods Through Microcomputers

Initially funded by Apple Computer, the nonprofit foundation will offer support and resources to organizations and individuals who are pioneering learning methods through the use of microcomputers. Funding authorizations through 1980 are valued in excess of \$250,000. The foundation will distribute hardware equipment for both developmental and demonstration projects involved in producing instructional computing materials. The foundation's primary

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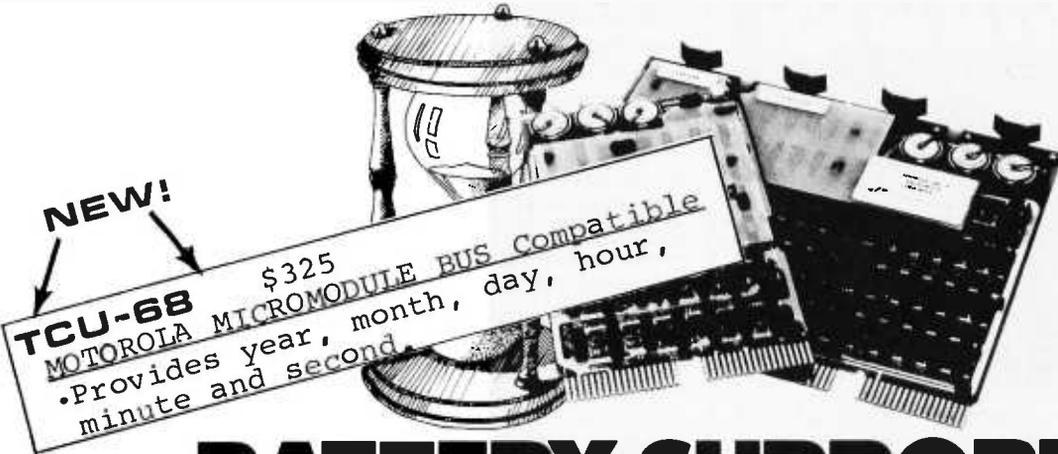
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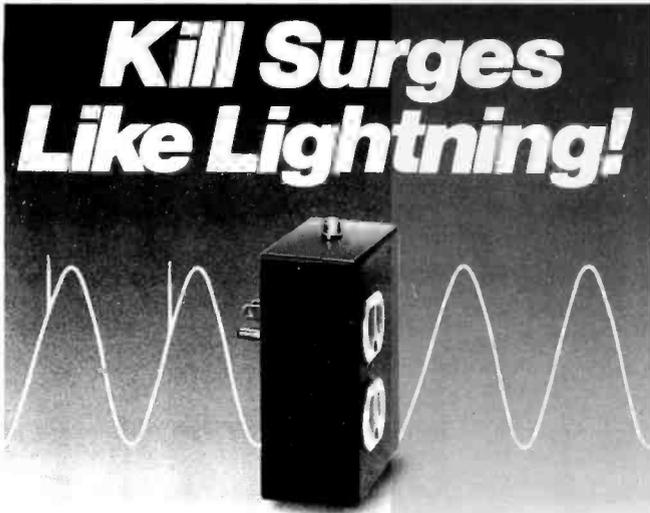
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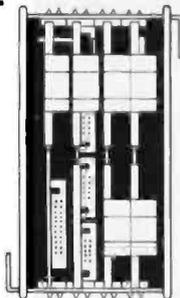
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goal is to place hardware into the hands of people who will further those educational methods that best take advantage of the personal microcomputer's capabilities.

As continuing evidence of its commitment to education, the foundation will sponsor the Education Program Information Center (EPIC). EPIC will support microcomputer users in developing new instructional programs and in obtaining available information on educational materials. Authors are encouraged to submit their work to the center for review and feedback on the most effective uses and placements of their materials.

Both the Apple Education Foundation and EPIC may be contacted through the Apple Education Foundation, 20605 Lazaneo Dr, Cupertino CA 95014.

### AIDs for Apple Dealers

AIDs (Apple Independent Dealers) was formed by and for independent Apple dealers, ie: those dealers with no direct contractual agreement or connection with any national chain or franchise. AIDs will provide a framework for improved communication, education, and support to its members, which will also be of benefit to consumers. This will include sharing of information on new software and hardware evaluations, successful marketing and problem solving, advertising ideas and more.

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### Report Studies Threat to Auto Electronics from Electric Fields

With the increased use of electronic control systems in automobiles, there is con-

cern about possible malfunction or deterioration of function due to ambient electrical fields created by radio and television transmitters, high-powered radar, power transmission lines, or lightning strokes.

Researchers at the National Telecommunications and Information Administration (NTIA) have surveyed sources emanating energy across the radio-frequency portion of the electromagnetic spectrum. Their report indicates that vehicles might sometimes — although rarely — be exposed to radio-frequency fields of 5 kV per meter which may cause the vehicle to become inoperative or may even damage its electronics.

The report is available from the National Technical Information Service, 5285 Port Royal Rd, Springfield VA 22161 for \$4.50. The accession number is PB 294-819/AS. For further information, contact NTIA Office of Congressional and Public Affairs (202) 377-1832. ■

## BYTE's Bugs

### Correct Reversi Termination

I would like to point out a programming error in "Reversi," which was published in the November 1979 BYTE, on page 76. The problem with the program is that it recognizes the end-of-game criterion too early, allowing the occurrence of a player not having a move only twice throughout the length of the game. This is due to the fact that counter-variable T3 is never re-initialized when a player is able to move. I recommend insertion of the following code: 296 LET T3=0.

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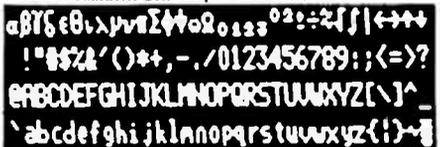
The Computer Terminal requires no I/O mapping and includes 1k of memory, character generator, 2 key rollover, processor controlled cursor control, parallel ASCII/BAUDOT to serial conversion and serial to video processing—fully crystal controlled for superb accuracy. PC boards are the highest quality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

## VIDEO DISPLAY SPECIFICATIONS

The heart of the Netronics Computer Terminal is the microprocessor-controlled Netronics Video Display Board (VID) which allows the terminal to utilize either a parallel ASCII or BAUDOT signal source. The VID converts the parallel data to serial data which is then formatted to either RS232-C or 20 ma. current loop output, which can be connected to the serial I/O on your computer or other interface, i.e., Modem.

When connected to a computer, the computer must echo the character received. This data is received by the VID which processes the information, converting to data to video suitable to be displayed on a TV set (using an RF modulator) or on a video monitor. The VID generates the cursor, horizontal and vertical sync pulses and performs the housekeeping relative to which character and where it is to be displayed on the screen.

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



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

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Netronics R&D Ltd., Dept. PE-9  
333 Litchfield Road, New Milford, CT 06776

Please send the items checked below—

- Netronics Stand Alone ASCII Keyboard/Computer Terminal Kit, \$149.95 plus \$3.00 postage & handling.
- Deluxe Steel Cabinet for Netronics Keyboard/Terminal In Blue/Black Finish, \$19.95 plus \$2.50 postage and handling.
- Video Display Board Kit alone (less keyboard), \$89.95 plus \$3 postage & handling.
- 12" Video Monitor (10 MHz bandwidth) fully assembled and tested, \$139.95 plus \$5 postage and handling.
- RF Modulator Kit (to use your TV set for a monitor), \$8.95 postpaid.
- 5 amp Power Supply Kit In Deluxe Steel Cabinet ( $\pm 8VDC$  @ 5 amps, plus 6-8 VAC), \$39.95 plus \$2 postage & handling.

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## Level "A" Specifications

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

Level "A" makes a perfect OEM controller for industrial applications and is available in a special Hex Version which can be programmed using the Netronics Hex Keypad/Display.)

PC Board: glass epoxy, plated through holes with solder mask • I/O: provisions for 25-pin (DB25) connector for terminal serial I/O, which can also support a paper tape reader

Level "A" at \$129.95 is a complete operating system, perfect for beginners, hobbyists, or industrial controller use... cassette tape recorder output... cassette tape control output... speaker output... LED output indicator on SOD (serial output) line... printer interface (less drivers)... total of four 8-bit plus one 6-bit I/O ports • Crystal Frequency: 6.144 MHz • Control Switches: reset and user (RST 7.5) interrupt... additional provisions for RST 5.5, 6.5 and TRAP interrupts onboard • Counter/Timer: programmable, 14-bit binary • System RAM: 256 bytes located at F800, ideal for smaller systems and for use as an isolated stack area in expanded systems... RAM expandable to 64k via S-100 bus or 4K on motherboard.

System Monitor (Terminal Version): 2k bytes of deluxe system monitor ROM located at F000 leaving 0000 free for user RAM/ROM. Features include tape load with labeling... tape dump with labeling... examine/change contents of memory... insert data... warm start... examine and change all registers... single step with register display at each break point, a debugging/training feature... go to execution address... move blocks of memory from one location to another... fill blocks of memory with a constant... display blocks of memory... automatic baud rate selection... variable display line length control (1-255 characters/line)... channeled I/O monitor routine with 8-bit parallel output for high speed printer... serial console in and console out channel so that monitor can communicate with I/O ports.

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

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

Netronics R&D Ltd., Dept. RE 10  
333 Litchfield Road, New Milford, CT 06776

Please send the items checked below—

- Explorer/85 Level "A" Kit (ASCII Version), \$129.95 plus \$3 p&h.
- Explorer/85 Level "A" Kit (Hex Version), \$129.95 plus \$3 p&h.
- 8k Microsoft BASIC on cassette tape, \$64.95 postpaid.
- 8k Microsoft BASIC in ROM Kit (requires Levels "B," "D," and "E"), \$99.95 plus \$2 p&h.
- Level "B" (S-100) Kit, \$49.95 plus \$2 p&h.
- Level "C" (S-100 6-card expander) Kit, \$39.95 plus \$2 p&h.
- Level "D" (4k RAM) Kit, \$69.95 plus \$2 p&h.
- Level "E" (EPROM/ROM) Kit, \$5.95 plus 50¢ p&h.
- Deluxe Steel Cabinet for Explorer/85, \$49.95 plus \$3 p&h.
- ASCII Keyboard/Computer Terminal Kit (features a full 128 character set, upper & lower case, full cursor control, 75 ohm video output convertible to baudot output, selectable baud rate, RS232-C or 20 ma. I/O, 32 or 64 character by 16 line formats, and can be used with either a CRT monitor or a TV set (if you have an RF modulator), \$149.95 plus \$2.50 p&h.
- Hex Keypad/Display Kit, \$69.95 plus \$2 p&h.
- Deluxe Steel Cabinet for ASCII Keyboard/Terminal, \$19.95 plus \$2.50 p&h.
- Power Supply Kit ( $\pm 8V$  @ 5 amps) in deluxe steel cabinet, \$39.95 plus \$2 p&h.
- Gold Plated S-100 Bus Connectors, \$4.85 each, postpaid.
- RF Modulator Kit (allows you to use your TV set as a monitor), \$8.95 postpaid.
- 16k RAM Kit (S-100 Board expands to 64k), \$199.95 plus \$2 p&h.
- 32k RAM Kit, \$329.95 plus \$2 p&h.
- 48k RAM Kit, \$459.95 plus \$2 p&h.
- 64k RAM Kit, \$589.95 plus \$2 p&h.
- 16k RAM Expansion Kit (to expand any of the above up to 64k), \$139.95 plus \$2 p&h each.
- Intel 8085 cpu User's Manual, \$7.50 postpaid.
- Special Computer Grade Cassette Tapes, \$1.90 each or 3 for \$5, postpaid.
- 12" Video Monitor (10 MHz bandwidth), \$139.95 plus \$5 p&h.
- North Star Double Density Floppy Disk Kit (One Drive) for Explorer/85 (includes 3 drive S-100 controller, DOS, and extended BASIC with per-



registers... single step with register display at each break point... go to execution address. Level "A" in the Hex Version makes a perfect controller for industrial applications and can be programmed using the Netronics Hex Keypad/Display.



Hex Keypad/Display.

## Hex Keypad/Display Specifications

Calculator type keypad with 24 system defined and 16 user defined keys. 6 digit calculator type display which displays full address plus data as well as register and status information.

## Level "B" Specifications

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



Explorer/85 with Level "C" card cage.

## Level "C" Specifications

Level "C" expands Explorer's motherboard with a card cage, allowing you to plug up to six S-100 cards directly into the motherboard. Both cage and cards are neatly contained inside Explorer's deluxe steel cabinet.

Level "C" includes a sheet metal superstructure, a 5-card gold plated S-100 extension PC board which plugs into the motherboard. Just add required number of S-100 connectors

## Level "D" Specifications

Level "D" provides 4k or RAM, power supply regulation, filtering decoupling components and sockets to expand your Explorer/85 memory to 4k (plus the original 256 bytes located in the 8155A). The static RAM can be located anywhere from 0000 to EFFF in 4k blocks.

## Level "E" Specifications

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

## Order A Coordinated Explorer/85 Applications Pak!

Experimenter's Pak (SAVE \$12.50)—Buy Level "A" and Hex Keypad/Display for \$199.90 and get FREE Intel 8085 user's manual plus FREE postage & handling!

Student Pak (SAVE \$24.45)—Buy Level "A," ASCII Keyboard/Computer Terminal, and Power Supply for \$319.85 and get FREE RF Modulator plus FREE Intel 8085 user's manual plus FREE postage & handling!

Engineering Pak (SAVE \$41.00)—Buy Levels "A," "B," "C," "D," and "E" with Power Supply, ASCII Keyboard/Computer Terminal, and six S-100 Bus Connectors for \$514.75 and get 10 FREE computer grade cassette tapes plus FREE 8085 user's manual plus FREE postage & handling!

Business Pak (SAVE \$89.95)—Buy Explorer/85 Levels "A," "B," and "C" (with cabinet), Power Supply, ASCII Keyboard/Computer Terminal (with cabinet), 16k RAM, 12" Video Monitor, North Star 5-1/4" Disk Drive (includes North Star BASIC) with power supply and cabinet, all for just \$1599.40 and get 10 FREE 5-1/4" minidiskettes (\$49.95 value) plus FREE 8085 user's manual plus FREE postage & handling!

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- Power Supply Kit for North Star Disk Drive, \$39.95 plus \$2 p&h.
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### DISK EXPANSION PACKAGE

This package includes everything necessary to add disk capabilities to your TRS-80. To buy everything in this package would normally cost \$1100 at your local Radio Shack store. We start with the Radio Shack expansion interface and add 16K RAM. You also receive a Percom 40-track disk drive with a dual drive cable. To start you off right, we've added the NEWDOS (40-track) disk operating system and a box of BASF diskettes. Also, the Percom data separator, the component which Radio Shack forgot.

**SAVE \$181.00** **\$899.95**

### SMALL BUSINESS PACKAGE

An ideal starter package for the small business. Includes a TRS-80 with 16K RAM and Level II BASIC, an expansion interface with an additional 16K RAM installed, two Percom disk drives with cable and data separator, NEWDOS disk operating system (40 track version) and the Centronics 730 line printer.

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### DELUXE EXPANSION PACKAGE

This package includes a 32K expansion interface with the Percom data separator installed, two Percom TFD-100 disk drives and a 4-drive cable, NEWDOS+ operating system and 2 boxes of BASF diskettes.

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Includes all the necessities for a small-to-medium size business to become computerized. Includes a Level II TRS-80 with 16K RAM installed and modified to display upper and lower case letters with Electric Pencil, a 32K RAM expansion interface with the Percom data separator installed, three Percom TFD-10 disk drives and a 4-drive cable, a Centronics 779-2 tractor feed printer, a 40-track NEWDOS and Electric Pencil Word Processor software. We have even added a system desk and printer stand.

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Line Printer III	\$1999	\$1849		
Centronics 779-2	\$1598	\$1095	\$655	\$850
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Centronics 730	\$999	\$899	\$545	\$750
Centronics P1 *	\$499	\$419	\$250	\$358
Quick Printer II	\$219	\$197	\$100	\$150
QP-II Exp. Int. Cable	\$20	\$18		
* Cable required	\$39	\$35		



#### EXPANSION INTERFACE:

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.... OK	\$299	\$269	\$165	\$230
.... 16K	\$448	379/403	\$245	\$340
.... 32K	\$597	479/537	\$325	\$440

#### DISK DRIVES:

	LIST PRICE	OUR PRICE	USED OFFER	USED PRICE
Percom, TFD-100, 40-track		\$399		
Percom, dual TFD-100		\$795		
Percom, TFD-200, 77-track		\$675		
2-drive cable		\$29		
4-drive cable		\$39		
Radio Shack, -0	\$499	\$469	\$290	\$390
Radio Shack, -1, 2, 3	\$399	\$459	\$270	\$370

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16K Memory Kit		\$99		
16K Memory Kit for E.I.		\$95		
RS232-C Interface	\$99	\$89	\$55	\$75
TRS-232 Interface		\$49.95		
Data Dubber		\$49.95		

NO SUBSTITUTIONS ON PACKAGE PRICES

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\* Prices subject to change  
\* Prices do not include shipping

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 Renumber source listing \$20.00

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 8080-Z80 Conversion Level II, 16K \$14.95  
 STAD Trace Monitor 16, 32 and 48K \$24.95

Electric Pencil by Michael Shrayner. Powerful machine language word processing system. Level II, 16K tape - \$100; Disk version - \$150

Spool will print an ASCII file to a parallel line printer at the same time you are using your computer for another program. For 32K Disk Systems only. Will NOT work with NEWDOS. (2.3 or VTOS 3.0 OK) On cassette \$19.95, on Disk \$24.95.

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Snake Eggs by Leo Christopherson. With sound - Level II, 16K \$14.95  
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 Keyboard by John Adamson. Level II, 16K \$9.95

BOOKS

Sargon Handbook by Dan & Kathe Spracklen. \$14.95 plus \$1.00 shipping and handling  
 The BASIC Handbook by Dr. David A. Lien. \$14.95 plus \$1  
 Z80 Instruction Handbook by Scelbi Publications \$4.95 + \$1.  
 Learning Level II by David A. Lien. \$15.95 plus \$1  
 Z-80 Software Gourmet Guide and Cookbook from Scelbi. \$14.95 + \$1.  
 The Little Book Of BASIC Style by John Nevison. \$5.95 plus \$1  
 TRS-80 Assembly Language Programming by William Barden, Jr. \$3.95 plus \$1 shipping  
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- PRICES DO NOT INCLUDE SHIPPING.
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- When ordering Percom add \$5 each, packaging and handling fee.
- Prices subject to change without notice. We are not responsible for typographical errors.

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## Audio Meter for Your TRS-80

David F Miller, 7462 Lawler Ave, Niles IL 60648

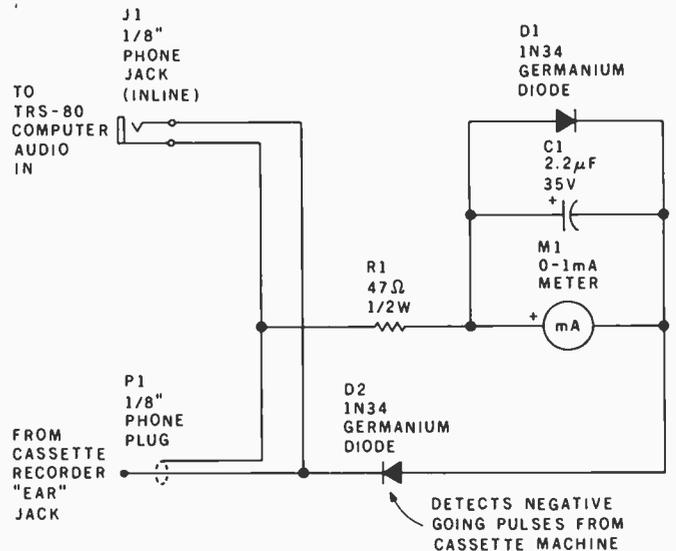
Perhaps I am old-fashioned, but I like to know what is happening when I CLOAD or CSAVE a tape on my TRS-80. I modified the CTR-41 cassette recorder to allow me to hear over its internal speaker what is going in and coming out at all times, but that did not tell me enough about the levels involved.

As you have probably discovered, audio levels in and out of the cassette port are very important for the successful loading and saving of your hard-fought-for efforts on tape. Interpolating the volume control settings of the cassette unit on playback can produce a degree of accuracy, but not for tapes received from others. The only sure way to understand what is going on is a visual indicator. The best device would be an oscilloscope, but I could not see dedicating my oscilloscope permanently to this type of duty.

The metering circuit shown in figure 1 has proven to be adequate for day-to-day monitoring and can be supplemented by the oscilloscope when a difficult tape is encountered. If you have an oscilloscope, look at the ear-phone output of the cassette recorder while playing back a tape. What you will see is a constant synchronization



Photo 1: A view of the audio metering box which connects to the Radio Shack TRS-80.



	RADIO SHACK NUMBER
C1	272-1407
D1 & D2	276-1123
J1 & P1	274-283
M1	22-052 OR EQUIVALENT
R1	271-009

Figure 1: Schematic for the TRS-80 audio metering box. The 2 diodes used must be germanium diodes.

train of negative pulses occurring at a frequency of 500 Hz, with negative data pulses popping in and out at 1000 Hz. (These figures are for Level II. Level I figures are half, or 250 Hz and 500 Hz.)

The metering circuit shown in figure 1 samples these negative pulses, rectifies and filters them, and drives the 1 mA meter movement. With the values shown, the meter will read about half scale with the volume on the cassette unit set at 5 (normal setting for Level II tapes). To trim the meter reading for your individual needs, change the value of the electrolytic capacitor across the meter (more capacity for a higher reading); this will probably have the most noticeable effect. You could also increase or decrease the 47 ohm series resistor, but watch for possible "loading" effects if you go too low in value (the value shown shows no such effects). The diode across the meter acts to protect the movement when high levels are encountered (such as during a tape search in fast forward or rewind with the "play" button also engaged). Both diodes are specified as germanium because there is only 0.3 V barrier potential (ie, voltage drop) across a germanium type, whereas a silicon diode has 0.7 V drop.

The earphone jack on the CTR-41, and most other recorders, outputs the audio signal from the record amplifier when in the record mode, so you will see what is CLOADed and what is CSAVEed.

Photo 1 shows how my unit is packaged. I mounted a 1/8 inch phone jack on the rear of the plastic meter box which accepts the plug to the TRS-80. This jack should be insulated from the box if you use a metal enclosure, or

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32K Econoram X	S-100	\$549	\$669	\$789
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16K Econoram XIV	S-100 (2)	\$299	\$359	\$459
16K Econoram XV-16	H8 (3)	\$329	\$395	n/a
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use an in-line female 1/8 inch phone jack and avoid having to keep the jack above possible outside grounds. A short shielded cable exits the meter box, terminates in an 1/8 inch phone plug, and plugs into the recorder ear jack.

That is all there is to it! If your cassettes are marked with the meter readings that are obtained on playback, you should be able to load almost anything on the first pass. If you see the level on playback begin to drop over a period of time, you will know that the tape heads need cleaning. I think you will find that this is a useful accessory. ■

## Algebraic Identities Are Not Numerical Identities

Alan B Forsythe PhD, University of California Los Angeles  
Department of Biomathematics, School of Medicine  
Los Angeles CA 90024

The development of statistical software can present some adverse computational problems. In "Elements of Statistical Computation" (January 1979 BYTE, page 182), I demonstrated the tip of this iceberg with two algorithms

for calculating the standard deviation for some data. The first algorithm, the one given in many texts, incorrectly gives zero as the answer. The simple modification given in that article corrects the defect. This clearly shows the fallacy of simply coding the computational procedures given in standard textbooks.

Subsequently, J G Bliss erroneously speculated that a division by four rather than five ( $N-1$  rather than  $N$ ) probably accounts for the incorrect answer. (See "Statistical Computations Recomputed," June 1979 BYTE, page 193.) As my original article pointed out, the root of the problem is the fact that digital computers have finite precision. Algebraic identities are *not* numerical identities. Thus, when very large numbers are added or subtracted, the last few digits are lost due to truncation. When faced with deviations from large numbers, the user has to be very careful with the computational formula employed. That is why a better answer can be obtained using the last algorithm given in the article.

A simple example on the TRS-80 is:

PRINT 1000000+1

The resulting display shows 1E6. That is, one million plus one is reported to equal one million. The single-precision representation is not adequate for this problem.

The heart of the computation of the standard deviation is the sum of the squares of the deviations about the mean. Algebraically this can be deduced from the sum of the squares of the individual values and their sum. The original article demonstrates that the use of this algebraic identity leads to the subtraction of two very large numbers and thereby to the loss of the critical digits. The computed result for the sum of squares of the deviations is zero. It is now clear that if a computationally poor procedure yields zero, then it certainly does not matter if we divide by five or four. In either case, we still get zero.

Why is there any question whether to divide by  $N$  or  $N-1$  in the calculation of the standard deviation? When given the values for the entire population, then divide by  $N$ ; when working with a *sample*, then divide by  $N-1$ . The example in the original article was a sample from a much larger population and so the correct divisor of  $N-1$  was used.

Mr Bliss references an accounting and auditing textbook. If, in the auditing situation, in order to verify each and every of the thousands of bills paid, then the divisor should be  $N$ . However, if only a sample was drawn, then  $N-1$  is the appropriate divisor for the standard deviation.

Since I am a statistician and not an accountant, I will not argue with Mr Bliss about accounting. If his usual procedure is to exhaustively study all transactions, rather than a sample, then he should divide by  $N$ . My experience with sampling from large populations has been that great economy of effort can be realized without much loss in precision with the use of an appropriate sampling plan. ■

### REFERENCES

- Bliss, J F, "Statistical Computations Recomputed," BYTE, June 1979, page 193.
- Forsythe, A B, "Elements of Statistical Computation," BYTE, January 1979, page 182.

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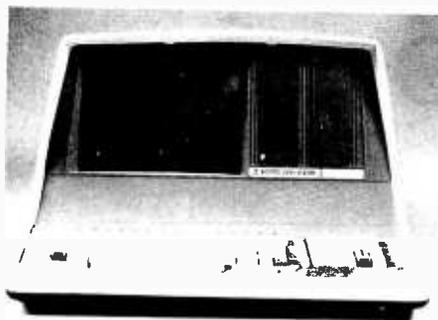


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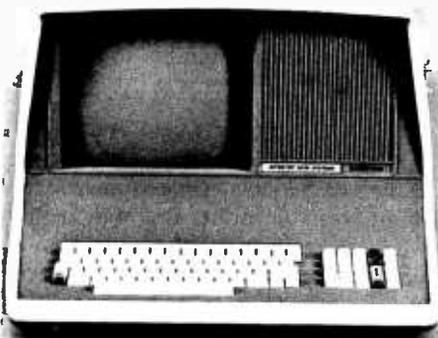
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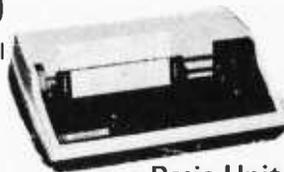
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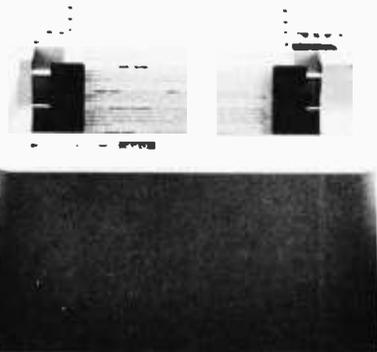
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# BASIC Formatted Output

*Listing 1: BASIC source code for the editing routines. Lines 100 to 927 are the driver program for the text editor. Lines 9000 to 9997 are the actual text editor. The editor is located at a high line number so it may be used with many BASIC programs. When using the editor, care must be taken not to use any line numbers in your driver program higher than 9000. The editor is broken into several routines. Lines 9000 through 9185 define the format that will be used. The format statement will be familiar to readers who have worked with FORTRAN format statements. Lines 9200 to 9268 parse the format statement. The parsed format is stored in arrays V\$ and V as described in the text.*

*Lines 9300 to 9548 are the free format input routine. The data is entered with commas separating the individual units. This routine then takes the data and puts it into the desired form.*

*Lines 9600 to 9997 take care of formatted output. The format used is a table developed by a routine such as that in lines 9200 to 9268.*

```
100 REM TEST PROGRAM FOR FORMAT SUBROUTINES
110 REM
200 DIM V$(30),V(30),Y(3,30)
210 E$="ENTER"
220 G$="FORMAT"
230 H$="FREE FORM"
240 I$="FORMATTED"
250 J$="STRINGS IN QUOTES"
260 K$=" & VARIABLES"
300 INPUT "INSTRUCTIONS (Y OR N):";Y$
310 IF Y$="N" GOTO 370
320 PRINT: PRINT "USE CODE FOR FOLLOWING TESTS"
330 PRINT "1 =";G$;" & TABLE"
340 PRINT "2 =";G$;" , ";H$;K$
350 PRINT "3 =";G$;" , ";I$;" STRING";K$
360 PRINT "4 = INPUT";G$;" , ";H$;" OUTPUT";G$
370 INPUT "ENTER CODE:";A$
375 PRINT
380 IF A$="?" GOTO 320
384 IF A$="END" OR A$="E" THEN STOP
386 A=VAL(A$)
390 ON A GOTO 400,500,700,800
400 PRINT E$;G$
410 INPUT F$
420 GOSUB 9060
425 PRINT: PRINT
430 FOR K=1 TO Y9-1
440 PRINT Y(1,K):Y(2,K):Y(3,K)
450 NEXT K
460 PRINT
470 GOTO 370
500 PRINT E$;G$
510 INPUT F$
520 PRINT E$;H$;J$
530 INPUT Z$
540 GOSUB 9060
550 GOSUB 9400
```

*Listing 1 continued on page 178*

---

William D Roch  
24000 Bessemer St  
Woodland Hills CA 91367

---

If your BASIC interpreter has a PRINT USING capability, you should have no trouble printing reports or other similar output. If not, then you are at an apparent impasse with the standard BASIC output that left-justifies everything at fixed positions on a line, an approach that has many limitations.

The routines in listing 1, lines 9000 to 9997, solve this problem and produce a formatted output. Also included are routines for reading an unformatted string and placing the fields in numerical or string arrays, and a routine for establishing arrays for a formatted input record. In addition, lines 100 to 927 are a test program that can be used to get the feel of how these routines work.

## Why Format Records?

There are several advantages to working with formatted string records:

- The position of each field in a record is always constant.
- Only one variable name is needed to input, read or print. Counting fields when there is more than one record type involved is no problem — you need only check a record type code and break up the record with the proper format statement.
- Records may be created and changed with one string type editor rather than an individual program or modification for each set of records.
- Most business type applications use formatted records.

## Format Definition Routine

Our primary concern is describing the appearance of the record format to the rou-

*Text continued on page 185*

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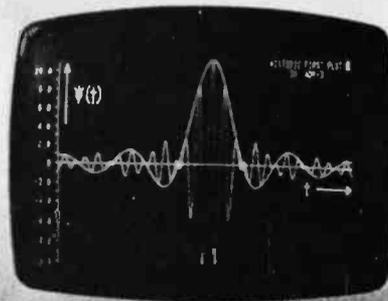
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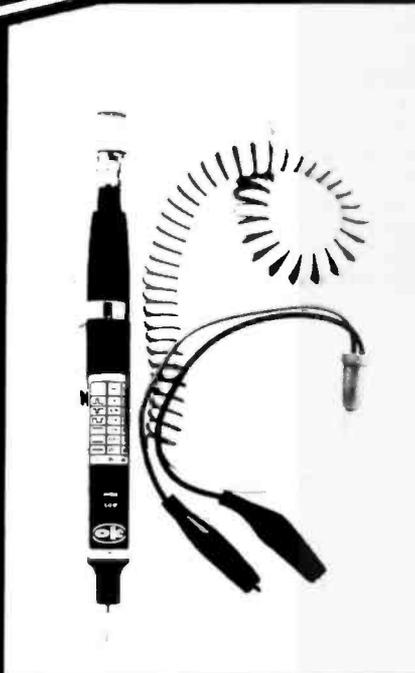
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Listing 1 continued:

```

560 PRINT: PRINT "STRINGS"
570 FOR K=1 TO V1
580 PRINT VS(K)
590 NEXT
600 PRINT: PRINT "NUMBERS"
610 FOR K=1 TO V2
620 PRINT V(K)
630 NEXT
640 PRINT
650 GOTO 370
700 PRINT ES:GS
710 INPUT FS
720 GOSUB 9060
730 PRINT: PRINT ES:IS:JS
740 INPUT ZS
750 GOSUB 9260
760 GOTO 560
800 PRINT ES:GS
810 INPUT FS
820 GOSUB 9060
830 PRINT ES:HS:JS
840 INPUT ZS
850 PRINT ES:" OUTPUT":GS
860 INPUT FS
870 GOSUB 9060
875 GOSUB 9400
880 GOSUB 9650
890 PRINT: PRINT US: PRINT
900 GOTO 370
927 REM
8998 REM
8999 REM
9000 REM   FORMAT DEFINITION SUBROUTINE [SUB I/O IA.0]
9003 REM
9006 REM THIS ROUTINE BREAKS UP A 'FORTRAN' TYPE FORMAT
9009 REM STATEMENT INTO A TABLE FOR USE WITH [SUB IB.IC.ID]
9010 REM EXAMPLE:
9012 REM   FS="(A3,4X,2F7.2,X,3I6)"
9015 REM   A3   - 3 CHAR STRING (3A - BAD ENTRY)
9018 REM   4X   - 4 BLANKS (4X6 - 6 IGNORED)
9021 REM   2F7.2 - 2 REAL NOS OF 7 CHARS W/ 2 DECIMAL PLACES
9024 REM   X    - 1 BLANK
9027 REM   3I6  - 3 INTEGERS 6 CHAR LONG
9030 REM
9033 REM INPUT:
9036 REM   FS - FORMAT
9039 REM OUTPUT:   DIM AS REQUIRED
9040 REM   V1 - STRING FIELD COUNT
9041 REM   V2 - NUMBER FIELD COUNT
9042 REM   Y(1,K) - TYPE 1=STRING, 2=INTEGER, 3=REAL, 4=BLANK
9045 REM   Y(2,K) - FIELD START POSITION IN INPUT OR OUTPUT RECORD
9048 REM   Y(3,K) - LENGTH OF FIELD
9051 REM   Y9   - NO OF FIELDS INCLUDING BLANKS + 1
9054 REM VARIABLE NAMES USED:
9057 REM   FS,US,WS,XS,V1,V2,V3,V4,V5,V6,V7,V8,V9,Y(1,K),Y9
9058 REM
9060 V1=1
9069 V2=1
9072 V5=1
9075 Y9=1
9081 Y(2,1)=1
9084 WS=""
9087 US="AIFX .)."
9090 FOR V7=2 TO LEN(FS)
9093 XS=MIDS(FS,V7,1)
9096 FOR V8=1 TO 8
9099 IF XS=MIDS(US,V8,1) GOTO 9112
9100 NEXT V8
9103 IF XS>="0" AND XS<="9" GOTO 9142
9106 PRINT "FORMAT ERROR (":XS:)"
9109 STOP
9112 IF V8<5 GOTO 9121
9115 V8=V8-4
    
```

Listing 1 continued on page 180

# MICAH

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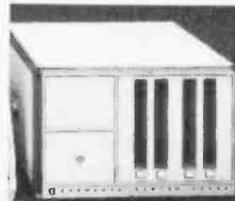
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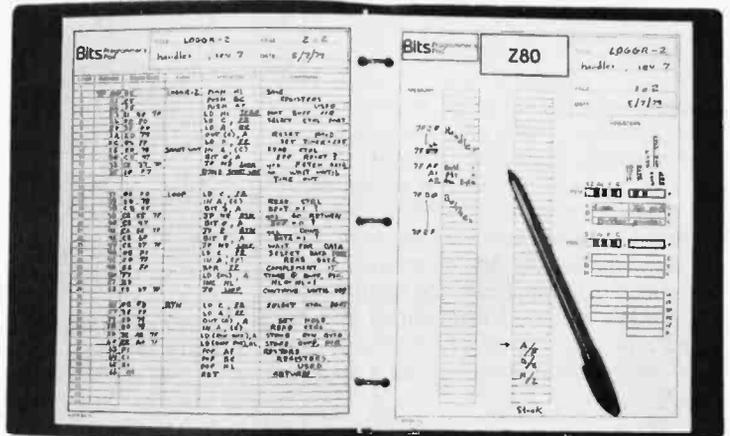
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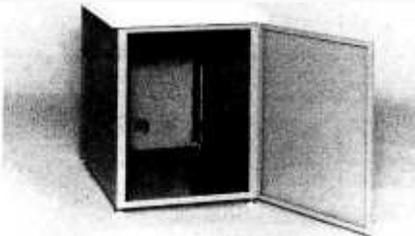
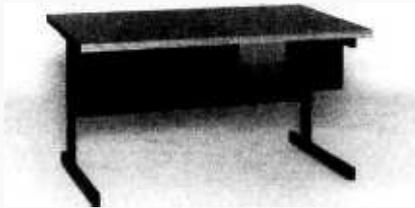
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*Listing 1 continued:*

```

9118 GOTO 9139
9121 V9=V8
9130 V6=V6+1
9133 IF V6=2 THEN V5=VAL(W$)
9136 GOTO 9181
9139 IF V8<>4 GOTO 9151
9142 W$=W$+X$
9145 V6=1
9148 GOTO 9184
9151 V4=VAL(W$)
9153 IF V5=0 THEN V5=1
9154 IF V9=4 THEN V4=V5
9157 IF V9=4 THEN V5=1
9160 FOR V3=1 TO V5
9161 Y(1,Y9)=V9
9163 Y(3,Y9)=V4
9166 Y(2,Y9+1)=INT(Y(2,Y9)+V4)
9169 Y9=Y9+1
9170 IF V9=2 OR V9=3 THEN V2=V2+1
9171 IF V9=1 THEN V1=V1+1
9172 NEXT V3
9175 V5=1
9178 V6=1
9181 W$=""
9184 NEXT V7
9185 RETURN
9190 REM
9192 REM
9200 REM BREAKS UP A FORMATTED STRING SUBROUTINE [SUB I/O 1B.0]
9203 REM
9206 REM THIS SUBROUTINE BREAKS UP A FORMATTED STRING RECORD FROM:
9209 REM 1. READ FROM INPUT STATEMENT
9212 REM 2. READ FROM DATA STATEMENT
9215 REM 3. FORMATTED INPUT - STRING MUST BE IN QUOTES (")
9218 REM 4. INPUT STATEMENT USING BASIC PATCHED FOR USE
9219 REM WITH RO-CHE MULTI-CASSETTE CONTROLLER
9221 REM INTO STRING AND NUMBER ARRAYS BASED ON A TABLE BUILT
9224 REM INTO THE PROGRAM OR FROM PARAMETERS CREATED BY [I/O 1A.0]
9227 REM
9230 REM INPUT:
9233 REM Z$ - INPUT STRING
9236 REM Y(K,1)- PARAMETER TABLE
9239 REM Y9 - NO OF FIELDS INCLUDING BLANK FIELDS
9242 REM OUTPUT:
9245 REM VS(1) - STRING FIELD ARRAY
9248 REM V(1) - NUMBER FIELD ARRAY
9251 REM VARIABLE NAMES USED:
9254 REM VS(1),Z$,V(1),V1,V2,V7,Y(1,K),Y9
9260 V1=0
9266 V2=0
9269 FOR V7=1 TO Y9-1
9272 ON Y(1,V7) GOTO 9275,9284,9284,9290
9275 V1=V1+1
9278 VS(V1)=MID$(Z$,Y(2,V7),INT(Y(3,V7)))
9281 GOTO 9290
9284 V2=V2+1
9287 V(V2)=VAL(MID$(Z$,Y(2,V7),INT(Y(3,V7))))
9290 NEXT V7
9293 Z$=""
9296 RETURN
9297 REM
9298 REM
9300 REM FREE FORM INPUT SUBROUTINE [SUB I/O 1C.0]
9303 REM
9306 REM THIS ROUTINE ACCEPTS A FREE FORM INPUT STRING AND PRO-
9309 REM DUCES A STRING AND/OR NUMBER ARRAY BASED ON A TABLE BUILT
9312 REM INTO THE PROGRAM OR CREATED BY [SUB I/O 1A].
9315 REM BLANKS ARE USED AS DELIMITERS BETWEEN FIELDS.
9316 REM STRING FIELDS CONTAINING BLANKS OR WITH
9318 REM LEADING OR TRAILING BLANKS MUST BE
9321 REM ENCLOSED WITH A DELIMITER. NUMERIC FIELDS ARE
9324 REM EDITED FOR NON-NUMERIC CHARACTERS. IF THE INPUT
9327 REM STRING HAS TOO MANY FIELDS THE EXTRA FIELDS WILL

```

*Listing 1 continued on page 182*

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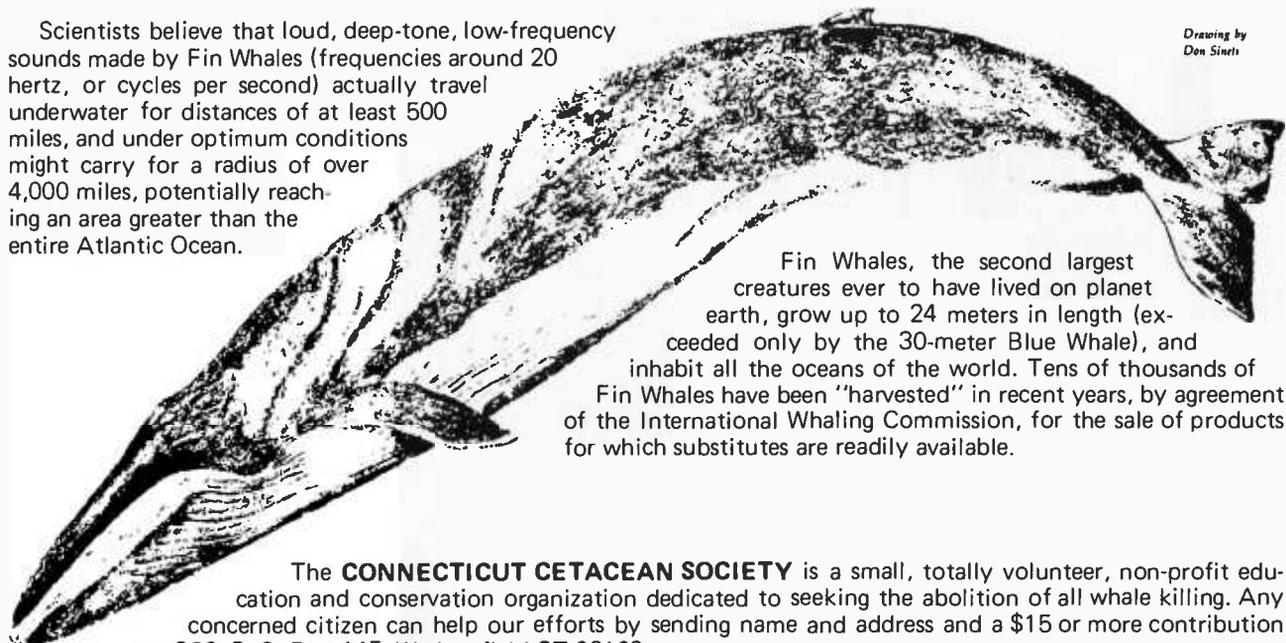
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### Listing 1 continued:

```

9330 REM BE IGNORED.
9333 REM IF THE INPUT STRING HAS TOO FEW FIELDS THE EXTRA
9336 REM FIELDS WILL BE 'BLANKED' OR 'ZEROED'. FOR
9339 REM BLANK FIELDS - ENTER '0' FOR NUMERIC AND ONE BLANK
9342 REM ENCLOSED BY DELIMITERS FOR STRINGS.
9345 REM
9348 REM INPUT:
9351 REM Z$ - INPUT STRING
9354 REM Y(I,K) - PARAMETER TABLE
9357 REM Y9 - NO OF FIELDS INCLUDING BLANKS + 1
9360 REM D$ - DELIMITER
9369 REM OUTPUT:
9372 REM V$(I) - STRING FIELDS ARRAY
9375 REM V(I) - NUMERIC FIELDS ARRAY
9376 REM ERR - 1-OK, 2-ERROR
9378 REM VARIABLE NAMES USED:
9381 REM D$,V$(I),W$,X$,V(I),V1,V2,V3,V4,V5,V6,V7,Y9
9400 FOR V3=1 TO V1
9403 V$(V3)=" "
9406 NEXT V3
9409 FOR V3=1 TO V2
9412 V(V3)=0
9415 NEXT V3
9416 REM ANY DELIMITER MAY BE USED
9418 D$="# "
9421 V1=0
9424 V2=0
9427 V4=1
9430 V5=0
9433 V6=1
9434 W$=" "
9435 ERR=1
9436 FOR V7=1 TO LEN(Z$)
9439 IF Y(1,V6)<>4 GOTO 9448
9442 V6=V6+1
9445 GOTO 9439
9448 X$=MID$(Z$,V7,1)
9451 IF X$<>D$ GOTO 9469
9454 V4=V4+1
9457 IF V7=LEN(Z$) GOTO 9515
9460 IF V4=2 GOTO 9545
9463 V4=1
9466 GOTO 9545
9469 IF X$=" " GOTO 9503
9472 V3=1
9475 IF Y(1,V6)=1 GOTO 9493
9478 IF X$>="0" AND X$<="9" GOTO 9493
9481 IF X$="-" GOTO 9493
9484 IF X$="." AND Y(1,V6)=3 GOTO 9493
9487 PRINT "FIELD (";V6;") NOT NUMERIC"
9490 ERR=2: RETURN
9493 V5=V5+1
9494 IF V5>INT(Y(3,V6)) GOTO 9545
9496 W$=W$+X$
9499 IF V7=LEN(Z$) GOTO 9512
9500 GOTO 9545
9503 IF V4=2 GOTO 9493
9506 IF V3=2 GOTO 9512
9509 V3=2
9512 IF Y(1,V6)<>1 GOTO 9524
9515 V1=V1+1
9518 V$(V1)=W$
9521 GOTO 9530
9524 V2=V2+1
9527 V(V2)=VAL(W$)
9530 V6=V6+1
9533 IF V7=LEN(Z$) GOTO 9548
9536 V5=0
9539 W$=" "
9542 IF V6=Y9 GOTO 9548
9545 NEXT V7
9548 RETURN
9600 REM FORMATTED OUTPUT SUBROUTINE [SUB I/O ID.0]
    
```

Listing 1 continued on page 184

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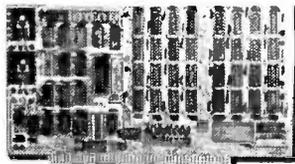
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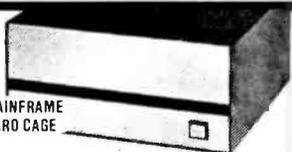
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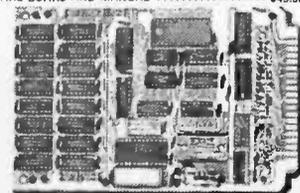
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- \* 200NSEC 4116 RAMS.
- \* FULL DOCUMENTATION
- \* ASSEMBLED AND TESTED BOARDS ARE GUARANTEED FOR ONE YEAR, AND PURCHASE PRICE IS FULLY REFUNDABLE IF BOARD IS RETURNED UNDAMAGED WITHIN 14 DAYS.

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WITH 16K RAM	\$349.00
WITHOUT RAM CHIPS	\$279.00
HARD TO GET PARTS ONLY (NO RAMS)	\$109.00
BARE BOARD AND MANUAL	\$49.00



```

9603 REM
9606 REM THIS ROUTINE ACCEPTS ARRAYS OF STRING AND NUMBER
9609 REM FIELDS AND PRODUCES A FORMATTED STRING RECORD
9612 REM BASED ON A TABLE BUILT INTO THE PROGRAM OR CREATED
9614 REM BY [SUB A/O TABLE BUILD PROGRAM].
9616 REM NUMBERS ARE RIGHT JUSTIFIED. DECIMAL POSITION
9618 REM OF REAL NUMBERS ARE HELD AND TRAILING ZEROS ARE
9621 REM ADDED IF REQUIRED.
9622 REM
9624 REM INPUT:
9627 REM VS(1) - STRING FIELD ARRAY
9630 REM V(1) - NUMBER FIELD ARRAY
9633 REM Y(I,K) - PARAMETER TABLE
9636 REM Y9 - NO OF FIELDS INCLUDING BLANKS + 1
9639 REM OUTPUT:
9642 REM US - OUTPUT STRING RECORD
9645 REM VARIABLE NAMES USED
9648 REM US.VS(1).WS.YS.V(1).V1.V2.V3.V4.V5.V6.V7.V8.V9.Y(I,K).Y9
9649 REM
9650 US=""
9652 V1=0
9654 V2=0
9656 FOR V9=1 TO Y9-1
9658 WS=""
9660 VS=Y(1,V9)
9663 V3=INT(Y(3,V9))
9666 ON V5 GOTO 9668,9689,9689,9669
9668 V1=V1+1
9669 FOR V8=1 TO V3
9671 IF V5<>1 GOTO 9675
9672 YS=MID$(VS(V1),V8,1)
9675 IF YS="" OR V5=4 THEN YS=" "
9678 IF V5=2 OR V5=3 THEN YS="*"
9681 WS=WS+YS
9684 NEXT V8
    
```

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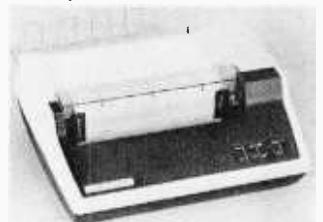
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Listing 1 continued:

```

9685 US=US+WS
9687 GOTO 9760
9689 V2=V2+1
9690 V7=INT(V(V2))
9693 V7=LEN(STRS(V7))-1
9694 YS=STRS(V(V2))
9696 IF LEFTS(YS,1)=". " THEN V7=V7+1
9697 IF MIDS(YS,2,1)=". " THEN V7=V7-1
9698 IF LEFTS(YS,1)="- " GOTO 9701
9699 IF V(V2)>1.0 GOTO 9701
9700 V7=0.0
9701 IF LEFTS(YS,1)<>". " THEN YS=MIDS(YS,2)
9703 V4=(Y(3,V9)*10)-(V3*10)
9706 IF V5=3 GOTO 9721
9708 IF V3-LEN(YS)=0 GOTO 9716
9709 FOR V8=1 TO V3-LEN(YS)
9712 WS=WS+" "
9715 NEXT V8
9716 WS=WS+YS
9718 GOTO 9757
9721 IF V7-1>=V3-V4 GOTO 9669
9724 IF INT(V(V2))=V(V2) THEN YS=YS+"."
9727 V6=0
9728 V7=V4+V7+1
9729 V7=V3-V7
9731 FOR V8=1 TO V3
9733 IF INT(V7+.005)>(V8-1) GOTO 9748
9736 V6=V6+1
9739 VS=MIDS(YS,V6,1)
9742 IF VS="" THEN VS="0"
9743 WS=WS+VS
9745 GOTO 9754
9748 WS=WS+" "
9754 NEXT V8
9757 US=US+WS
9760 NEXT V9
9763 RETURN
9997 END

```

Copies of these routines are available for \$5 on paper tape or Tarbell format cassettes for 8 K V3.1, 3.2 and 4.0 BASIC from Elliam Associates, 24000 Bessemer St, Woodland Hills CA 91367.

Record Description	
Product Class	A2
Product Code	A6
Description	A15
Vendor Code	I3
Quantity On Order	I4
Quantity On Hand	I4
Sold Year To Date	I4
Unit Sales Price	F7.2

Format Statement	
F\$="	(A2,A6,A15,I3,I4,I4,I4,I4,F7.2)"

Data Record							
TWHD110V	Tape Winder	107	45	37	123	27.00	
V\$(1)	V\$(2)	V\$(3)	V(1)	V(2)	V(3)	V(4)	V(5)

Table 1: Format statement and corresponding data record. The descriptions for formats used here are FORTRAN types. The product class is an alphanumeric quantity having two characters, the product code consists of six alphanumeric characters and the description of 15 characters. The particular vendor code is a 3 digit integer. The quantity on order, on hand and the number sold up to this date are all 4 digit integers. The unit sales price is a 7 digit floating point number with two digits after the decimal place and four digits before the decimal place.

statements to convert the input or output string into string and number array variables. Any number of formats may be used in a program, but the format definition routine must be rerun each time a different format is used.

Fixed Form Input

The normal action of BASIC requires an entry for each field listed as a variable with an INPUT statement. This is a nuisance when you have an input and output (IO) field record and the last five entries are blank most of the time. The fixed form input does not require that the trailing fields be entered, since they will be blanked or zero filled. It is sometimes easier to keep the keyed input in neat columns (fixed format) rather than following one field after another (normal BASIC).

Example:

```

Normal BASIC
14,16,98
1457,258,7
2,3,7

Fixed Format
14 16 98
1457 258 7
2 3 7

```

The main advantage is in inputting formatted records from cassette tape or floppy disk. (See formatted output section, para-

Text continued from page 176:

tinc. This is done with a FORTRAN type format statement which defines:

- A = Alphabetic or String Field.
- I = Integer Number.
- F = Floating Point or Real Number.
- X = Blank.

Table 1 shows how these formats are used. The format definition routine takes the format string statement (F\$) and converts it into a 3 column array (V). The first column defines the type of field: string, alphanumeric, integer, real, or blank. The second column provides the starting position of the field within the record. The third field provides the length of the field and number of decimal positions. This routine creates a parameter table that is used by the other routines.

The parameter table could also be built using values from DATA statements read into the proper variables thus eliminating the table build routine. Once the table is created, it can be used with INPUT, READ and PRINT

graph after next, for further discussion of external IO.)

### Free Form Input

Now that formatted input has been presented, let's look at the advantages and disadvantages of free form input. The major advantage is that data fields need only be separated by a blank and the routine will reformat that field to its proper place in the input record. Strings and numbers may be intermixed, but strings containing leading blanks or blanks within the string must be enclosed with a delimiter. The routine delimiter is a pound sign (#), although any character might be used. Blank fields must also be enclosed with delimiters, and numeric fields require a zero. Each method has its advantages and drawbacks depending on the type of data being handled. An example is shown in table 2.

Table 2: In this example a free form input is read by a formatting routine and stored on a record as indicated.

Example:	
keyed input	TW HD110V #TAPE WINDER #107 45 123 27.0
format	F\$="(A2,A6,A15,I3,I4,F7.2)"
record	TWHD100VTAPE WINDER 107 45 123 27.00

Table 3: Examples of how the format will affect the data that is being output. Note that some of the resulting output formats are indented. This is a result of leading blanks created to satisfy the format requirements for certain cases.

Data Format	Format Statement	Output Format
ABCDE	A6	ABCDE
ABCDEFG	A6	ABCDEF
123	I4	123
12345	I4	****
12.34	F6.2	12.34
12.3475	F6.2	12.35
12.	F6.2	12.00
11234.1	F6.2	*****

Table 4: Format and example output using the format and the data in table 3.

F\$="(A2,X,A6,X,A15,I3,I5,F8.3)"
TW HD100V Tape Winder 107 45 37 123 27.00

Table 5: Some typical transformations that may be performed on the stored and formatted data. The last line is the result of these transformations using the given format.

V\$(1)="Retail Value O/H"	change a string
V\$(2)=V\$(3)	move a string
V(1)=V(3)*V(5)	calculate a value
F\$="(A16,2X,A15,F8.2)"	format
Retail Value O/H Tape Winder 199.00	output record

### Formatted Output

The formatted output routine uses the parameter table values and the variable array values in the V array and places them in the output string. Blanks as called out in the format statement are included. Strings are left justified (start in the first position of the field) and numeric values are right justified (any spaces appear on the left). Numeric values larger than the field call out cause the field to be filled with asterisks. Floating point (real) numbers with fewer than the required decimal places are zero filled. Numbers with more decimal places than the format allows are rounded as shown in table 3. Taking table 2 as an example input, the data could be printed with a different format such as in table 4.

### About the Routines

The line numbers used by these routines are set high (above location 9000 in memory) so that BASIC programs can be written under them. Care must be taken that your programs do not have line numbers higher than 9000. All of the variable names used in each routine are listed in the comments. These variable names must not be used in your programs. All the comments are included before the routines so they may be deleted to save space.

### More About Records

Obviously, it takes only a minimum amount of extra code to switch fields, add string constants and perform mathematical functions. Using the input data record of table 1, the transformations in table 5 may be made.

Once these routines are in your library, it is a simple matter to load them into memory, to key in your program and to add format statements. ■

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# Book Reviews

## Let's Talk LISP

by Laurent Siklossy  
Prentice-Hall,  
Englewood Cliffs NJ 1976  
237 pages hardcover  
\$14.20

*Let's Talk LISP* is a fun and useful book to read, at least for those of us who learn best when the material is presented in an interesting way. This is especially helpful for LISP, because for someone who is familiar with traditional programming languages, LISP seems very peculiar at first. After reading *Let's Talk LISP* and writing a few programs, I wondered how I had managed to avoid LISP for so long.

The structure of the book is extremely straightforward.

The first two chapters introduce the fundamental building blocks of LISP. After that, the reader is led through function definitions, recursion, MAP functions, and assorted elements of the language. Midway through the book, the author demonstrates how to write a LISP interpreter in LISP, and discusses the storage functions of LISP. At this point the reader has been introduced to almost everything in the language, but is probably not certain how to write a program. The remainder of the book consists of programming examples.

The first question which one should ask of a LISP book is how it treats language variations; LISP is not standardized. There are two major dialects (EVAL

and EVALQUOTE), and many variations between implementations of the same dialect. The author discusses both of the major dialects, and points out where implementations are likely to differ. I have used two versions of LISP: a large version running on an Amdahl 470 and a Z80 version which was adapted from *Dr Dobb's Journal of Computer Calisthenics and Orthodontia*, number 30. Neither of these implementations matched the language used in *Let's Talk LISP*, but neither of them required much work to make the sample programs run. In short, the book attempts to cover possible differences, and gets most of them, but unless you are using MACLISP at MIT, you will have to make some changes.

If you want to learn LISP and you are not turned off by a lighthearted but thorough treatment of the subject, *Let's Talk LISP* is a good book to read.

John A Lehman  
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## Gödel, Escher, Bach: An Eternal Golden Braid

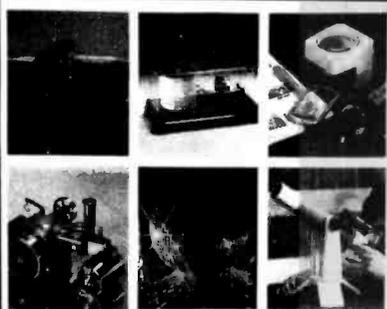
Douglas R Hofstadter  
Basic Books  
New York 1979  
742 pages plus notes and references, hardcover  
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*Gödel, Escher, Bach* is a book of youthful wisdom and deep beauty. It spans the domains of art, science and philosophy — a fact which evidently causes considerable consternation to book store clerks, who occasionally misshelve it with the "occult."

At some fundamental level, the works of Bach, Escher and Gödel may be seen as variant manifestations of a single common theme. Hofstadter uses this theme of recursion or self-reference to unify his exploration of questions and issues from such apparently disparate fields as artificial intelligence and molecular biology.

*Gödel, Escher, Bach* is an enchanting book, in the same sense that Lewis Carroll's writings are enchanting. Although Hofstadter, a contemporary American, writes more idiomatically and with less polish than Lewis Carroll, the book's childlike exuberance, together with artistic forms, whimsical passages and concealed meanings, make it a sheer delight. The entire book has the form of a fugue — it is what it is about. Prose and dialogues alternate. The latter are in the spirit of Lewis Carroll and each imitates the form of a particular Bach composition.

Hofstadter is a physicist by training and a computer scientist by vocation. Students of artificial intelligence will appreciate his deeply knowledgeable treatment of this subject. Of particular interest are his remarks concerning



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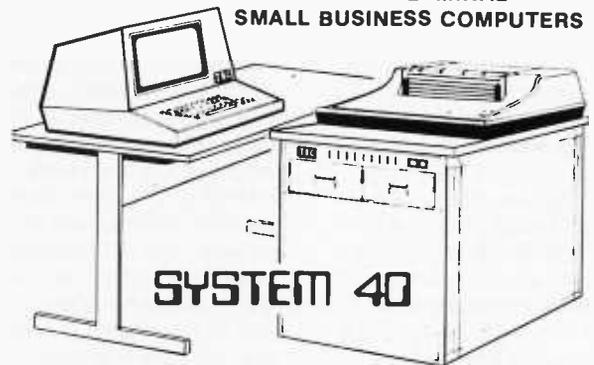
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representations of knowledge, and his speculations concerning the future of artificial intelligence. For example,

"Question: Will a computer program ever write beautiful music? Speculation: Yes, but not soon. Music is a language of emotions, and until programs have emotions as complex as ours, there is no way a program will write anything beautiful . . . To think — and I have heard this suggested — that we might soon be able to command a preprogrammed mass-produced mail-order twenty-dollar desk-model 'music box' to bring forth from its sterile circuitry pieces which Chopin or Bach might have written had they lived longer is a grotesque and shameful misestimation of the depth of the human spirit . . ."

Psychologists and other scientists who study humans are customarily reluctant to deal with such elusive topics as "consciousness" or "free will." Hofstadter has no such reticence, and consequently contributes unique and appealing insights to these subjects. In view of the book's global frame of reference, it is important to stress that the author is not reckless. On the contrary, one of his topics concerns the "nature of evidence," and in this regard it is clear that his own implicit criteria of acceptable evidence are definitely conservative. Neither is he a bigot, scientific or otherwise. His approach to centuries-old problems and dilemmas is characterized by carefulness and fair-mindedness.

An interesting paradox arises from the observation that no two human brains are perfectly isomorphic; yet humans have a powerful ability to communicate with other humans, however remote in time or place.

Hofstadter invents the concept of a "partial software isomorphism" between the brains of people who have similar thinking styles. An analysis of "Jabberwocky" translations clearly reveals the impossibility of exact translation between even closely related languages. One cannot help thinking that Hofstadter's book itself must represent the ultimate challenge for a translator. The dialogues not infrequently contain more than two levels of meaning. There are puns and acrostics, word puzzles and number puzzles — indeed, levels of meaning sometimes communicate with one another.

Although the prose is tractable, it is manifestly impossible to convey the true flavor of the book or to completely describe its subject matter in a brief review. Perhaps the best synopsis is found in the book on page 370, where the author diagrams a "tiny portion" of his "semantic network." This

"tiny portion" contains more than 100 interrelated symbols including: Truth vs provability, Gödel code, Genetic code, Recursion, Figure vs ground, Escher, Canons and fugues, RICER-CAR, Holism vs reductionism, Minds, Computers, Turing and more. What Hofstadter has to say on these subjects is uniquely interesting because it is founded on knowledge, derived by honest (unprejudiced) reasoning and expressed with a simple lucidity.

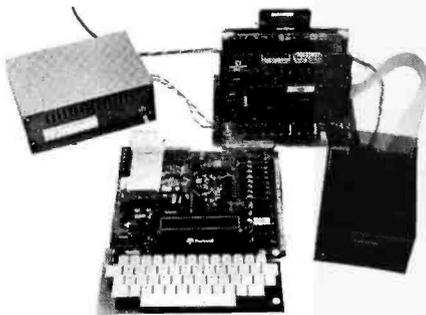
In the past few decades, much has been said and written about "intelligence," a concept now suspect but once thought to have a clear intuitive meaning. Whatever human intelligence is, one feels that this book manifests its highest qualities. *Gödel, Escher, Bach* is an exceptionally good book. ■

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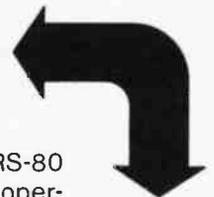
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TRS-80 MOD II

# A Financial Analysis Program

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John A Lehman  
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Ann Arbor MI 48103

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## Introduction

Financial analysis, as it will be used in this article, means the study and analysis of financial statements. Financial statements are the documents which are produced by an accounting system; they report the position of a firm (such as the balance sheets shown in table 1) and how well it has done over the last period (income statements). They are used both by small businesses and by major corporations. The latter are required to make public statements in annual reports and in filings with the Securities and Exchange Commission; these statements serve as one of the primary sources of information to investors.

The program logic described in figure 1 is versatile enough to work on the financial statements of almost any company, although some statements may first need to be consolidated a bit. The basic tools used to analyze statements are ratios and percentages. These can be calculated for a firm, and then compared with both the firm's previous performance and with other firms in the same in-

dustry. In this way, a comprehensive study can evaluate the position of the firm and identify trends in performance.

There are a number of different people who can make use of this sort of analysis. Investors form a major group. Those who wish to make their own investment decisions rather than follow the suggestions of a broker or other advisor, usually want to base their investments on something more than blind faith. The analysis of financial statements is a good way to begin evaluating prospective investments. Unfortunately, many investors wish to evaluate a fairly large number of possibilities. This may present problems because the detailed analysis of ratios and percentages needed to evaluate your investments requires a great deal of time to calculate. This is where the personal computer comes in. With this program, you can evaluate a set of detailed reports in about the same time it takes to calculate a simple percentage analysis with a calculator. The results may be used as is, or used as inputs to any statistical calculations which you wish to use. In short, a personal computer can significantly reduce the time spent on the tedious calculations involved in financial analysis, and leave the analyst more

time for creative thought.

Investors are not the only ones who can use this sort of program. Banks regularly use ratio and percentage analysis to evaluate loan applications from businesses. Many banks are well equipped with computing facilities. But the businessman who is applying for the loan is often not. A banker is likely to be impressed if the financial statements submitted with the loan application include ratios and percentages. Not only does it make the banker's job easier, but it indicates that the applicant is well prepared.

A pro forma statement is a useful indicator to provide. These are forecasts of your financial position at some future point (eg: when the loan falls due). The program will also calculate pro formas.

Aside from using all of these financial indicators to impress the bank, a small businessman might want to use them to analyze his business. Where are things going well, and what weaknesses could stand some attention? There is plenty of available documentation which shows how to interpret ratios and percentages, but again, the calculations are tedious.

This program might also prove useful for the financial analyst—professional or academic. Since I count myself in the latter category, I have

---

## About the Author

*John A Lehman is a doctoral student in business administration at the University of Michigan.*

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**Table 1: The financial statements from the MITS corporation before it was absorbed. These figures come from the Annual Report. This illustrates the format used in a standard financial report.**

MITS INC		
Balance Sheet		
December 31 1975 and 1974		
Assets		
	<u>1975</u>	<u>1974</u>
Current Assets:		
Cash	\$ 112,461	\$ 30,596
Accounts receivable, less allowance for doubtful accounts of \$5,500, \$2,500 in 1974 (Note 2)	258,790	35,808
Notes receivable, stockholder	350	350
Inventories (Note 2)	640,432	266,219
Current portion of prepaid expenses	104,809	33,986
Total current assets	<u>1,116,842</u>	<u>366,959</u>
Property, plant and equipment (at cost) (Notes 2 and 3):		
Tooling	225,821	117,669
Transportation	130,607	8,140
Shop equipment	55,150	13,349
Office equipment	40,305	24,931
Leasehold improvements	12,749	9,848
Drafting equipment	5,753	2,694
	<u>470,385</u>	<u>176,631</u>
Less accumulated depreciation	<u>119,248</u>	<u>58,233</u>
	<u>351,137</u>	<u>118,398</u>
Other assets:		
Deposits	1,766	240
Deferred portion of prepaid expenses	29,938	—
	<u>31,704</u>	<u>240</u>
	<u>\$ 1,499,683</u>	<u>\$ 485,597</u>

See accompanying accountants' report and notes to financial statements.

Liabilities and Stockholders' Equity (Deficit)		
	<u>1975</u>	<u>1974</u>
Current liabilities:		
Accounts payable - trade	\$ 331,791	\$ 171,279
Customer deposits	455,425	85,517
Working capital loans (Note 2)	321,463	406,963
Current portion of long-term debt (Note 3)	39,288	8,602
Accrued liabilities	83,327	17,944
Total current liabilities	<u>1,231,294</u>	<u>690,305</u>
Deferred portion of long-term debt (Note 3)	<u>118,626</u>	<u>1,080</u>
Commitments (Note 4)		
Stockholders' equity:		
Common stock, \$.01 par value, 25,000,000 shares authorized, 947,495 shares issued in 1975, 902,940 shares issued in 1974	9,475	9,029
Additional paid-in capital	294,683	250,575
Retained deficit	<u>(153,295)</u>	<u>(465,392)</u>
	150,863	(205,788)
Less treasury stock, at cost, 1,100 shares	1,100	—
	<u>149,763</u>	<u>(205,788)</u>
	<u>\$ 1,499,683</u>	<u>\$ 485,597</u>

Table 1 continued on page 194

Table 1 continued:

MITS INC		
Statement of Income (Loss)		
Years ended December 31 1975 and 1974		
	1975	1974
Sales	\$ 3,240,772	\$ 959,972
Cost of sales	2,112,551	794,579
Gross profit	1,128,221	165,393
Expenses:		
Selling	441,596	152,407
Administrative	265,274	176,295
Other income and deductions	109,254	50,795
	816,124	379,497
Net income (loss)	\$312,097	\$ (214,104)
Net income (loss) per common share	\$ .33	\$ (.24)

See accompanying accountants' report and notes to financial statements.

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no doubt that the program is indeed useful for such people. I wrote this program to handle analytical problems which I had to perform quite often. Again, the outputs from this program may be used as they are, or as inputs to additional analyses.

### Overview of the Program

The program in listing 1 is set up to work on standard financial statements with data for up to ten periods. It is arranged to use a standard chart of accounts for the income statement and balance sheet. Since the chart of accounts is not very specific, more detailed statements will have to be condensed first. This would be necessary for analysis in any case, since ratios are not usually calculated on the basis of all of the different categories of inventory, etc. The ten periods allowed may be either in years or quarters, and the output will be labeled correspondingly. Ten periods were selected since many annual reports and other published financial statements include ten-year summaries.

For whichever periods are entered, the user may select either a ratio analysis, a percentage analysis, or both. The ratio analysis subroutine calculates fourteen different ratios.

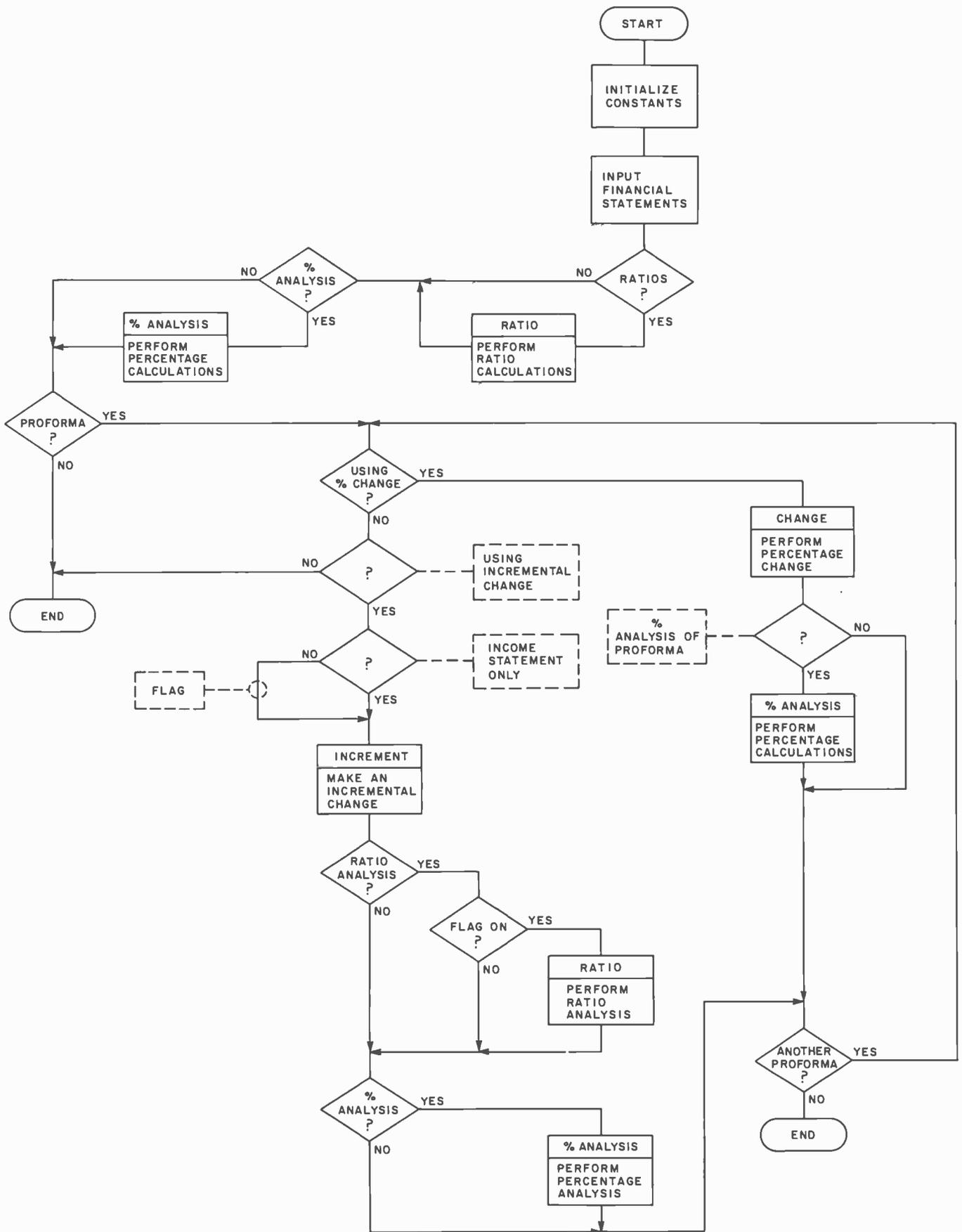


Figure 1: Flowchart of the financial analysis program.

**Listing 1: BASIC listing of the financial analysis program. The entire program and the memory space required for BASIC can be stored in 16 K bytes of memory. A sample output of the program analyzing two years of data is also included.**

```

10 REM FINANCIAL ANALYSIS, RATIO & %
20 REM ALSO DOES PROFORMAS USING % OP ABSOLUTE INCREMENTS
21 REM Z(33,11) IS THE MATRIX FOR THE FINANCIAL STATEMENTS
22 REM PERIOD ELEVEN IS THE SPACE FOR THE PROFORMAS
23 REM N$ IS THE ACCOUNT NAMES VECTOR
24 REM R$ IS THE RATIO NAMES, R() THE RATIO VALUES
25 REM Q INDICATES QUARTERS OR YEARS, C$=COMPANY NAME
26 REM B IS A FIRST CELL POINTER, M IS A LAST CELL POINTER
27 REM SWITCH CHANGES BETWEEN THE TELETYPE AND THE VIDEO DISPLAY
28 REM UP TO TEN PERIODS CAN BE TESTED FOR. STATEMENTS 21-29
29 REM SHOULD BE REMOVED IF YOU HAVE 16 K OR LESS OF MEMORY.
30 REM BY JOHN A LEHMAN
40 DIM Z(33,10),N$(33),R(13,13),R$(13)
50 FOR I=1 TO 33:READ N$(I):NEXT I
60 DATA "SALES","OTH REV","TOT INC","CGS","DEPR","SGA"
70 DATA "INT","TAX","DIV","TOTAL EXP","NET INC"
80 DATA "CASH","RCBLS","INV","PPE ITEMS","TOT CUR"
90 DATA "LAND","BLDG/EQ","ACC DEPR","TOT FIXED","OTH AS"
100 DATA "TOT ASTS","ACCTS PBL","NOTES PBL","CUR LT"
110 DATA "OTHER LIAB","CUR LIAB","LT DEBT","TOT LIAB"
120 DATA "C STK","APIC","RE","TOT CR"
130 FOR I=1 TO 13:READ R$(I):NEXT I
140 DATA "CURRENT","ACID","RCBL TO","INV TO","ASSET TO","PROF ON SALES"
150 DATA "ROA","ROI","EPS","PAYOUT","EBT-EQU","T INT EARNED","BK/SHARE"
160 INPUT "QUARTERS OR YEARS";A$
170 IF LEFT$(A$,1)="Q" THEN 210
180 IF LEFT$(A$,1)="Y" THEN 250
190 GOTO 160
200 REM QUARTERS. L$ IS A LABEL
210 L$="QUARTERS"
220 LET Q=.25
230 REM AN INCREMENT
240 GOTO 270
250 L$="YEARS "
260 Q=1
270 INPUT "COMPANY NAME";C$
280 INPUT "FOR HOW MANY PERIODS DO YOU HAVE FIGURES";N
290 INPUT "BEGINNING WITH JANUARY OF WHAT YEAR";Y
300 ? "OK, FIGURES FOR ";N;L$;" BEGINNING IN ";Y
310 FOR J=1 TO 33
320 FOR K=1 TO N
330 Y1=INT(Y+Q*K-1)
340 ? N$(J);" FOR ";Y1
350 INPUT Z(J,K)
360 NEXT K
370 NEXT J
380 FOR J=1 TO N
390 ? "# SHARES OUTSTANDING PERIOD ";J;" ?"
400 INPUT H(J)
410 NEXT J
420 INPUT "CORRECTIONS";A$:IF LEFT$(A$,1)="N" THEN 440
430 INPUT "WHICH ACCT# & PD#";J,K:INPUT "VALUE";Z(J,K):GOTO 420
440 B=1:REM 1ST CELL POINTER
450 SWITCH
460 "DO YOU WANT A LIST OF COMPARATIVE FINANCIAL RATIOS?"
470 " PLEASE ANSWER YES OR NO. THE ALTERNATIVE IS COMPARATIVE %"
480 INPUT A$
490 IF LEFT$(A$,1)="Y" THEN 530
500 IF LEFT$(A$,1)="N" THEN 540
510 ? "PLEASE ANSWER YES OR NO"
520 GOTO 460
530 GOSUB 1030
540 INPUT "DO YOU WANT COMPARATIVE % FROM INCOMES STMT & BS";A$
550 IF LEFT$(A$,1)="Y" THEN 590
560 GOTO 940
570 ? "PLEASE ANSWER YES OR NO"
580 GOTO 540
590 GOSUB 1310
600 GOSUB 1410
610 INPUT "DO YOU WANT TO CREATE A PROFORMA INCOME STATEMENT";A$
620 IF LEFT$(A$,1)="Y" THEN 650
630 IF LEFT$(A$,1)="N" THEN 1840
640 GOTO 610
650 INPUT "DO YOU WANT TO USE % CHANGES FROM LAST PERIOD";A$
660 IF LEFT$(A$,1)="N" THEN 710
670 IF LEFT$(A$,1)="Y" THEN 690
680 GOTO 650
690 GOSUB 1510
700 GOTO 940

```

*Listing 1 continued on page 198*

These include the following: current, quick, acid test, accounts receivable in days, inventory turnover, asset turnover, profit on sales, return on assets, return on investment, earnings per share (simple), dividend payout, debt/equity, times interest earned, and book value per share. A detailed description of the use of these ratios and how they are calculated is included in the glossary at the end of this article. Percentages will be calculated for each period in two groups. Income statement items will be presented as percent of total sales; balance sheet items will be presented as percent of total assets.

In addition to the above analyses, the program will calculate pro forma income statements and balance sheets. As I mentioned earlier, a pro forma statement is a prediction of what that statement will look like at a given time. The statements for the last period are the basis upon which the program calculates pro forma statements. These may be done by assuming a constant percentage change for all accounts, or by giving dollar amounts by which each account is predicted to change. As well as calculating the pro forma statements, the program will do ratio and/or percentage analyses on the pro formas if desired. This is particularly useful when examining the effects of alternate possibilities. It is possible to come up with several alternatives for the coming period and observe the forecasted result for each one.

### Computer Program

The financial analysis program has been written in BASIC and runs in 16 K bytes or more, including the space required for BASIC, but not including the space required for the system monitor. If you are running it with only 16 K (as I do) you will either have to remove some of the remark statements from the listing or adjust the dimension (DIM) statement to handle less than ten periods.

The only peripheral-dependent part of the program is the SWITCH statement which occurs at lines 450 and 1840. This is used to switch the logical console device between user defined and the Teletype. The configuration upon which I run it allows me to set up all of the statements

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Listing 1 continued:

```

710 ? "DO YOU WANT TO MAKE INCREMENTAL CHANGES FROM"
720 INPUT "THE LAST PERIOD USING AMOUNTS OF CHANGE";A$
730 IF LEFT$(A$,1)="N" THEN 860
740 IF LEFT$(A$,1)="Y" THEN 770
750 ? "PLEASE ANSWER YES OR NO"
760 GOTO 710
770 ? "DO YOU WANT JUST THE INCOME STATEMENT (ENTER 15) OR"
780 INPUT "INCOME STATEMENT+BALANCE SHEET (ENTER ANYTHING ELSE)";Z$
790 IF Z$="IS" THEN 840
800 F=33
810 REM POINTS TO LAST ACCOUNT TO BE USED
820 GOSUB 1700
830 GOTO 860
840 F=11
850 GOSUB 1700
860 INPUT "DO YOU WANT A RATIO ANALYSIS OF THE PROFORMA (IF ANY)";A$
870 IF LEFT$(A$,1)="Y" THEN 890
880 IF LEFT$(A$,1)="N" THEN 940
890 LET N=1
900 IF Z$<>"IS" THEN 930
910 ?"CAN'T CALC WITH JUST INC STATEMENT"
920 GOTO 940
930 GOSUB 1030
940 INPUT "DO YOU WANT A % ANALYSIS OF THE PROFORMA";A$
950 IF LEFT$(A$,1)="Y" THEN 980
960 IF LEFT$(A$,1)="N" THEN 1000
970 GOTO 940
980 N=M
990 GOSUB 1310
1000 INPUT "DO YOU WANT ANOTHER PROFORMA";A$
1010 IF LEFT$(A$,1)="Y" THEN 650
1020 IF LEFT$(A$,1)="N" THEN 1840
1030 REM SUBROUTINE TO CALCULATE RATIOS
1040 FOR I=B TO N
1050 R(1,1)=Z(16,1)/Z(27,1):REM CURRENT RATIO
1060 R(2,1)=(Z(12,1)+Z(13,1))/Z(27,1):REM ACID TEST
1070 R(3,1)=365/(Z(1,1)/Z(13,1)):REM RECL DAYS
1080 R(4,1)=365/(Z(4,1)/Z(14,1)):REM INV TO
1090 R(5,1)=Z(1,1)/Z(22,1):REM ASSET TO
1100 R(6,1)=Z(11,1)/Z(1,1):REM PROFIT ON SALES
1110 R(7,1)=Z(11,1)/Z(22,1):REM ROA
1120 R(8,1)=Z(11,1)/(Z(33,1)-Z(29,1)):REM ROI
1130 R(9,1)=Z(11,1)/H(1):REM EPS
1140 R(10,1)=Z(9,1)/Z(11,1):REM DIV PD
1150 R(11,1)=Z(29,1)/Z(22,1):REM D/E
1160 R(12,1)=(Z(11,1)+Z(9,1)+Z(8,1)+Z(7,1))/Z(7,1):REM T.I.E
1170 R(13,1)=(Z(33,1)-Z(29,1))/H(1):REM BK/SHARE
1180 NEXT I
1190 INPUT "MOVE PAPER TO TOP OF PAGE & PRESS A KEY";A$
1200 ? C$,"RATIO ANALYSIS":?
1210 ? "RATIOS FOR ";N;L$;" BEGINNING IN ";Y: ?
1220 FOR I=1 TO 13
1230 ? R$(I)
1240 FOR J=B TO N
1250 Y1=INT(Y+Q*J-1)
1260 ? Y1,R(I,J)
1270 NEXT J
1280 NEXT I:?:?:?
1290 RETURN
1300 REM SUBROUTINE TO DO % ANALYSIS
1310 INPUT "MOVE PAPER TO TOP OF PAGE & PRESS A KEY";A$
1320 ? "INCOME STATEMENT ITEMS AS % OF TOTAL INCOME"
1330 FOR I=1 TO 11
1340 ? N$(I)
1350 FOR J=B TO N
1360 Y1=INT(Y+Q*J-1)
1370 R(J,1)=Z(I,J)/Z(3,J)*100
1380 ? Y1,R(J,1):NEXT J
1390 NEXT I: ?
1400 RETURN
1410 ? "E.S. ITEMS AS % OF TOTAL ASSETS": ?
1420 FOR I=12 TO 33
1430 ? N$(I)
1440 FOR J=1 TO N
1450 Y1=INT(Y+Q*J-1)
1460 R(J,1)=Z(I,J)/Z(22,J)*100
1470 ? Y1,R(J,1):NEXT J
1480 NEXT I:?:?:?
1490 RETURN
1500 REM SUBROUTINE TO CALCULATE PROFORMA WITH % CHANGES
1510 M=N+1:REM SAVE LAST CELL POINTER
1520 B=M
1530 FOR I=1 TO 9
1540 ? "CHANGE FOR ";N$(I)

```

Listing 1 continued on page 200

using a video display and then have the results printed on the Teletype. If your system does not allow for the SWITCH command, you can leave it out with no ill effects.

If you have more than 16 K bytes of memory, you may want to extend the strings from lines 60 thru 120 and 140 thru 150. This will make the output more readable.

## Glossary

**accounts receivable in days:** *Accounts receivable are divided by total sales to produce receivable turnover per year, then divided by 365. This gives some indication of how fast receivables are being collected. Values vary with industry. Generally, the lower the number of days, the better.*

**asset turnover:** *Net sales divided by average total assets. This is one indication of how well assets are being used.*

**book value per share:** *Common stock divided by the number of shares. How much the shares of stock are worth in an accounting sense.*

**current ratio:** *A current account is cash or anything which can be converted into cash within one year. The current ratio is obtained by dividing the current assets by current liabilities. If the ratio is one, debts which must be paid within one year are just covered by assets which are expected to be received within one year. To maintain financial peace of mind the current ratio should be greater than one.*

**debt/equity ratio:** *Total liabilities divided by total assets (also referred to as total equities). How much of the firm's capital was furnished by creditors as opposed to owners. It varies by industry, but the lower the better for safety, and the higher the better for earnings per share. This contradiction is due to something called leverage, which is a fancy term for investing other people's money and keeping the profits.*

**dividend payout:** *Cash dividends divided by net income. This shows how much of earnings were paid to investors as opposed to those kept for*

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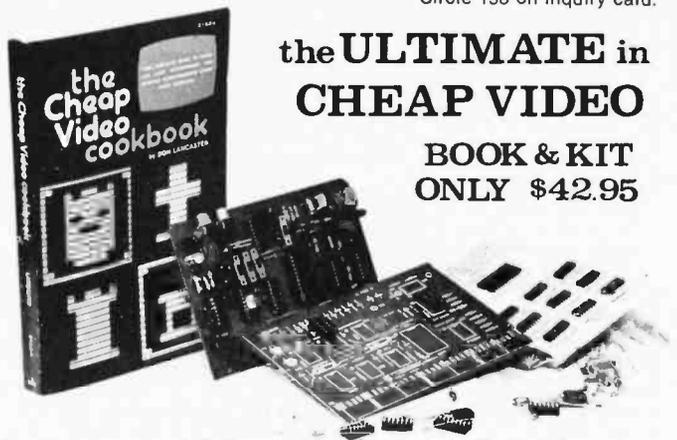
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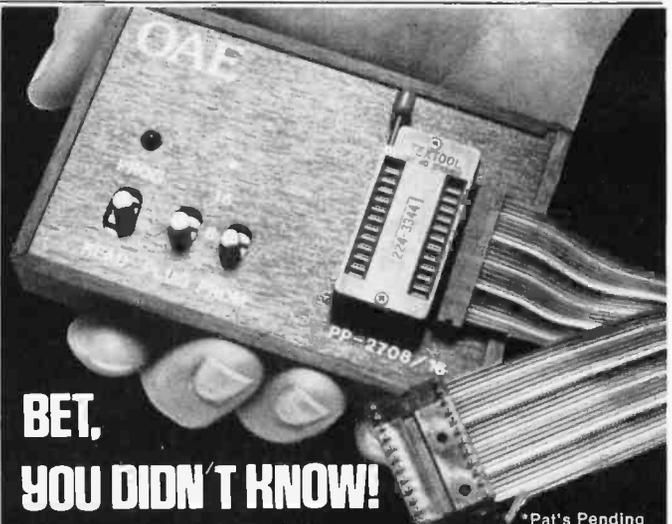
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Listing 1 continued:

```

1550 INPUT P
1560 Z(1,M)=Z(1,(M-1))*(1+(P/100))
1570 NEXT I
1580 LET Z(3,M)=Z(1,M)+Z(2,M)
1590 Z(10,M)=0
1600 FOR I=4 TO 9
1610 LET Z(10,M)=Z(10,M)+Z(1,M)
1620 Z(11,M)=Z(3,M)-Z(10,M)
1630 NEXT I
1640 INPUT"MOVE PAPER TO TOP OF PAGE AND PRESS A KEY";A$
1650 ? C$=?
1660 FOR I=1 TO 11
1670 ? N$(I),Z(1,M)
1680 NEXT I:?:?:?
1690 RETURN
1700 REM CALCULATE PROFORMA WITH INCREMENTALS
1710 M=N+1
1720 B=M
1730 FOR I=1 TO F
1740 ?"AMOUNT OF CHANGE FOR ";N$(I)
1750 INPUT P
1760 LET Z(1,M)=Z(1,(M-1))+P
1770 NEXT I
1780 INPUT"MOVE PAPER TO TOP OF PAGE & PRESS A KEY";A$
1790 ? C$=?
1800 FOR I=1 TO F
1810 ? N$(I),Z(1,M)
1820 NEXT I:?:?:?
1830 RETURN
1840 SWITCH
1850 END

```

DO YOU WANT A LIST OF COMPARATIVE FINANCIAL RATIOS?  
PLEASE ANSWER YES OR NO. THE ALTERNATIVE IS COMPARATIVE 1  
? YES  
MOVE PAPER TO TOP OF PAGE & PRESS A KEY?

K

RATIO ANALYSIS	
RATIOS FOR 2 YEARS BEGINNING IN 1974	
CURRENT	
1974	.53159
1975	.907047
ACID	
1974	.0961952
1975	.301513
RCBL TO	
1974	13.6149
1975	29.1469
INV TO	
1974	122.291
1975	110.652
ASSET TO	
1974	1.97689
1975	2.16097
PROF ON SALES	
1974	-.223032
1975	.0963033
ROA	
1974	-.440909
1975	.208109
ROI	
1974	1.04041
1975	2.08394
EPS	
1974	-.237236
1975	.329392
PAYOFF	
1974	0
1975	0
EBT-EQU	
1974	1.42378
1975	.900137
T INT EARNED	
1974	-6.1368
1975	8.80243
BK/SHARE	
1974	-.228021
1975	.158062

Listing 1 continued on page 201

use by the firm. This should be high for an income stock and low for a growth stock (all other things being equal).

**earnings per share:** How much the firm made per share of common stock. Often this and the price/earnings ratio are the only things investors look at. There are actually two ways of calculating the earnings per share ratio; the more complicated one would require a program much longer than that provided in this article. Both types of earnings per share ratios are required in annual reports, so it is best to rely on both for needed information if a firm has a complicated capital structure.

**inventory turnover:** The cost of goods sold is divided by average inventory, and this is divided by 365.

**profit on sales:** Net income divided by net sales. This provides a very conservative estimate of profits. Therefore, it is frequently used when companies wish to appear as though they are not making much of a profit.

**quick ratio (acid test):** Unlike the current ratio, the quick ratio does not consider inventory and prepaid expenses as current assets. The quick ratio takes cash, marketable securities, and accounts receivable, and divides these by current liabilities. The result is the proportion of liabilities falling due within one year, which can be covered by assets sure to be worth cash. It is normally a little less than one.

**return on assets:** Net income divided by average total assets. How much you are making on what you have to make it with. As with any profit measure, the higher the better.

**return on investment:** Net income divided by the quantity assets minus liabilities. This shows how much the firm made on what the owners put into it. Assets which were bought with borrowed money are not included in the base.

**times interest earned:** The quantity of net income plus interest and tax payments divided by interest charges. This indicates how much more the firm made than was required to pay the interest on its debt. A firm which has a times interest earned ratio of less than one is bankrupt.

Listing 1 continued:

DO YOU WANT COMPARATIVE % FROM INCOMES STMT & BS? YES

MOVE PAPER TO TOP OF PAGE & PRESS A KEY?

K  
INCOME STATEMENT ITEMS AS % OF TOTAL INCOME

SALES	
1974	100
1975	100
OTH REV	
1974	0
1975	0
TOT INC	
1974	100
1975	100
CGS	
1974	82.7711
1975	65.1867
DEPR	
1974	2.08339
1975	1.88227
SGA	
1974	34.2408
1975	21.8118
INT	
1974	3.12509
1975	1.23427
TAX	
1974	0
1975	0
DIV	
1974	0
1975	0
TOTAL EXP	
1974	39.5321
1975	25.183
NET INC	
1974	-22.3032
1975	9.63033

B.S. ITEMS AS % OF TOTAL ASSETS

CASH	
1974	6.3007
1975	7.49898
RCBLS	
1974	7.37402
1975	17.2563
INV	
1974	54.823
1975	42.7045
PPD ITEMS	
1974	6.99943
1975	6.98874
TOT CUR	
1974	75.5686
1975	74.4719
LAND	
1974	0
1975	0
BLDG/EQU	
1974	36.374
1975	31.3656
ACC DEP?	
1974	11.992
1975	7.95155
TOT FIXED	
1974	24.382
1975	23.4141
OTH AS	
1974	.0494237
1975	2.11405
TOT ASSETS	
1974	100
1975	100
ACCTS PEL	
1974	35.2718
1975	22.1241
NOTES PEL	
1974	83.8067
1975	21.4354
CUR LT	
1974	1.77143
1975	2.61975
OTHER LIAB	
1974	21.3059
1975	35.9244

CUR LIAB	
1974	142.156
1975	82.1036
LT DEBT	
1974	.222407
1975	7.91007
TOT LIAB	
1974	142.378
1975	90.0137
C STK	
1974	1.85936
1975	.6318
APIC	
1974	51.6014
1975	19.6497
RE	
1974	-95.8391
1975	-10.2218
TOT CR	
1974	100
1975	100

DO YOU WANT TO CREATE A PROFORMA INCOME STATEMENT? YES

DO YOU WANT TO USE % CHANGES FROM LAST PERIOD? YES

CHANGE FOR SALES

? 100

CHANGE FOR OTH REV

? 0

CHANGE FOR TOT INC

? 100

CHANGE FOR CGS

? 50

CHANGE FOR DEPR

? 50

CHANGE FOR SGA

? 50

CHANGE FOR INT

? 50

CHANGE FOR TAX

? 50

CHANGE FOR DIV

? 50

MOVE PAPER TO TOP OF PAGE AND PRESS A KEY?

MTS

SALES	6.48154E+06
OTH REV	0
TOT INC.	6.48154E+06
CGS	3.16893E+06
DEPR	91500
SGA	1.06031E+06
INT	60000
TAX	0
DIV	0
TOTAL EXP	4.38063E+06
NET INC	2.10091E+06

DO YOU WANT A % ANALYSIS OF THE PROFORMA? YES

MOVE PAPER TO TOP OF PAGE & PRESS A KEY?

K  
INCOME STATEMENT ITEMS AS % OF TOTAL INCOME

SALES	
1976	100
OTH REV	
1976	0
TOT INC	
1976	100
CGS	
1976	48.89
DEPR	
1976	1.4117
SGA	
1976	16.3588
INT	
1976	.925705
TAX	
1976	0
DIV	
1976	0
TOTAL EXP	
1976	67.5862
NET INC	
1976	32.4138

DO YOU WANT ANOTHER PROFORMA? NO

# Another Plotter to Toy With, Revisited

## Design and Construction Details

---

Robert K Newcomb  
502 Washington Ave  
Wilmette IL 60091

---

Following the suggestion of Peter Lucas in the February 1979 issue of BYTE ("Another Plotter to Toy With," page 66) I built a plotter using an Etch-A-Sketch and two stepper motors. After solving the interface problem, I connected it to an I/O (input/output) port on my KIM-1 which is equipped with a teletypewriter, 8 K bytes of extra memory, and Tiny BASIC. Photo 1 shows the result: stepper motors mounted on the Etch-A-Sketch, along with a circuit board. The KIM-1 controls the apparatus using 4 bits of an I/O port. The stepper motors can be driven by any other computer having 4 bits of transistor-transistor logic (TTL) level output available.

The Etch-A-Sketch proved to be able to draw bar graphs with excellent results, drawing an even, horizontal baseline, while accurately reproducing data from the computer's memory. I later tried geometric figures, including a parabola. Because each step is only 0.0085 inches (0.216 mm), the device gives good approximations of curves. The main limitation of my plotting system resides in the inability of Tiny BASIC to handle fractional numeric values.

### Stepping Motors and Drivers

North American Philips series 82701 stepping motors were chosen for drivers, even though the Etch-A-Sketch does not require all of the torque that these motors can produce. The extra torque will come in

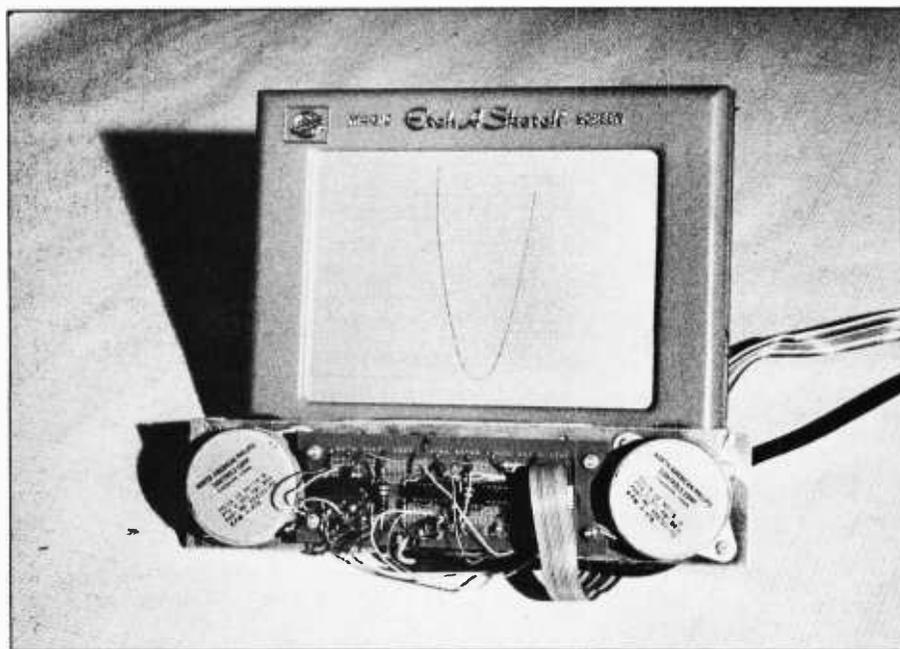


Photo 1: The stepper motor and control assembly is mounted on the Etch-A-Sketch. The knobs have been removed to allow attachment of the driven gears to the shafts.

handy if you later wish to drive something else. The motors are driven by North American Philips (or Signetics) SAA 1027 driver integrated circuits which produce the succession of pulses needed to energize the four windings on each motor. Each driver receives toggling pulses to rotate the motor shaft, while a high or low-level signal on the rotation input determines direction. A single 7406 buffer takes 5 V from the output ports and provides 12 V switching to both

drivers. Figure 1 shows the circuit diagram. Each motor has an output torque of 7 ounce-inches at fifty steps per second and drives the Etch-A-Sketch through a 5 to 8 reduction gear.

### Electrical Construction

A pre-etched and drilled Calectro J4-404 circuit board was used, after I sawed off the ends (to clear the stepper motors) and drilled holes for stand-offs. Two 14-pin integrated cir-

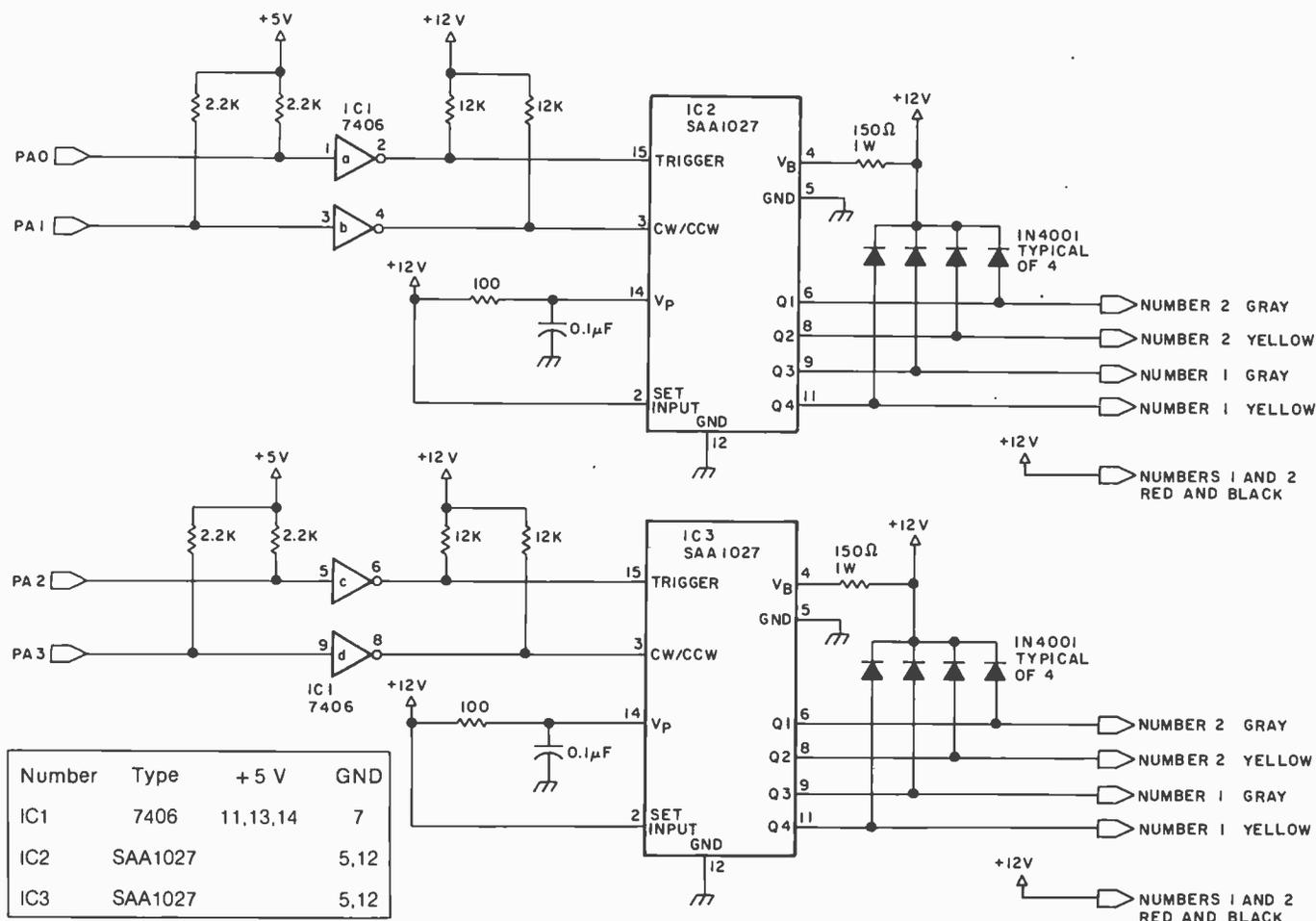


Figure 1: Schematic diagram of the stepper motor control and drive circuit. The integrated circuit IC2 controls the X axis; IC3 drives the motor for the Y axis.

cuit sockets were mounted, one for the 7406 buffer and one to receive flat wire connections from the computer. For the 12 V power supply, run a two conductor, #18 cord directly to a fused (1½ A) unregulated 12 V power supply (18 V maximum peak). Number 22 wire should be used for all other connections. The last step in wiring should be to connect the stepper motors.

### Mechanical Construction

The motor frame is a 3/16 inch (0.476 cm) thick aluminum plate, cut to 2½ by 11 inch (6.35 by 27.94 cm) dimensions, with the stepping motors mounted on 8¼ inch (20.95 cm) centers to match the Etch-A-Sketch. You must drill clearance holes for the motor shafts (big enough to clear the twenty-tooth gears), and drill for the following items: four holes for circuit board stand-offs, two mounting holes per motor, and two holes at each end for the locating pieces that center the Etch-A-Sketch under the motor

mount. Use of a drill press speeds up this work considerably. These locating pieces are 3/8 by 1 by 1½ inches (0.95 by 2.54 by 4.76 cm) long and are tapped at the top for two screws each, and at bottom for two screws which hold a ¼ by 1 by 11 inch (0.635 by 2.54 by 27.94 cm) clamp piece that keeps the motor mount and Etch-A-Sketch together. Tack or staple two pieces of 3/8 inch (0.476 cm) outside diameter rubber tubing to a piece of ¾ by 1 by 4¾ inch (1.9 by 2.5 by 12.4 cm) wood to form a cushioned spacer between the motor mount and the Etch-A-Sketch. This prevents the plastic housing from cracking and spaces the assembly so that the gears line up. The driven gears (thirty-two teeth) are screw clamped to the Etch-A-Sketch control shafts after the knobs have been pulled off the device. When you slide the Etch-A-Sketch into place, move it until the gears mesh and bottom out against one another, and then slide it back about 1/32 of

an inch (0.08 cm). Lubricate the gears with a small amount of grease.

### Programming

The first programming to be done is a routine which will rotate the stepping motors in the desired direction, one at a time. To move the Etch-A-Sketch stylus in the +Y (up) direction, output port pin PA1 should be set equal to 0 and pin PA0 is then toggled. For -Y (movement down), set PA1 to 1 and toggle PA0. Movement right and left (+X and -X) works the same way with pin PA3 setting direction. A machine language program which does this, written for the KIM-1, is given in listing 1. Figure 2 gives the flowchart, and listing 2 gives the code for a program to move the stylus along the Y axis according to data in memory, while the stylus moves one unit in the +X direction.

If a series of memory locations contain a value of 0, the stylus will move only horizontally. If a memory location contains a 1, the stylus will move

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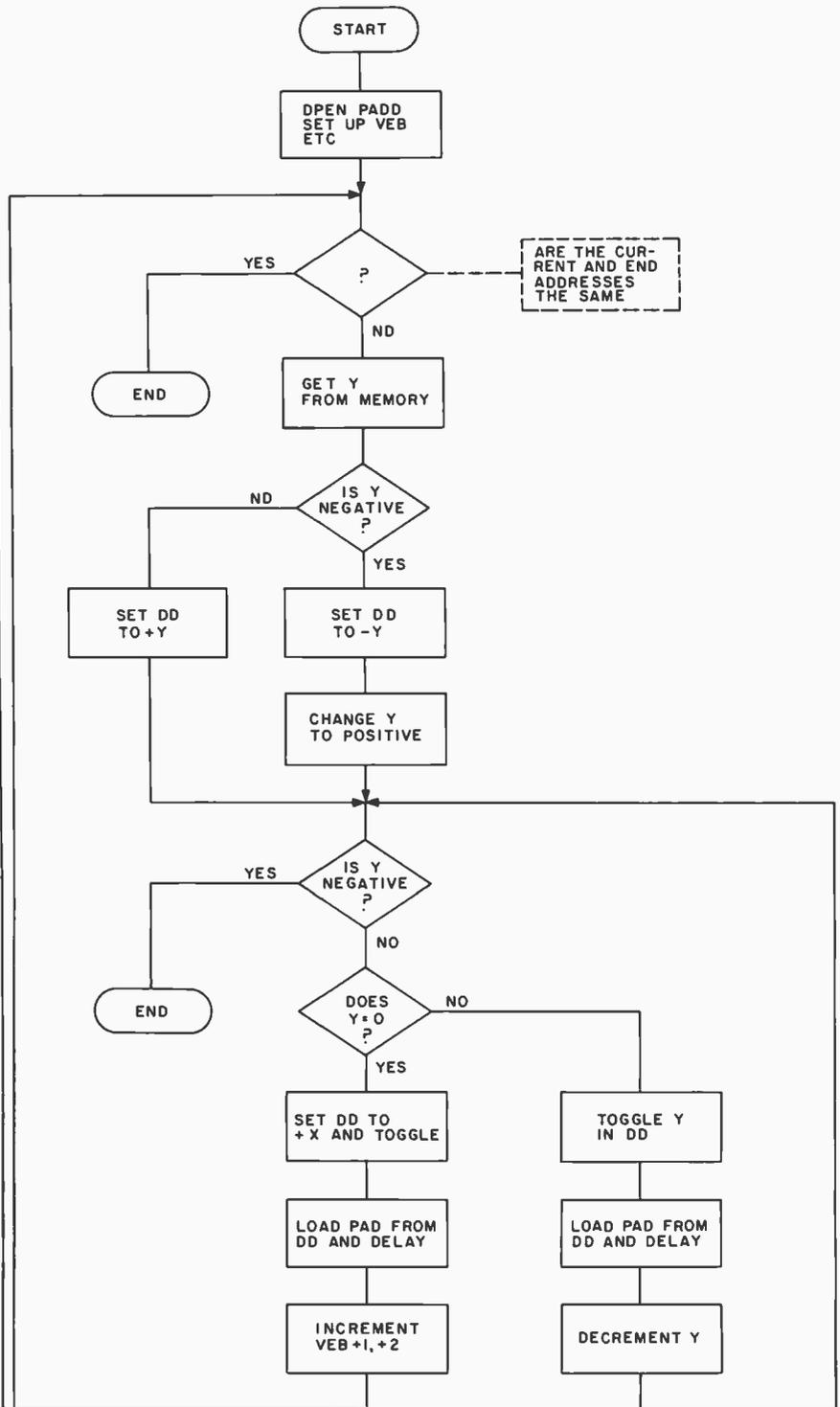


Figure 2: Flowchart of the routine in listing 2 which moves the stylus along the Y axis according to plot data in memory while maintaining constant movement along the X axis.

up at a 45° angle. To load the plotting data from BASIC, we set up two jumps to machine language subroutines as shown in listing 3. The first subroutine sets up a memory pointer. The second subroutine increments this pointer to load consecutive memory locations each time

the BASIC program calls it. A Tiny BASIC parabola plotting program using these instructions is given as listing 4.

When you set up your programs, it is nice to avoid running off the Etch-A-Sketch screen, although no harm will result. Thus you should try not

**Listing 1: Routines written in 6502 assembler for the KIM-1 to move the Etch-A-Sketch stylus along a single axis by individually activating the stepper motors.**

Address	Hexadecimal Code	Label	Op Code Mnemonic	Operand	Commentary
3A40	A9 0F		LDAIM	\$000F	SUBROUTINE TO OPEN PADD
3A42	8D 01 17		STA	PADD	
3A45	60		RTS		
3B1C	A0 FF	SPEED	LDYIM	\$00FF	SUBROUTINE TO SET SPEED
3B1E	A2 20		LDXIM	\$0020	
3B20	CA		DEX		DECREMENT X, LOOP IF NOT 0
3B21	D0 FD		BNE	\$3B20	
3B23	88		DEY		DECREMENT Y, LOOP IF NOT 0
3B24	D0 F8		BNE	\$3B1E	
3B26	A5 DE		LDAZ	\$00DE	RESTORE X AND Y
3B28	AA		TAX		
3B29	A5 DF		LDAZ	\$00DF	
3B2B	A8		TAY		RESTORE X AND Y
3B2C	60		RTS		
3A46	20 40 3A		JSR	\$3A40	MOVES STYLUS IN PLUS Y DIRECTION UNTIL INTERRUPTED
3A49	A9 01		LDAIM	\$0001	
3A4B	8D 00 17		STA	PAD	SET Y ROTATION OFF, Y TRIGGER ON DELAY APPROPRIATELY
3A4E	20 1C 3B		JSR	SPEED	
3A51	A9 00		LDAIM	\$00	SET Y TRIGGER OFF
3A53	8D 00 17		STA	PAD	
3A56	20 1C 3B		JSR	SPEED	MOVES STYLUS IN MINUS Y DIRECTION UNTIL INTERRUPTED
3A59	4C 49 3A		JMP	\$3A49	
3A66	20 40 3A		JSR	\$3A40	UNTIL INTERRUPTED
3A69	A9 03		LDAIM	\$0003	
3A6B	8D 00 17		STA	PAD	SET Y ROTATION ON, Y TRIGGER ON
3A6E	20 1C 3B		JSR	SPEED	
3A71	A9 02		LDAIM	\$0002	MOVES STYLUS IN PLUS X DIRECTION UNTIL INTERRUPTED
3A73	8D 00 17		STA	PAD	
3A76	20 1C 3B		JSR	SPEED	SET X ROTATION OFF, X TRIGGER ON
3A79	4C 69 3A		JMP	\$3A69	
3A86	20 40 3A		JSR	\$3A40	UNTIL INTERRUPTED
3A89	A9 04		LDAIM	\$0004	
3A8B	8D 00 17		STA	PAD	SET X ROTATION ON, X TRIGGER ON
3A8E	20 1C 3B		JSR	SPEED	
3A91	A9 00		LDAIM	\$00	MOVES STYLUS IN MINUS X DIRECTION UNTIL INTERRUPTED
3A93	8D 00 17		STA	PAD	
3A96	20 1C 3B		JSR	SPEED	SET X ROTATION ON, X TRIGGER ON
3A99	4C 89 3A		JMP	\$3A89	
3AA6	20 40 3A		JSR	\$3A40	UNTIL INTERRUPTED
3AA9	A9 0C		LDAIM	\$000C	
3AAB	8D 00 17		STA	PAD	SET X ROTATION ON, X TRIGGER ON
3AAE	20 1C 3B		JSR	SPEED	
3AB1	A9 08		LDAIM	\$0008	MOVES STYLUS IN MINUS X DIRECTION UNTIL INTERRUPTED
3AB3	8D 00 17		STA	PAD	
3AB6	20 1C 3B		JSR	SPEED	SET X ROTATION ON, X TRIGGER ON
3AB9	4C A9 3A		JMP	\$3AA9	

**Listing 2: Program written for the KIM-1 which moves the stylus along the X axis at a constant rate while movement along the Y axis is varied according to plot data stored in memory.**

Address	Hexadecimal Code	Label	Op Code Mnemonic	Operand	Commentary	
3B11	A5 DD	LODPAD	LDAZ	\$00DD	THIS ADDS LOADING OF THE OUTPUT PORT TO THE TIMING SUBROUTINE OF LISTING 1	
3B13	8D 00 17		STA	PAD		
3B16	8A		TXA			
3B17	85 DE		STAZ	\$00DE		
3B19	98		TYA			
3B1A	85 DF		STAZ	\$00DF	THIS IS THE PROGRAM SHOWN IN FIGURE 2. ZERO PAGE LOCATIONS CC THROUGH CF ARE VECTOR EB. LOCATION DD IS STORAGE FOR PORT A DATA	
3B30	A9 0F		LDAIM	\$000F		
3B32	8D 01 17		STA	PADD		
3B35	ADF5 17		LDA	SAL		
3B38	85 CC		STAZ	CURADL		
3B3A	ADF6 17		LDA	SAHI		
3B3D	85 CD		STAZ	CURADH		
3B3F	A9 AD		LDAIM	\$00AD		
3B41	85 CB		STAZ	GETY		
3B43	A9 A8		LDAIM	\$00A8		
3B45	85 CE		STAZ	\$00CE		
3B47	A9 60		LDAIM	\$0060		
3B49	85 CF		STAZ	\$00CF		
3B4B	A5 CC	COMEND	LDAZ	CURADL		COMPARE VEB + 1, VEB + 2 WITH END ADDRESS
3B4D	CD F7 17		CMP	ENDALO		

*Listing 2 continued on page 206*

Listing 2 continued:

3B50	A5 CD		LDAZ	CURADH	
3B52	ED F8 17		SBC	ENDAHI	
3B55	B0 43		BCS	END	TO END IF ADDRESSES MATCH
3B57	20 CB00		JSR	GETY	
3B5A	10 0E	YPLUS	BPL	SETPLS	Y POSITIVE
3B5C	A9 02		LDAIM	\$0002	
3B5E	05 DD		ORAZ	\$00DD	SET ROTATION IN DD FOR - Y
3B60	85 DD		STAZ	\$00DD	
3B62	98	MITOPL	TYA		CHANGE - Y TO + Y
3B63	49 FF		EORIM	\$00FF	
3B65	A8		TAY		
3B66	C8		INY		
3B67	4C 70 3B		JMP	YMINUS	JUMP PAST SET PLUS ROTATION
3B6A	A9 FD	SET PLS	LDAIM	\$00FD	SET Y ROTATION FOR PLUS
3B6C	25 DD		ANDZ	\$00DD	
3B6E	85 DD		STAZ	\$00DD	
3B70	98	YMINUS	TYA		Y IS STILL MINUS, END ROUTINE
3B71	30 27		BMI	END	
3B73	F0 0D		BEQ	\$3B82	Y = 0, BRANCH
3B75	A9 01	TOGY	LDAIM	\$0001	TOGGLE Y IN DD
3B77	45 DD		EORZ	\$00DD	
3B79	85 DD		STAZ	\$00DD	
3B7B	20 11 3B		JSR	LODPAD	LOAD PAD FROM DD AND DELAY
3B7E	88		DEY		DECREMENT Y
3B7F	4C 70 3B		JMP	YMINUS	JUMP BACK TO SECOND "IS Y MINUS"
3B82	A9 07		LDAIM	\$0007	SET DD TO PLUS X
3B84	25 DD		ANDZ	\$00DD	
3B86	85 DD		STAZ	\$00DD	
3B88	A9 04	TOGX	LDAIM	\$0004	TOGGLE X IN DD
3B8A	45 DD		EORZ	\$00DD	
3B8C	85 DD		STAZ	\$00DD	
3B8E	20 11 3B		JSR	LODPAD	LOAD PAD FROM DD AND DELAY
3B91	E6 CC		INCZ	CURADL	INCREMENT VEB + 1
3B93	D0 02		BNE	\$3B97	
3B95	E6 CD		INCZ	CURADH	INCREMENT VEB + 2
3B97	4C 4B 3B		JMP	COMEND	REPEAT
3B9A	00	END	BRK		END

Listing 3: Machine language subroutines which are called from the Tiny BASIC program of listing 4. The first routine sets up a memory pointer. The second routine increments the pointer to load consecutive memory locations each time the BASIC program calls it.

Address	Hexadecimal Code	Label	Op Code Mnemonic	Operand	Commentary
1780	A9 8D		LDAIM	\$008D	SET UP MEMORY POINTER WITH
1782	85 DA		STAZ	\$00DA	MEMORY STARTING ADDRESS
1784	A9 00		LDAIM	\$00	SET LOW STARTING ADDRESS
1786	85 DB		STAZ	SUBPAD	
1788	A9 02		LDAIM	\$0002	SET HIGH STARTING ADDRESS
178A	85 DC		STAZ	\$00DC	STARTING ADDRESS DEFAULT
178C	A9 60		LDAIM	\$0060	IS 0200.
178E	85 DD		STAZ	\$00DD	
1790	60		RTS		RETURN
1791	20 DA00		JSR	\$00DA	LOAD MEMORY WITH CONTENTS
1794	E6 DB		INCZ	SUBPAD	OF ACCUMULATOR
1796	D0 02		BNE	\$179A	
1798	E6 DC		INCZ	\$00DC	INCREMENT MEMORY POINTER
179A	60		RTS		RETURN

Listing 4: Program written for the KIM-1 in Tiny BASIC to plot a parabola using the machine language routines of listing 3.

```

100 LET N = USR (6016)
105 REM THIS IS 1780 HEXADECIMAL
110 LET C = - 120* 120/10
120 LET A = - 119
130 LET B = A*A/10
140 LET D = B - C
150 LET C = B
160 IF D = - 2 THEN LET D = - 3
190 IF D = 2 THEN LET D = 3
200 LET D = D/3
210 LET N = USR(6033,0,D)
215 REM THIS EQUALS 1791 HEXADECIMAL
216 REM SUBROUTINE IS ENTERED WITH D IN ACCUMULATOR
220 LET A = A + 1
230 IF A > 120 GOTO 250
240 GOTO 130
250 END

```

## Parts List

2 gears: Sterling S1268ZS20AP1 (32 pitch, 32 teeth) or equivalent  
2 hubs: Sterling E62-4 (3/16 inch bore for above) or equivalent  
2 gears: Sterling S1086ZH2920P1 (32 pitch, 20 teeth, 1/4 Inch bore) or equivalent  
2 stepper motors: North American Phillips Controls Corp K82701P2  
2 stepper motor driver Integrated circuits: Signetics SAA1027  
1 circuit board: Calectro J4-404  
Miscellaneous sheet aluminum and screws, wood block, and rubber tubing.

A limited quantity of kits of the above items (ready to assemble with no cutting or drilling necessary) are available from the author for \$109 postpaid, plus tax for Illinois residents.

The following items are stocked by most electronic distributors:

2 16-pin soldertail integrated circuit sockets  
2 14-pin soldertail integrated circuit sockets  
1 type 7406 integrated circuit hex inverting driver  
4 2.2K ohm 1/4 W resistors  
4 12K ohm 1/4 W resistors  
2 100 ohm 1/2 W resistors  
2 150 ohm 1 W resistors  
2 0.1  $\mu$ F 36 V capacitors  
8 1N4001 rectifier diodes  
1 0.001  $\mu$ F 16 V capacitor

to use more than 790 (decimal) memory locations in the program of listing 3. The total of all negative or positive numbers in the parabola plotting program of listing 4 should be less than decimal 558.

The stepper drivers generate some electrical noise. I have no trouble with BASIC crashing, provided that the 12 V supply is off. For cassette recording, both 12 V and 5 V supplies should be off. For playback, both supplies can be on. Before disconnecting the I/O ports from the Etch-A-Sketch, push reset (RS) to switch the ports to their high impedance position. This eliminates the possibility of destroying the 7406 buffer device.

Once you have loaded the program into memory and have stored it on a cassette, plug the connections from the 7406 buffer into your computer and turn on the 12 V supply (with the 1 1/2 A fuse in place). Using the monitor, execute the appropriate subroutines from listing 1 to move the stylus to the desired origin (typically upper left). Starting execution at hexadecimal location 3B30 will plot whatever data is contained in memory.

With experience in programming, you can set up a grid against which plotting can be done. The fine line produced by the Etch-A-Sketch makes measuring easy. Two advantages of the Etch-A-Sketch are that you don't use any memory preserving information on the screen, and the device is completely nonvolatile.

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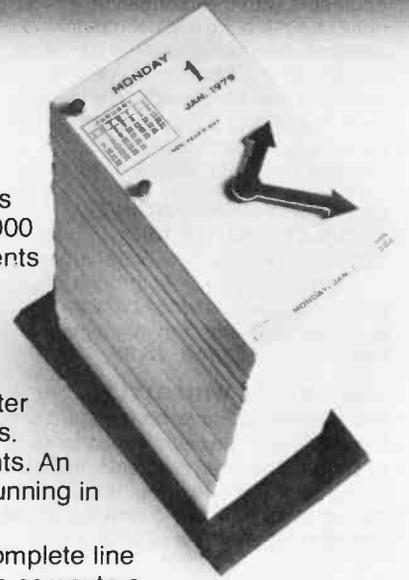
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Those interested in more details may contact Paul L Hazan, Assistant to the Director for Advanced Computer Technology, Johns Hopkins University, Applied Physics Laboratory, Johns Hopkins Rd, Laurel MD 20810. ■

## BYTE's Bugs

### Chess Moves Rechecked

Thanks to John Gropper for pointing out an error in "Alpha-Beta Pruning," by W D Maurer (November 1979 BYTE, page 84). Figure 1 gives white's second move as Q-N7. The correct move is Q-N8. The move is shown correctly in figure 2. ■

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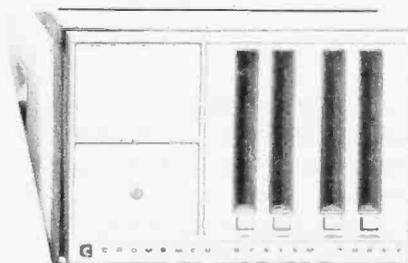
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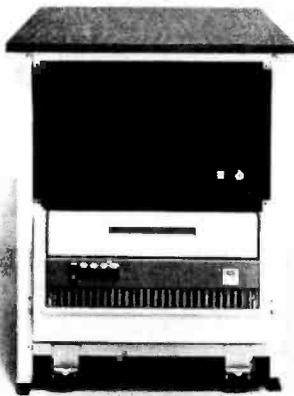


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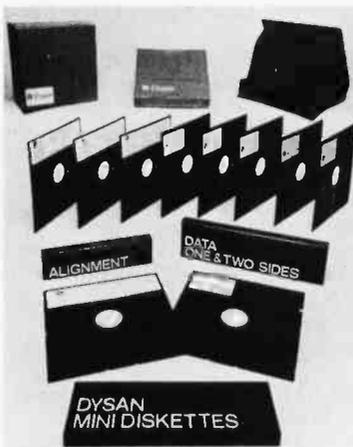
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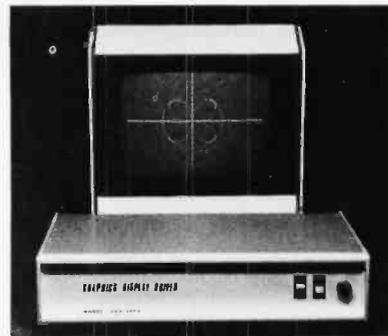
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Circle 460 on inquiry card.

### Word Processor for Apple II and Apple II Plus Systems

Super-Text is a multiple paging system that allows users to view two text screens simultaneously, keep notes or instructions on one text screen and edit on the other. It features full floating cursor and cursor control; insertion and deletion of characters, words or lines; tabbing; justification; full scrolling; movement to the last change made in the text; global search and replace; block operations; and advanced file handling and print controls. The system runs in 48 K bytes of memory and costs \$99.95. It is available from Muse Co, 7112 Darlington Dr, Baltimore MD 21234.

Circle 461 on inquiry card.

### Text Formatter for UCSD Pascal Systems

Using the Moonshadow Text Formatter, documents produced with the screen editor are post-processed to provide underlining, automatic pagination, and other essential text-processing functions. It takes standard Pascal text files, operates on them, and sends fully formatted text output to the console display, a printer, or a disk file. Moonshadow Text Formatter provides a full range of formatting functions, plus advanced features such as combining of files into one document, variables in text (for form letters), and output character translation (for printers using nonstandard character sets).

The program is written in UCSD Pascal and works on systems using either North Star 5-inch floppy disks or IBM format 8-inch floppy disks. It is available from Merrimack Systems, POB 5218, Redwood City CA 94063, for \$99.

Circle 462 on inquiry card.

### APL for the 8080, 8085, and Z80

Softronics APL has most of the functions and operators of full APL, including n-dimensional inner and outer product, reduction, compression, general transpose, reversal, take, drop, execute and format, system functions and variables, and system commands. It runs under the CP/M operating system, residing in 30 K bytes of memory. In addition to standard ASCII mnemonic representations, it supports typewriter and bit-pairing ASCII-APL character sets. The shared variable mechanism allows CP/M disk input and output. Softronics APL comes with an optional driver program for video display with programmable character generator. It is priced at \$350 on disk, with a user's manual. For more information, contact Softronics, 36 Homestead Ln, Roosevelt NJ 08555.

### Double-Sided Dual Disk Drive

The Micro Squared M-250 unit is capable of single or double density and consists of two double-sided drives, a power supply, cable, and chassis. It has 140 tracks, with a capacity of 358 K bytes of memory. The double-density feature allows 875 K bytes of memory storage. The unit also features a write protect sensor, time erase timing circuits internal to the disk drive, and has a sensor that stops the spindle drive motor rotation when no disk is installed. The unit costs \$1195 and is available from Micro Squared Inc, Suite 5B, 7131 Owensmouth Ave, Canoga Park CA 91303.

Circle 463 on inquiry card.

### Pertec Introduces 8-Inch, 20 M Byte Winchester Drive

This new drive will use a limited motion, 50 ms average access rotary positioner. The Mini-Wini can perform diagnostic routines without the help of the central processing unit by creating a bidirectional bus interface using a 6801 microprocessor. The Mini-Wini has the same physical dimensions, mounting scheme and voltage requirements as floppy disk drives, but offers more storage space than floppy disks. The price is \$3000 and is available from Pertec Computer Corp, 9600 Irondale, Chatsworth CA 91311.

Circle 464 on inquiry card.

# What's New?

## SOFTWARE

### North Star List Processor

HELPH5 is a collection of subroutines which use dynamic memory assignment to perform list processing. The user can create a sequential set of array elements which describe objects. By filing sets on and removing sets from various lists, complex processes can be simulated. Available subroutines include Create, Destroy, File First, File Last, File Ranked—which places an entity on a sorted list based on the value of a selected array element—Remove First, Remove Last, and Remove. Four debug-

ging routines allow the user to print all the objects on a list, determine if a particular object is on a specified list, if an array element has a specified value, and print the array elements for a particular entity.

HELPH5 is written in North Star BASIC and needs a minimum of 32 K bytes of programmable memory. The price is \$48, including a user's manual and sample simulation program. Contact American Planning Corp, 4600 Duke St, Suite 425, Alexandria VA 22304.

Circle 465 on inquiry card.

### NEVADA COBOL for Microcomputers

NEVADA COBOL translates source language programs into machine language on 8080, Z80 and 8085 microprocessors. Designed for small businesses using microcomputers, it features random access file support; sequential files, both fixed and variable length; debugging capability; copy statement; character string, 16-bit binary and packed decimal (COMP-3); 18-bit accuracy; hexadecimal non-numeric

literals; and an interactive ACCEPT/DISPLAY. The compiler, which is a subset of ANSI-74, generates programs at a rate up to 650 lines per minute on an 8080-based system. Operating under Processor Technology's operating system (PTDOS), the compiler requires a minimum of 32 K bytes of programmable memory. *The NEVADA COBOL Programmers Reference Manual* is available for \$25 and the Diskette is \$275, from Ellis Computing, 1480 17th Ave, San Francisco CA 94122.

Circle 466 on inquiry card.

### Library Cross-Reference for Floppy Disks

The CATALOG system provides a means to index up to 200 single- or double-density 5-inch floppy disks. Using the alphabetical lists of files produced by CATALOG, any program or data file can be located in a few seconds. The name, extension, size, date and disk number for each file is listed in each of three reports. These reports are organized by the date within extension within name, extension within name within disk number, and date within

name within extension. A list of disks is provided after each use of the CATALOG program. The program runs on 8080 or Z80 microprocessors with 48 K bytes of memory, floppy disk, video display and printer. The program requires CP/M with Microsoft MBASIC or MITS/Pertec Disk Extended BASIC. The SORT System is required for use of CATALOG. The CATALOG System is priced at \$95 and is available from the Software Store Ltd, 706 Chippewa Sq, Marquette MI 49855.

Circle 467 on inquiry card.

### 6809 Systems Software

Technical Systems Consultants Inc, POB 2574, W Lafayette IN 47906, has developed software which includes a 6809 version of the popular FLEX disk operating system, a text editor, a resident assembler, BASIC interpreter, and an assembly language debug package. Most software written for 6800 FLEX can be reassembled for 6809 by changing any equates into FLEX to the proper addresses. FLEX features dynamic file allocation, random and sequential files, printer spooling, batch job type program entry, automatic space compression, user start-up facility, and English error

messages. The resident 6809 assembler accepts 6809, 6800, and 6801 mnemonics so that existing software can be immediately reassembled to produce 6809 object code.

FLEX is available for the SwTPC disk systems on a 5- or 8-inch floppy disk. The other software is available on a standard 5- or 8-inch FLEX disk which may be used on any soft-sectored 6809 FLEX disk system. Cassette versions are available for all but FLEX. Including the text editor and assembler, the FLEX package is \$90. The BASIC interpreter is \$65, and the debug package is \$75.

Circle 468 on inquiry card.

### Six Software Programs for Apple Users

These six programs from Williamsville Publishing require an Apple II with 32 K bytes of programmable memory, one disk drive, Disk II, Applesoft II in read-only memory (ROM) on a firmware card. The programs include Book Library; Record Library; Malum II...Imperial Roman Programmable Computer By Command of Caesar, which takes the Latin equivalent of BASIC commands and uses Roman numerals for numeric input and output; Graphics Game; Checkbook Program; and Page Processor.

Individual disks sell for \$19.95 from Williamsville Publishing Co, POB 250, Fredonia NY 14063.

Circle 469 on inquiry card.

### Software for Radio and Television Stations

Solar Computer Systems Corp, 2360 43rd Ave E, Suite 308, Seattle WA 98112, has a series of software programs designed to run on Smoke Signal Broadcasting's Chieftan Systems that are of interest to radio and television stations. Available programs include audience measurement, attitude research, music research, lifestyle surveys, ARBITRON analyses and more. Information is available upon request.

Circle 470 on inquiry card.

### Math Program Performs Symbolic Operations for Algebra, Trigonometry, and Calculus

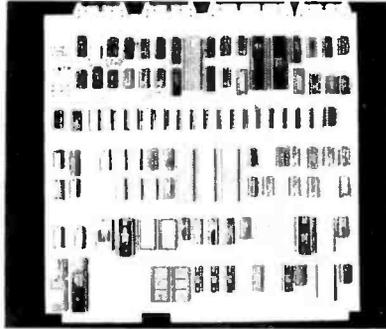
This symbolic mathematics system enables users to solve polynomial multiplications, symbolic differentiations and integrations, simplification of trigonometric expressions, and exact solutions of nonlinear equations. The muMATH-79 programs run on 8080, 8085, and Z80 systems using TRSDOS, standard CP/M, or upward compatible operating systems such as Cromemco CDOS, or IMSAI IMDOS. The program is useful for engineers and scientists in checking or deriving lengthy analytical data. It is also useful for artificial intelligence applications as well as for students and teachers in math education. The price for the package is \$190. For more information, contact The Soft Warehouse, POB 11174, Honolulu HI 96828.

Circle 471 on inquiry card.

# What's New?

## SYSTEMS

### Single Board Computer Supports Pascal



DOSC Inc, 500 Fifth Ave, New York NY 10033, has announced its TCB-85 single board microcomputer capable of supporting CP/M and Pascal. The 64 K board is compatible with Intel's Multibus and features a dual-density floppy disk controller that supports up to four disk drives or two double-sided disks, video display controller with up to 80 characters by 25 lines, RS-232 serial input/output (I/O) port, parallel printer interface, scanned keyboard interface, vectored interrupts, and three timers.

The price is \$1500 per unit.

Circle 472 on inquiry card.

### Versatile Business Manager System

This system includes a Versatile 4 Dual Drive computer, a Texas Instruments 810 RO Tractor Feed Printer, application software for business, and a movable table. The business software includes a General Ledger, Accounts Payable and Receivable, Inventory, Personnel/Payroll, and Labor Job Cost Analysis. The system is priced at under \$8500 and is available from CDS Inc, Building 3, Drummond Plaza, Newark DE 19711.

Circle 473 on inquiry card.

### Compucolor II System

Compucolor Corp, POB 569, Norcross GA 30071, has developed three models of the Compucolor II. Model 3 has 8 K bytes of programmable memory, the Model 4 has 16 K bytes, and the Model 5 provides 32 K bytes of memory. The Compucolor II uses an 8080A microprocessor and includes 16 K bytes of read-only memory. One RS-232C serial port is provided for a printer or modem. The Compucolor II features a keyboard that is separate

### Hewlett-Packard Introduces Personal Computer for Professionals

The HP-85 is a complete computer system designed for use in business and industry by engineers, scientists, accountants, and investment analysts. It can also be used in the home by hobbyists and as an instructional computer in secondary schools, colleges, and universities.

The system features a video display, thermal printer, tape cartridge, and graphics capability in a package the size of a typewriter. It is equipped with four input/output (I/O) ports to allow the user to expand the system to include plotters, printers, disk drives, and other peripherals that are already on the market.

The HP-85 comes with 16 K bytes of programmable memory and can be expanded to 32 K by plugging an optional memory module into one of the ports on the back of the machine. The graphics display is useful to engineers for plotting functions and for test analysis, and to business persons to plot statistics. The display on the screen can be easily printed out on the built-in printer.

The system has a 5-inch, high-resolution, black and white video display with 16 lines of display and 32 characters per line. The thermal printer, which operates in both alphanumeric



and graphics modes, prints two 32-character lines per second. The HP-85 tape drive uses HP Data Cartridges, which have a capacity of 200 K bytes, and feature a tape directory that enables the system to automatically find exact tape locations of recorded programs and data.

The HP-85 measures 41 by 46 by 15 cm (16 by 18 by 6 inches), and weighs 9.06 kg (under 20 pounds). It comes with a user's manual and a standard application software package that contains 15 programs. The price of the HP-85 is \$3250. For more information, contact Inquiries Manager, Hewlett-Packard Co, 1507 Page Mill Rd, Palo Alto CA 94304.

Circle 474 on inquiry card.

### 8086 and 8088-Based Microcomputers

Microbyte, 2499 Cerritos Ave, Signal Hill CA 90806, has introduced two 16-bit 8086 and 8088 microprocessor-based computers with real-time clock, priority vectored interrupts, four port serial input and output (I/O) board that supports four terminals, 32 K bytes of programmable memory, dual-density floppy disk controller that supports up to four drives with direct memory ad-

dress (DMA) data transfer, video display and keyboard, 19-slot backplane, and an interrupt switch-on from console to allow re-boot of the system without register destruction. The systems use Microbyte DOS86 batch operating system software and also feature 4 K bytes of programmable memory on-board, 24 operand addressing modes, three programmable timers, and more. The approximate prices for the 8086 and 8088 are \$4000 and \$3900, respectively.

Circle 475 on inquiry card.

from the processor and video display unit. The video terminal has erase-line and erase-page commands; two character sizes; fifteen plot modes; local, full, and half duplex modes; full cursor control; and other functions. The system uses Disk BASIC 8001 with an interpreter in read-only memory. Twenty-nine statement types, three command types, nineteen mathematical functions, and nine string functions are included.

One 5-inch floppy disk is built into

the main unit. The capacity for each side of a 5-inch disk is 51.2 K bytes.

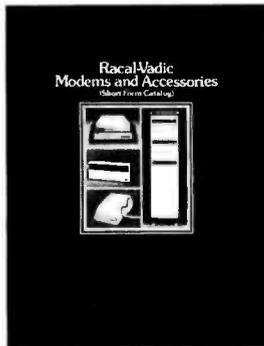
The video display features eight colors with 32 lines and 64 characters per line. The usable screen area is 23 cm (9 inches) wide by 17 cm (6.75 inches) high. Compucolor has developed software for the system including games, small business applications, home finance, and other programs. The prices for the three models are \$1495, \$1695, and \$1995.

Circle 476 on inquiry card.

# What's New?

## PUBLICATIONS

### Short Form Catalog of Modems and Accessories



This six-page catalog contains Racal-Vadic's 1200 bits per second (bps) full-duplex acoustic coupler; the "50" series of direct connect modems; and the VA3467 triple modem which emulates a Racal-Vadic VA3400 series modem, a Bell 212A, or a Bell 103. Other products include Bell-compatible 300 bps, 1200 bps half-duplex, and 2400 bps modems; CCITT compatible modems; automatic dialers; and a Multiline Automatic Calling System, which can handle up to 60 modems for each dialing port. For further information, contact Racal-Vadic, 222 Caspian Dr, Sunnyvale CA 94086.

Circle 477 on inquiry card.

### Introduction to VLSI Systems

*Introduction to VLSI Systems*, by Carver Mead and Lynn Conway, deals with the theory and practice of designing, fabrication, and implementing of silicon chips, and it provides detailed coverage of the underlying physics to complete very large-scale integration (VLSI) digital computer systems. *Introduction to VLSI Systems* is suitable as a textbook and reference book for graduate and undergraduate courses.

The book is available from Addison-Wesley Publishing Co, Reading MA 01867, for \$25.95.

Circle 478 on Inquiry card.

### 1979 Mapping Collection from Harvard Library of Computer Graphics

This six volume collection has been structured to give an organization every kind of information it may need about computer mapping. The collection features works on management's use of maps; natural resource and environmental applications; urban, regional, and

### Sharp APL Reference Manual

This text is complete with illustrations and examples, and it discusses the features of Sharp APL in terms understandable by beginners and professional programmers alike. Some of the topics reviewed are syntax of APL, event trapping, primitive functions and operations, structure of data, shared variables, report formatting, batch APL, and line editing in Sharp APL. The manual is available for \$18 from I P Sharp Associates Ltd, 145 King St W, Toronto, Ontario M5H 1J8, CANADA.

Circle 479 on inquiry card.

### Communication Fiber-optics Short Form Catalog



Valtec Corp's catalog, which includes their optical fibers and cables, fiberoptic modems and interfaces, and baseband video links, covers every application from computer terminal connections to long-haul telephone and CATV trunking.

To obtain a copy of the catalog, write Valtec Corp, Communication Fiber-optics, 99 Hartwell St, West Boylston MA 01583.

Circle 480 on inquiry card.

state applications; computer mapping in education; mapping software and cartographic data bases; thematic map design; and sections on cadastral systems and use of satellite derived data. The cost is \$45 for the first volume, and \$30 for each additional selection. The complete six volume set is \$150. Contact the Laboratory for Computer Graphics, Harvard University, 48 Quincy St, Cambridge MA 02138.

Circle 481 on inquiry card.

### Publication for the Ohio Scientific Challenger 1P

*Getting Started With Your Challenger 1P* introduces the fundamentals of C1P BASIC and explains its characteristics, limitations, and useful features. This document discusses calculator and program mode, input and output, data representation, and program storage on cassette. It also describes C1P control and logic, including testing and branching, subroutine use, and logical operations. This beginner's workbook contains exercises and sample programs. It is available from dealers or by writing to TIS, POB 921, Los Alamos NM 87544. The price is \$5.95 plus \$1 for postage and handling.

Circle 482 on inquiry card.

### Microprocessor User's Guide

*The Microprocessor User's Guide* contains articles written by engineers for other engineers and corporate managers with a production-oriented, problem solving approach in mind. The 78-page booklet focuses on designing with microprocessors; engineering design approach to microprocessors; microprocessor architecture; analysis of 6800, 8080/8085 and Z80 architectures; and analysis of single-chip microprocessors. Pro-Log's STD BUS, a bus structure for 8-bit microprocessors, is examined in detail.

The guide is available at no charge from Pro-Log Corp, 2411 Garden Rd, Monterey CA 93940.

Circle 483 on inquiry card.

### Using a Programmable Calculator Instead of a Central Computer

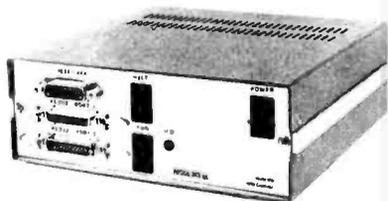
Providing techniques for using calculators in the HP-67/97 or TI-59 families, the *Handbook of Electronic Design and Analysis Procedures Using Programmable Calculators* offers programs and programming techniques for solving problems in network analysis, active and passive filter design, high frequency amplifier design, and engineering mathematics. Documentation including flowcharts, algorithms, sample problems, tips, and references clarify many aspects of problem solution. The book is available for \$26.50, from Van Nostrand Reinhold Electrical/Computer Science and Engineering Series, 135 W 50th St, New York NY 10020.

Circle 484 on inquiry card.

# What's New?

## MISCELLANEOUS

### GPIB Controller Implements IEEE 488 Bus and RS-232 Standard



The Model 609 GPIB Controller can be used in place of programmable calculators, microcomputers, or as intelligence for a data collector logger system. Programs in BASIC enter in 4 K bytes of programmable memory, then are transferred to an internal programmable read-only memory (PROM). This eliminates the tape loading routines and insures that, when the controller is turned on, the program is present and ready. The Model 609 has control

features such as serial or parallel poll and reception of binary-coded decimal (BCD) or ASCII messages, the ability to be transparent in a large system, and a front panel pass/fail test system. The front panel contains all connectors and controls and has been designed to eliminate inadvertent false operation. The unit costs \$1395. For more information, contact Physical Data Inc, Dept 37, 8220 SW Nimbus Ave, Beaverton OR 97005. Circle 485 on inquiry card.

### National Introduces New Addition to One Chip Data Acquisition System Family

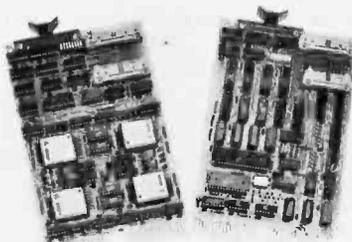


Available in two versions, the ADC0808 and ADC0809 complementary MOS (CMOS) integrated circuits incorporate the essential elements of a microprocessor-compatible data-acquisition system onto a single chip, including an 8-bit analog-to-digital (A/D) converter, an 8-channel multiplexer and microprocessor-compatible control logic. The ADC0808/09 uses a successive approximation conversion technique with a high-impedance chopper stabilized comparator which makes the device virtually immune to temperature, long term drift, and input offset errors, and it provides effective and accurate conversion while running on only 15 milliwatts. A 256R voltage ladder network approach was chosen to guarantee against missing codes. Resolution is 8 bits, and the ADC0808/09 can perform a conversion in 100 microseconds. Latched and decoded address inputs and outputs make possible interfacing to the 8080, 8085, Z80, 6800, and National's 8060 SC/MP microprocessor, among others.

For more information on prices and availability, contact Keith Mueller, National Semiconductor, 2900 Semiconductor Dr, Santa Clara CA 95051.

Circle 486 on Inquiry card.

### Magnetic Bubble Mass Storage for DEC Microcomputers



This new LSI-11-compatible bubble memory system is comprised of a dual height controller module (designated Bubbl-Board MBC-11) and one or more dual height bubble memory modules (designated Bubbl-Pac MBB-11). The MBC-11 controller contains its own 8-bit

microprocessor and is capable of controlling up to 16 MBB-11 bubble memory modules. The microprocessor handles bubble device formatting and control, as well as interfacing the bubble memory system to the LSI-11 bus structure. The controller maps standard floppy disk track and sector addresses into bubble device page addresses, so that the bubble memory is fully compatible with all DEC software for the LSI-11, including the mass storage operating systems such as RT-11. The bubble memory system appears just like a floppy disk to the processor, though with much faster access time. Data storage is absolutely nonvolatile. Each MBB-11 bubble memory module uses one LSI-11 chassis slot and contains 46 K bytes of storage. Access time to the first data byte averages less than 7 ms.

The MBC-11 is priced at \$650 and the MBB-11 at \$950. Contact Bubbl-Tec, 3120 Crow Canyon Rd, San Ramon CA 94583. Circle 487 on Inquiry card.

### The Ruler That Thinks

The Panasonic Electronic Ruler/Computer uses a small displacement measuring wheel to directly measure lengths, distances, areas, and volumes, in linear, square, or cubic units, in any scale, from any document. A multifunction calculator is integrated in the ruler permitting measured data to be used automatically in computations. Intermediate measurements can be stored in the calculator's memory to yield a total quantity. The computer displays values directly in millimeters, centimeters or meters, and converts to either inches or feet simply by pressing a function key. The Electronic Ruler/Computer can measure any regular or irregular surface, such as curved walls, floors, containers, etc. Documents to be measured need not be in original scale; variations caused by reduction or enlargement can be programmed into the computer with results automatically displayed in the original scale.

Additional features include addressable memory; metric and area con-



version; percent, add-on, and discount computations; automatic square root and  $\pi$ ; floating decimal point system; mixed calculations, and more.

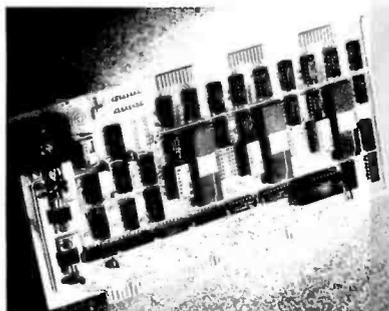
The Electronic Ruler/Computer is priced at \$99.95. For further information, contact the distributors, Chafitz Inc, 1055 First St, Rockville MD 20850.

Circle 488 on Inquiry card.

# What's New?

## MISCELLANEOUS

### S-100 Communications Board



Designed specifically for S-100 applications, Inco's six port EIA/RS-232 board, based on the Zilog Z80A, features synchronous and asynchronous communications at a wide range of data rates. The board also contains two real-time clocks programmable in several modes, and meets the proposed IEEE S-100 standards. It performs hardware cyclic redundancy check (CRC) generation and checking, and provides standard protocol support. The board, documentation and a software guide are available for \$895 from Inco Inc, 7916 Westpark Dr, McLean VA 22102.

Circle 489 on inquiry card.

### Floppy Disk Controller Board for the TM990



A floppy disk controller compatible with the TM990 series of microcomputer board products has been announced by

Texas Instruments Inc, POB 1433, MS 6404, Houston TX 77001. The TM990/303 board supports up to four double-sided drives. The board is programmable for data encoding formats and number and types of disk drives. The TM990/303 has the ability to interface to single- and dual-density drives. The controller is compatible with IBM 3740 and TI disk formats. Data transfer format and stepper motor rates are both programmable. In addition, the controller also features write precompensation, soft-sector compatibility, internal phase acquisition, and address mark detection. The board is priced at \$845.

Circle 490 on inquiry card.

### MC6809 Microprocessor Development Systems



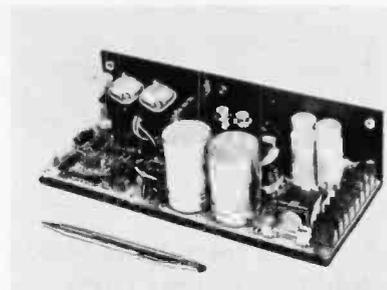
Motorola has announced six update packages to adapt a user's previous EXORciser I, IA, or II systems to MC6809 system design. These products enable designers to develop and debug any system centered around this power-

ful eight-bit microprocessor. The new EXORciser II and EXORterm 220 differ from the MC6809 units in current production in that they contain a microprocessing module with a M6809 component complement, as well as extending the capabilities of other internal modules to MC6809 specifications. EXORciser and EXORterm systems can be upgraded to permit M6809 designs by adding an MC6809 microprocessing module, a DEbug module, a floppy-disk controller, programmable read-only memory (PROM) firmware, and an MC6809 MDOS floppy disk, containing a macroassembler and video editor. By updating these units for operation with the MC6809 modules, the features of EXORciser II, such as dynamic systems bus, dual memory map, memory parity, second-level interrupt vectors, and more, are achievable.

The prices for the updating systems are \$3200. The prices for the complete MC6809-based EXORciser and EXORterm development systems range from \$7900 to \$9365. For additional information, contact Motorola Inc, POB 20912, Phoenix AR 85036.

Circle 491 on inquiry card.

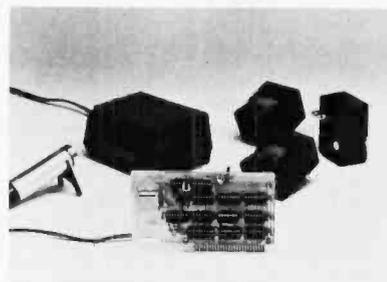
### Power Saver from Power Dynamics



Power Dynamics has developed a single output open frame switcher. The unit measures 7 by 10 by 23 cm (2.75 by 4 by 9 inches). It is available in all the standard output voltages from 5 to 48 volts. The price is \$175. For more information, contact Power Dynamics Corp, 9421 Telfair Ave, Sun Valley CA 91352.

Circle 492 on inquiry card.

### Device for Remote Control of Electrical Devices



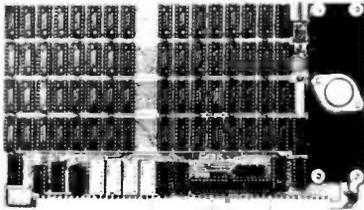
Introl/X-10 allows Apple users to remotely control 110 V AC devices by commands sent through a BSR/System X-10 Command Console over existing building wiring. The unit comes with software to control devices on predetermined schedules. It provides for selection of daily or weekly schedules, specification of the exact date for a particular event, specification of intervals of time for an event, and, for energy management, device wattage ratings for power consumption accounting. The system consists of the Introl Controller board with timer and ultrasonic transducer, the BSR/X-10 Command Console, and three Remote Modules for \$279. The Introl/X-10 Controller Card costs \$189 and additional remote modules are available for \$15. For more information, contact Mountain Hardware Inc, 300 Harvey West Blvd, Santa Cruz CA 95060.

Circle 493 on inquiry card.

# What's New?

## MISCELLANEOUS

### 32 K Byte Static Memory Boards for 6800/6809



Gimix, 1337 W 37th Pl, Chicago IL 60609, is delivering a fully static 32 K byte programmable memory board for use with the SS-50 (6800) and SS-50C (6809) bus. The board features four independently dip-switch addressable 8 K byte blocks. Each block can be addressed to any 8 K boundary or disabled. The board is capable of decoding the four additional address lines of the SS-50C bus to allow memory decoding up to 1 M bytes. The switches enable or

disable the extended addressing and set it to one of sixteen possible banks. The board is designed for high noise immunity. The price of the full 32 K board is \$548.15. The 16 K version costs \$328.12 and 24 K version costs \$438.14. Both can be expanded to contain up to 32 K bytes of memory.

Circle 510 on inquiry card.

### Lowercase and Keyboard Modification Kit for TRS-80

This kit includes wire, solder, control key, 2102 memory device, slide switch, mounting hardware, and documentation. The low power 2102 memory part is connected to a slide switch that allows the TRS-80 to be used with or without lowercase letters. To minimize the chance of damage to the 2102, its connecting wires have been pre-assembled. The control key has gold-plated contacts for long life and can be easily mounted on the keyboard. The kit is priced at

### Low Power, 32 K Programmable Memory for Heath H8 Computers

A board with 32 K bytes of programmable memory, using less than 6 W of power and compatible with current Heath peripherals, is available from D-G Electronic Developments Co, 3223 Forest Ln, Garland TX 75042. Other features include circuit protection to prevent damage to memory output buffers if two blocks are assigned to the same address space, memory addressing controlled by a dual in-line (DIP) switch, and it is arranged as four independently addressable 8 K byte blocks with transparent refresh. The price for the board is \$479, and it comes fully assembled and tested.

Circle 511 on inquiry card.

\$19.95, and is available from Emmanuel B Garcia Jr and Associates, 3950 N Lake Shore Dr, Rm 2310, Chicago IL 60613.

Circle 512 on inquiry card.



**FREE!** Up to \$170 in merchandise with purchase of one of following PET-CBM items !!!

Axiom EX-801 PET Printer (with graphics)	\$ 475.00
Axiom EX-820 PET Plotter	\$ 749.00
Anderson Jacobson 841 Selectric	\$1015.00
Leedex Video 100 12" Monitor	\$ 119.00
Heath WH19 Terminal (factory asm.)	\$ 770.00
Heath WH14 Printer (factory asm.)	\$ 735.00
IEEE-RS232 Printer Adaptor for PET	\$ 88.00

BETSI PET to S-100 Interface	\$ 119.00
PET Connectors-Parallel or IEEE	\$ 1.95
Cassette Port	\$ 1.45
Hands on Basic with a PET	\$ 9.45
Programming the 6502 (Zaks)	\$ 9.45
6502 Applications Book (Zaks)	\$ 10.45
6500 Manuals (MOS Technology)	\$ 6.50
Programming a Microcomputer: 6502	\$ 8.45
6502 Assembly Language (Osborne) NEW!	\$ 8.10

KIM-1 \$159 (add \$30 for power supply)	SYM-1 \$209
BAS-1 Microsoft ROM Basic for SYM	\$ 85
Memory Plus (KIM, SYM, AIM)	\$195
SYM Assembler in ROM	\$ 85
SEA-16 New 16K Static RAM	\$325
Seawell Motherboard - 4K RAM Space	\$139
KTM-2/80 Synertek Video Board	\$349
S-100 16K Static RAM Kit	SALE \$219
TIS PET Workbooks - set of 6	\$ 21.50
Dust Cover for PET	\$ 8.90

**All Books and Software 15% Off**

CBM Word Processor for PET - Machine Language Auto Scroll, insert, delete, form letter append, etc. 8K Version \$24.00 16K or 32K with disk \$89.00

Cassettes (all tapes guaranteed) AGFA PE611 Premium quality, high out put lownoise in 5 screw housing with labels:

C-10	10/5.65	50/25.00	100/48.00
C-30	10/6.90	50/30.00	100/57.00

### PET SPECIALS

\*FREE

PET 16N 16K full size graphics keyboard	\$ 995	\$130
PET 16B 16K full size business keyboard	\$ 995	\$130
PET 32N 32K full size graphics keyboard	\$1295	\$170
PET 32B 32K full size business keyboard	\$1295	\$170
PET 8N 8K full size graphics keyboard	\$ 795	\$100
PET 2040 DUAL DISK DRIVE-343,000 bytes	\$1295	\$170
PET 2022 Tractor Feed Printer	\$ 995	\$130
PET 2023 Pressure Feed Printer	\$ 849	\$110
PET C2N External Cassette Deck	\$ 95	\$ 12
Used 8K PETs (limited quantities)	\$ 495	

\*Amount of Free Merchandise with Purchase of PET-CBM Item.

2716 EPROM (5 volt)	\$ 39
6550 RAM (for 8K PET)	\$ 12.70
6502 \$9.75	6522 \$9.00 6520 \$5.50
2114 L 450 ns \$5.35	24@ \$4.95 100 @ \$4.45



### MINIMAX by COMPU/THINK

MINIMAX I (8 Megabyte Disks) \$4495  
MINIMAX II (2.4 Megabyte Disks) \$5995

SPECIAL - MINIMAX prices include Compu/Think PAGEMATE Database and Report Writer at no charge.

### The most advanced complete microcomputer system available.

Includes CPU, 12" CRT, Full Keyboard, 2 Quad-Density Disk Drives, 2 Megahertz 6502 Hybrid Processor (double speed), 108 K System Memory, High Resolution (512 x 240) Graphics, Programmable Character Fonts, Microsoft Extended BASIC, DOS with Random Access I/O, Full Complement of I/O Ports, Monitor with Debug, Trace, and Tiny Assembler, Fifth (PL/M and Forth combination) Interpreter, Complete editing and entry with split screen capability, 64 Microprogrammable Opcodes, Business software (with Database) available.

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### ATARI - INTRODUCTORY SPECIAL

ATARI 400, Atari 800 and all Atari Modules 20% OFF.

Programmers Toolkit - PET ROM Utilities	\$ 44.90
Sargon II (TRS-80 or Apple) NEW!	\$ 24.90
Microchess for PET (Peter Jennings)	\$ 17.90
PET 4 Voice Music System	\$ 29.90
4 Voice Music Monitor for PET	\$ 15.90
CmC Word Processor program for PET	\$ 25.00
Adventures by Scott Adams	15% Off



### SALE

3M "Scotch" 8" Disks	10/\$31.00
3M "Scotch" 5" diskettes	10/\$31.50
Verbatim 5" diskettes	10/\$26.50
Diskette Storage Pages	10/\$ 3.95
Disk Storage Boxes 8" \$2.85 5 1/4" \$1.95	(Write for quantity prices)

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699-5826

## A B Computers

# What's New?

## MISCELLANEOUS

### tinyFORTH 2.1 for TRS-80

The Software Farm, POB 2304, Reston VA 22090 has developed the tinyFORTH 2.1 system for TRS-80 systems. Programs written in tinyFORTH can run faster and use less memory than similar programs in BASIC because tinyFORTH includes a

compiler in addition to an interpreter. This system includes a powerful text editor, a Z80 assembler, and a graphics package. The tinyFORTH system occupies 8 K bytes of memory and comes with cassette tape and documentation for 16 K Level II TRS-80s. The system costs \$29.95.

Circle 500 on inquiry card.

### 32 K Structured BASIC

Cromemco 32 K Structured BASIC, which runs in 64 K Cromemco Systems, assists a programmer in building a program from logical blocks of code. This facilitates program development and reduces debugging and maintenance of programs. It contains all features of 16 K BASIC plus long variable names of up to 31 characters, statement labels that replace statement numbers to reference lines in a BASIC program, an

in-line BASIC editor, a keyed sequential access method (KSAM), procedures, and control structures including *if . . . then . . . else, while . . . endwhile, and repeat . . . until.*

Cromemco 32 K Structured BASIC is available for use on Cromemco systems on 8-inch or 5-inch floppy disks for \$295. For additional information, contact Cromemco Inc, 280 Bernardo Ave, Mountain View CA 94043.

Circle 501 on inquiry card.

### Motorola Introduces MC68000 Design Module

Motorola has introduced the MEX68KDM, an MC68000 design module. The MEX68KDM permits easy chip evaluation, using either an EXORciser development system or an IBM370 or PDPII, in conjunction with cross-computer software. For system emulation, the module includes 32 K bytes of programmable memory, two 16-bit parallel input/output (I/O) ports, three 16-bit programmable timers and two serial RS-232 ports.

MEX68KDM includes MACSbug, a powerful 16-bit microprocessor debugging tool. Once a memory file is resident in programmable memory, a user may

begin his program debugging. The memory map for the MEX68KDM allows for the use of any of the on-card I/O and additional external memory or I/O. A 6800 bus interface card is provided to allow the MEX68KDM to read or write data to an external memory or I/O card. The design module may be used in a stand-alone mode, in an EXORciser development system in the nonexpanded bus mode, or in a card cage with standard 6800 memory.

The design module with two RS-232 cables is priced at \$1795. Contact Motorola Semiconductor Inc, POB 20912, Phoenix AZ 85036, for more information.

Circle 502 on inquiry card.

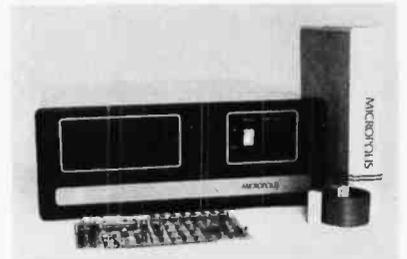


### PROSYS I System

Aimed primarily at the process control and industrial/measurement markets, the system allows a process control engineer or technician to communicate with a digital computer-controlled process system. PROSYS I includes the ADAC System 1000 enclosure with the 64 K byte version of the Digital Equipment Corp LSI-11/2 microcomputer, dual-port serial interface, single drive, double-density floppy disk and video terminal. The software resides in less than 32 K bytes of memory. The software includes an operating system. The system can accommodate up to eighteen PROSYS I optional modules. The price for the system is \$14,000, and it is available from ADAC Corp, 70 Tower Office Park, Woburn MA 01801.

Circle 503 on inquiry card.

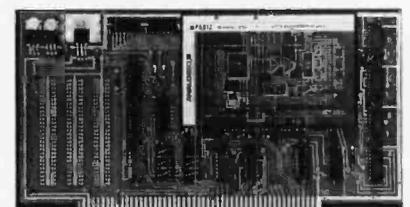
### Multiuser Operating System for Micropolis Microdisk



Micropolis Corp, 7959 Deering Ave, Canoga Park CA 91304, is marketing their fully integrated rigid disk subsystem which includes their 8-inch rigid disk drive with up to 31.2 M bytes of formatted data storage capacity, an intelligent disk adapter-interface card, and a software package for microcomputer systems that use the S-100 bus. The Microdisk subsystems are available in capacities of 6.2, 18.7 and 31.2 M bytes and are expandable by daisy chaining. Up to three add-on modules may be connected to a master unit. Prices for the Microdisk system begin at under \$5000.

Circle 504 on Inquiry card.

### S-100 16-Channel 12-Bit Analog to Digital Converter Board



The Tecmar S-100 Analog to Digital (A/D) board interfaces the Analogic MP 6812 Complete Data Acquisition System to the S-100 bus. The board accepts sixteen single ended inputs and has data rates up to 30 kHz with twelve bit accuracy. The total of multiplex settling time and sample-hold acquisition time is about 7 microseconds. The board provides two's complement right-justified outputs and variable voltage ranges. The board may be configured to act as an input/output (I/O) device or to act as a memory mapped device. The board requires little software. The price is \$495, and it is available from Tecmar Inc, 23414 Greenlawn Ave, Cleveland OH 44122.

Circle 505 on inquiry card.

# What's New?

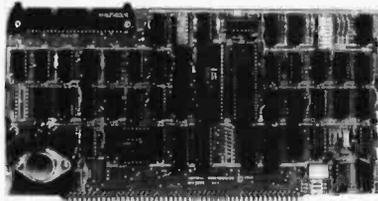
## MISCELLANEOUS

### Network Information Resource

The SOURCE is a computer-based electronic message and information system. It allows users to send messages over computer terminals via a nationwide switching network. The SOURCE provides advanced electronic mail features such as text editing, scanning, delayed delivery, interactive conversation, and bulletin boards. It also acts as an information supermarket offering news, educational programs, travel and shopping services, and much more. To use the SOURCE, subscribers need only a microcomputer or terminal. The cost of the service is \$100 initial registration fee plus \$2.75 an hour. The service is \$15 an hour between 7 AM and 6 PM, Monday thru Friday. For information, contact Telecomputing Corp of America, 1616 Anderson Rd, McLean VA 22102.

Circle 506 on inquiry card.

### Double-Density Floppy Disk Interface



Tarbell Electronics has released its new interface board, which is supplied with the BASIC INPUT/OUTPUT SYSTEM software for CP/M on single-density floppy disk, permitting users to mix single- and double-density disks. As

many as four drives can be selected, using either single- or double-density. The 8-inch, Shugart-compatible disk interface contains phase-lock-loop and write precompensation, and the bootstrap programmable read-only-memory (PROM) is disabled on completion of the bootstrap operation, freeing all 64 K bytes of memory for other use. Extended addressing capability provides eight additional address bits as specified by the new IEEE standard, allowing direct transfers to and from any location within a 16 M byte address range. The interface comes with BIOS for CP/M on floppy disk for \$425 from Tarbell Electronics, 950 Dowlan Pl, Suite B, Carson CA 90746.

Circle 508 on Inquiry card.

### Package Turns Exidy Sorcerer into Z80 Development System



Available for \$99, a software package called the Development Pac can turn an Exidy Sorcerer into a sophisticated, cassette-based, Z80 development system. The package includes four modules: a

designer's debugging tool (DDT), a line-oriented text editor, a relocating assembler, and a linking loader. All can operate with the Sorcerer's dual cassette interface to allow tape-based system development. The system supports global symbols for intermodule communication and allows the user to define the input/output (I/O) devices for source code, object code, and listings. The debugging tool allows the user to display and modify any programmable memory location or any Z80 register. Using the Development Pac, a programmer can design a program that is far larger than the Sorcerer's memory without having to worry about size limits, due to partitioning of memory and two predefined buffers that can be used for program storage. The package is available from Exidy Data Systems, 2599 Garcia Ave, Mountain View CA 94043.

Circle 509 on inquiry card.

### S-100 Card Adds Sound

Two General Instrument AY-3-8910 programmable sound generators are interfaced to the S-100 bus on the Noisemaker to create sounds and noises. The board provides six tone generators, two noise sources, two envelope generators and four 8-bit input/output ports. Sound effects and noises may be created and added to graphics and computer games. An on-board audio amplifier and breadboard area allows inclusion of the board into any system. The Noisemaker is available now as an unpopulated, solder masked and screened, printed circuit board for \$34.95. Contact Ackerman Digital Systems, Suite 208, 110 York Rd, Elmhurst IL 60126.

Circle 507 on inquiry card.



### 8086 Boards

CPU with Vektored Interrupts \$650.  
PROM-I/O \$495.  
RAM 8K x 16/16K x 8 \$395.

### ANALOG Boards

A/D 16 Channel, \$495.  
12 Bit, High Speed  
D/A 4 Channel, \$395.  
12 Bit, High Speed



### VIDEO DIGITIZATION

Real Time Video \$850.  
Digitizer and Display  
Computer Portrait System \$4950.

### S-100 Boards

Video and/or Analog  
Data Acquisition  
Microcomputer Systems

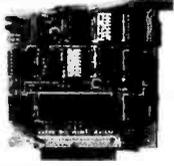


The High Performance S-100 People

TECMAR, INC.  
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(216) 382-7599

## TRS-80 E.S. SERIAL I/O

- Can input into basic
- Can use LLIST and LPRINT to output, or output continuously
- RS-232 compatible
- Can be used with or without the expansion bus
- On board switch selectable baud rates of 110, 150, 300, 600, 1200, 2400, parity or no parity odd or even, 5 to 8 data bits, and 1 or 2 stop bits. D.T.R. line
- Requires +5, -12 VDC
- Board only \$19.95 Part No. 8010, with parts \$59.95 Part No. 8010A, assembled \$79.95 Part No. 8010C. No connectors provided, see below.



EIA/RS-232 connector Part No. DB25P \$6.00, with 9' 8 conductor cable \$10.95 Part No. DB25P9.



3' ribbon cable with attached connectors to fit TRS-80 and our serial board \$19.95 Part No. 3CAB40.

## MODEM

- Type 103
- Full or half duplex
- Works up to 300 baud
- Originate or Answer
- No coils, only low cost components
- TTL input and output-serial
- Connect 8  $\Omega$  speaker and crystal mic. directly to board
- Uses XR FSK demodulator
- Requires +5 volts
- Board only \$7.60 Part No. 109, with parts \$29.95 Part No. 109A

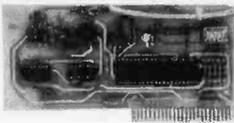


## DISKETTES



Box of 10, 5" 8" \$29.95, 5" - \$4.50, 8" - \$6.50.

## APPLE II\*\* SERIAL I/O INTERFACE



Baud rate is continuously adjustable from 0 to 30,000

- Plugs into any peripheral connector
- Low current drain. RS-232 input and output
- On board switch selectable 5 to 8 data bits, 1 or 2 stop bits, and parity or no parity either odd or even
- Jumper selectable address
- SOFTWARE
- Input and Output routine from monitor or BASIC to teletype or other serial printer
- Program for using an Apple II for a video or an intelligent terminal.

Also can output in correspondence code to interface with some electrics. • Also watches DTR

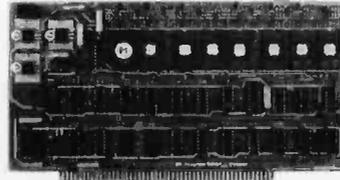
- Board only \$15.00 Part No. 2, with parts \$42.00 Part No. 2A, assembled \$62.00 Part No. 2C

## 8K EPROM PIICEON

Saves programs on PROM permanently (until erased via UV light) up to 8K bytes. Programs may be directly run from the program saver such as fixed routines or assemblers.

- S-100 bus compatible
- Room for 8K bytes of EPROM non-volatile memory (2708's).
- On-board PROM programming
- Address relocation of each 4K of memory to any 4K boundary within 64K
- Power on jump and reset jump option for "turnkey" systems and computers without a front panel
- Program saver software available
- Solder mask both sides
- Full silkscreen for easy assembly.

Program saver software in 1 2708 EPROM \$25. Bare board \$35 including custom coil, board with parts but no EPROMS \$139, with 4 EPROMS \$179, with 8 EPROMS \$219.



## WAMECO PRODUCTS WITH

### ELECTRONIC SYSTEMS PARTS

- FDC-1 FLOPPY CONTROLLER BOARD** will drive shugart, pertek, remex 5" & 8" drives up to 8 drives, on board PROM with power boot up, will operate with CPM (not included). PCB \$42.95
- FPB-1 Front Panel.** (Finally) IMSAI size hex displays. Byte or instruction single step. PCB \$42.95
- MEM-1A 8Kx8 fully buffered, S-100, uses 2102 type RAMS.** PCB \$24.95, \$168 Kit
- GMB-12 MOTHER BOARD, 13 slot, terminated, S-100 board only** \$89.95 Kit \$34.95
- CPU-1 8080A Processor board S-100 with 8 level vector interrupt PCB** \$25.95 \$89.95 Kit
- RTC-1 Realtime clock board.** Two independent interrupts. Software programmable. PCB \$25.95, \$60.95 Kit
- EPROM-1 1702A 4K EPROM card PCB** \$25.95 \$49.95 with parts less EPROMS
- EPROM-2 2708/2716 16K/32K EPROM card PCB** \$24.95 \$49.95 with parts less EPROMS
- GMB-9 MOTHER BOARD.** Short Version of GMB-12. 9 Slots PCB \$30.95 \$67.95 Kit
- MEM-2 16Kx8 Fully Buffered 2114 Board PCB** \$25.95, \$269.95 Kit

## T.V. TYPEWRITER

- Stand alone TVT
- 32 char/line, 16 lines, modifications for 64 char/line included
- Parallel ASCII (TTL) input
- Video output
- 1K on board memory
- Output for computer controlled cursor
- Auto scroll
- Non-destructive cursor
- Cursor inputs: up, down, left, right, home, EOL, EOS
- Scroll up, down
- Requires +5 volts at 1.5 amps, and -12 volts at 30 mA
- All 7400, TTL chips
- Char. gen. 2513
- Upper case only
- Board only \$39.00 Part No. 106, with parts \$145.00 Part No. 106A



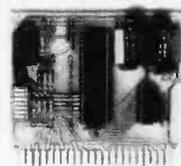
## TAPE INTERFACE

- Play and record Kansas City Standard tapes
- Converts a low cost tape recorder to a digital recorder
- Works up to 1200 baud
- Digital in and out are TTL-serial
- Output of board connects to mic. in of recorder
- Earphone of recorder connects to input on board
- No coils
- Requires +5 volts, low power drain
- Board only \$7.60 Part No. 111, with parts \$29.95 Part No. 111A



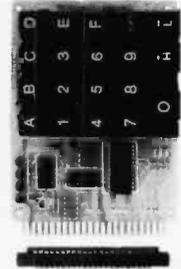
## UART & BAUD RATE GENERATOR

- Converts serial to parallel and parallel to serial
- Low cost on board baud rate generator
- Baud rates: 110, 150, 300, 600, 1200, and 2400
- Low power drain +5 volts and -12 volts required
- TTL compatible
- All characters contain a start bit, 5 to 8 data bits, 1 or 2 stop bits, and either odd or even parity.
- All connections go to a 44 pin gold plated edge connector
- Board only \$12.00 Part No. 101, with parts \$35.00 Part No. 101A, 44 pin edge connector \$4.00 Part No. 44P



## HEX ENCODED KEYBOARD E.S.

This HEX keyboard has 19 keys, 16 encoded with 3 user definable. The encoded TTL outputs, 8-4-2-1 and STROBE are debounced and available in true and complement form. Four onboard LEDs indicate the HEX code generated for each key depression. The board requires a single +5 volt supply. Board only \$15.00 Part No. HEX-3, with parts \$49.95 Part No. HEX-3A, 44 pin edge connector \$4.00 Part No. 44P.



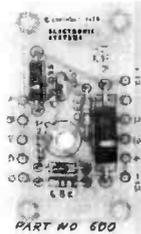
## RS-232/ TTL INTERFACE

- Converts TTL to RS-232, and converts RS-232 to TTL
- Two separate circuits
- Requires -12 and +12 volts
- All connections go to a 10 pin gold plated edge connector, kit \$ 9.95 Part No. 232A 10 Pin edge connector \$3.00 Part No. 10P.



## RS-232/TTY INTERFACE

This board has two active circuits, one converts RS-232 to 20mA, and the other converts 20mA to RS-232. Requires +12 and -12 volts. \$9.95 Part No. 600A Kit.



## S-100 BUS ACTIVE TERMINATOR

Board only \$14.95 Part No. 900, with parts \$24.95 Part No. 900A



## DC POWER SUPPLY

- Board supplies a regulated +5 volts at 3 amps, +12, -12, and -5 volts at 1 amp.
- Power required is 8 volts AC at 3 amps., and 24 volts AC C.T. at 1.5 amps.
- Board only \$12.50 Part No. 6085, with parts excluding transformers \$42.50 Part No. 6085A



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### COMPUCRUISE

Put a computer in your car, which gives you the most effective and functional cruise control ever designed, plus complete trip computing, fuel management systems, and a remarkable accurate quartz crystal time system.

So simple a child can operate, the new CompuCruise combines latest computer technology with state-of-the-art reliability in a package which will not likely be available on new cars for years to come.

- Cruise Control • Time, E. T., Lap Timer, Alarm
- Time, Distance, Fuel to Arrival • Time, Distance, Fuel to Empty • Time, Distance and Fuel on Trip • Current or Average MPG, GPH • Fuel Used, Distance since Fillup • Current and Average Vehicle Speed
- Inside, Outside or Coolant Temperature
- Battery Voltage • English or Metric Display. \$169.95 without cruise control \$129.95.



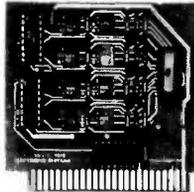
### FLOPPY DISK STORAGE BINDER

This black vinyl three-ring binder comes with ten transparent plastic sleeves which accommodate either twenty, five-inch or ten, eight-inch floppy disks. The plastic sleeves may be ordered separately and added as needed. A contents file is included with each sleeve for easy identification and organizing. Binder & 10 holders \$14.95 Part No. B800; Extra holders 95¢ each. Part No. 800



### OPTO-ISOLATED PARALLEL INPUT BOARD FOR APPLE II

There are 8 inputs that can be driven from TTL logic or any 5 volt source. The circuit board can be plugged into any of the 8 sockets of your Apple II. It has a 16 pin socket for standard dip ribbon cable connection. Board only \$15.00. Part No. 120, with parts \$69.95. Part No. 120A.



### TIDMA

- Tape Interface Direct Memory Access • Record and play programs without bootstrap loader (no prom) has FSK encoder/decoder for direct connections to low cost recorder at 1200 baud rate, and direct connections for inputs and outputs to a digital recorder at any baud rate • S-100 bus compatible • Board only \$35.00 Part No. 112, with parts \$110 Part No. 112A



### SYSTEM MONITOR

8080, 8085, or Z-80 System monitor for use with the TIDMA board. There is no need for the front panel. Complete with documentation \$12.95.

### 16K EPROM

Uses 2708 EPROMs, memory speed selection provided, addressable anywhere in 65K of memory, can be shadowed in 4K increments. Board only \$24.95 part no. 7902, with parts less EPROMs \$49.95 part no. 7902A.



### ASCII KEYBOARD

TTL & DTL compatible • Full 67 key array • Full 128 character ASCII output • Positive logic with outputs resting low • Data Strobe • Five user-definable spare keys • Standard 22 pin dual card edge connector • Requires +5VDC, 325 mA. Assembled & Tested. Cherry Pro Part No. P70-05AB. \$119.95.



### ASCII KEYBOARD

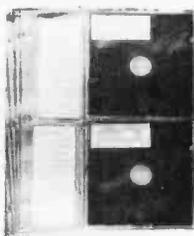
53 Keys popular ASR-33 format • Rugged G-10 P.C. Board • Tri-mode MOS encoding • Two-Key Rollover • MOS/DTL/TTL Compatible • Upper Case lockout • Data and Strobe inversion option • Three User Definable Keys • Low contact bounce • Selectable Parity • Custom Keycaps • George Risk Model 753. Requires +5, -12 volts. \$59.95 Kit.

### ASCII TO CORRESPONDENCE CODE CONVERTER

This bidirectional board is a direct replacement for the board inside the Trendata 1000 terminal. The on board connector provides RS-232 serial in and out. Sold only as an assembled and tested unit for \$229.95. Part No. TA 1000C

### DISK JACKET™

Made from heavy duty .0095 matte plastic with reinforced grommets. The mini-diskette version holds two 5-1/4 inch diskettes and will fit any standard three ring binder. The pockets to the left of the diskette can be used for listing the contents of the disk. Please order only in multiples of ten. \$9.95/10 Pack.



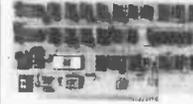
### ATARI 800

Computer with 8K \$995.00, disk drive \$549.00, printer \$599.99



### VIDEO TERMINAL

16 lines, 64 columns • Upper and lower case • 5x7 dot matrix • Serial RS-232 in and out with TTL parallel keyboard input • On board baud rate generator 75, 110, 150, 300, 600, & 1200 jumper selectable • Memory 1024 characters (7-21L02) • Video processor chip SFF96364 by Neculonic • Control characters (CR, LF, →, ←, ↑, ↓, non destructive cursor, CS, home, CL • White characters on black background or vice-versa • With the addition of a keyboard, video monitor or TV set with TV interface (part no. 107A) and power supply this is a complete stand alone terminal • also S-100 compatible • requires +16, & -16 VDC at 100mA, and 8VDC at 1A. Part No. 1000A \$199.95 kit.



### RS-232/20mA INTERFACE

This board has two passive, opto-isolated circuits. One converts RS-232 to 20mA, the other converts 20mA to RS-232. All connections go to a 10 pin edge connector. Requires +12 and -12 volts. Board only \$9.95, part no. 7901, with parts \$14.95 Part No. 7901A.



### COMPUCOLOR II

Model 3, 8K \$13.95, Model 4, 16K \$14.95, Model 5, 32K \$16.95. Prices include color monitor, computer, and one disk drive.



### PET COMPUTER

With 16K & monitor - \$795. Dual Disk Drive - \$10.95



### apple II or APPLE II PLUS

16K - \$975, 32K - \$1059, 48K - \$1123. Disk & cont. \$589



### CASSETTE TAPE ERASER



REMOVES RECORDINGS IN ONE SECOND! The process eliminates static positive / negative ions and maintains original tone quality with minimal tape hiss • To improve tone quality • To reduce hissing • For quick and easy to erase • No battery or liquid required • Powerful and effective action • Unconditional 2 year guarantee. ERASER-8 \$19.95.

### 16K RAMS

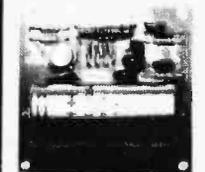
For the Apple, TRS-80 or Pet \$8 each Part No. 4116/2117.

### APPLE II HOBBY/PROTOTYPING CARD

\$14.95 Part No. 7907

### T.V. INTERFACE

- Converts video to AM modulated RF, Channels 2 or 3. So powerful almost no tuning is required. On board regulated power supply makes this extremely stable. Rated very highly in Doctor Dobbs' Journal. Recommended by Apple • Power required is 12 volts AC C.T., or +5 volts DC • Board only \$7.60 part No. 107, with parts \$13.50 Part No. 107A



### PARALLEL TRIAC OUTPUT BOARD FOR APPLE II

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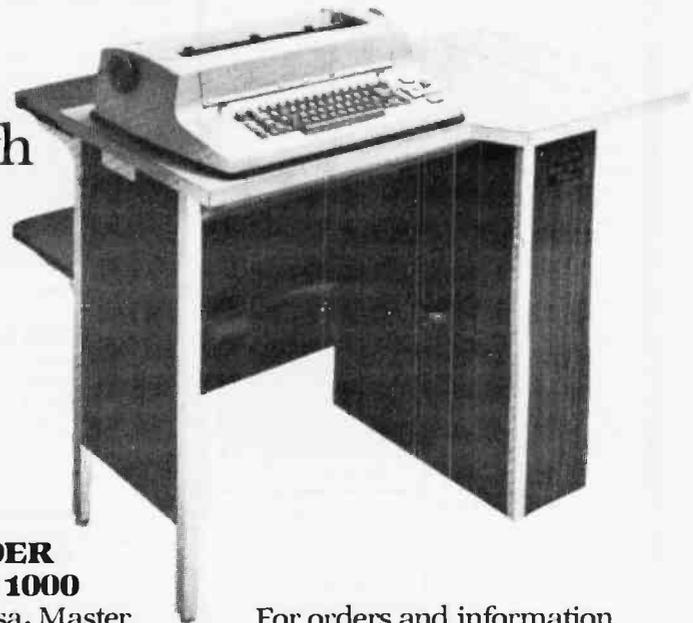
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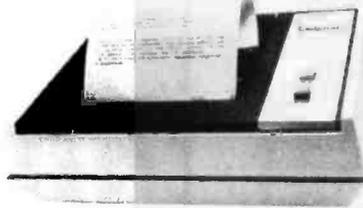
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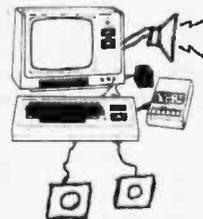
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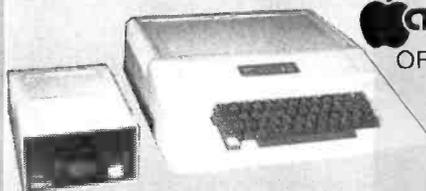
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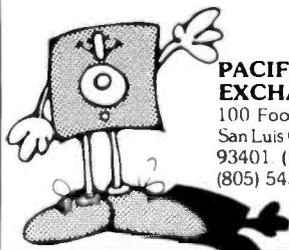


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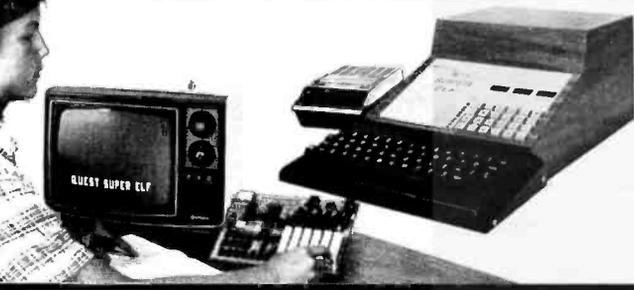
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The Super Elf includes a ROM monitor for program loading, editing and execution with SINGLE STEP for program debugging which is not included in others at the same price. With SINGLE STEP you can see the microprocessor chip operating with the unique Quest address and data bus displays before, during and after executing instructions. Also, CPU mode and instruction cycle are decoded and displayed on 8 LED indicators.

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A 1K Super ROM Monitor \$19.95 is available as an on board option in 2708 EPROM which has been preprogrammed with a program loader/editor and error checking multi file cassette read/write software, (relocatable cassette file) another exclusive from Quest. It includes register save and readout, block move capability and video graphics driver with blinking cursor. Break points can be used with the register save feature to isolate program bugs quickly, then follow with single step. The Super Monitor is written with

A 24 key HEX keyboard includes 16 HEX keys plus load, reset, run, wait, input, memory protect, monitor select, and single step. Large, on board displays provide output and optional high and low address. There is a 44 pin standard connector slot for PC cards and a 50 pin connector slot for the Quest Super Expansion Board. Power supply and sockets for all IC's are included in the price plus a detailed 127 pg. instruction manual which now includes over 40 pgs. of software Info. including a series of lessons to help get you started and a music program and graphics target game.

Many schools and universities are using the Super Elf as a course of study. DEM's use it for training and research and development.

Remember, other computers only offer Super Elf features at additional cost or not at all. Compare before you buy. Super Elf Kit \$106.95, High address option \$8.95, Low address option \$9.95. Custom Cabinet with drilled and labelled plexiglass front panel \$24.95. Expansion Cabinet with room for 4 S-100 boards \$41.00. NiCad Battery Memory Saver Kit \$6.95. All kits and options also completely assembled and tested. Questdata, a 12 page monthly software publication for 1802 computer users is available by subscription for \$12.00 per year.

Tiny Basic Cassette \$10.00, on ROM \$38.00, original Elf kit board \$14.95. 1802 software; Moew Video Graphics \$3.50. Games and Music \$3.00. Chip 8 Interpreter \$5.50.

subroutines allowing users to take advantage of monitor functions simply by calling them up. Improvements and revisions are easily done with the monitor. If you have the Super Expansion Board and Super Monitor the monitor is up and running at the push of a button.

Other on board options include Parallel Input and Output Ports with full handshake. They allow easy connection of an ASCII keyboard to the input port. RS 232 and 20 ma Current Loop for teletype or other device are on board and if you need more memory there are two S-100 slots for static RAM or video boards. Also a 1K Super Monitor version 2 with video driver for full capability display with Tiny Basic and a video interface board. Parallel I/O Ports \$9.85, RS 232 \$4.50, TTY 20 ma I/F \$1.95, S-100 \$4.50. A 50 pin connector set with ribbon cable is available at \$15.50 for easy connection between the Super Elf and the Super Expansion Board.

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7440P	LM323M-15	1.50	CD4051	1.25
7440N	LM323M-15	1.50	CD4052	1.25
7440P	LM323M-15	1.50	CD4053	1.25
7440N	LM323M-15	1.50	CD4054	1.25
7440P	LM323M-15	1.50	CD4055	1.25
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7440P	LM323M-15	1.50	CD4059	1.25
7440N	LM323M-15	1.50	CD4060	1.25
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7440P	LM323M-15	1.50	CD4077	1.25
7440N	LM323M-15	1.50	CD4078	1.25
7440P	LM323M-15	1.50	CD4079	1.25
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7440P	LM323M-15	1.50	CD4085	1.25
7440N	LM323M-15	1.50	CD4086	1.25
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7440P	LM323M-15	1.50	CD4093	1.25
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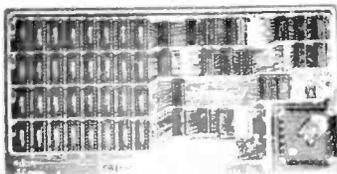
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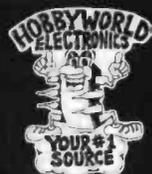
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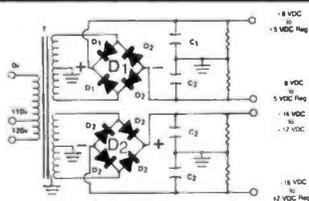
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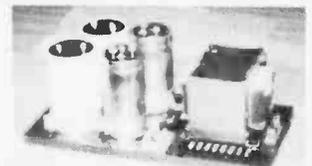
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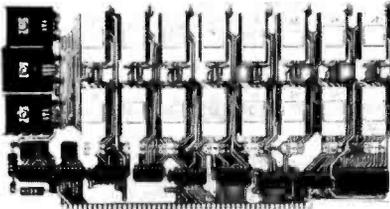
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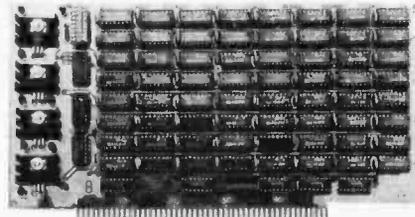
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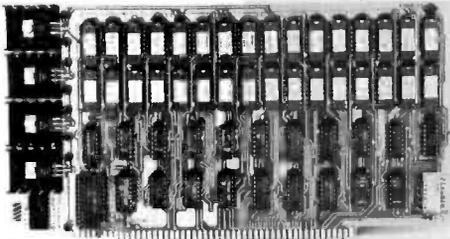
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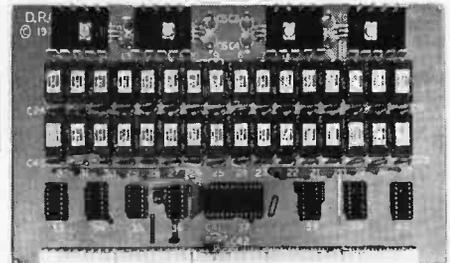
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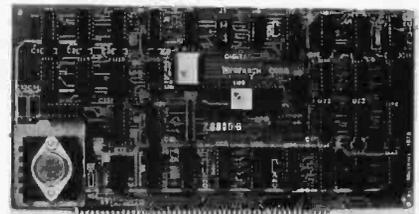
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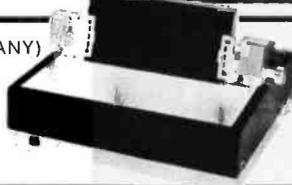
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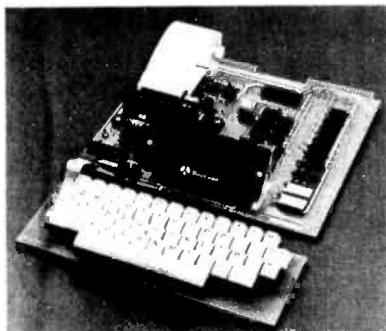
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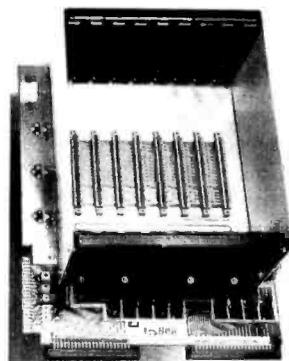
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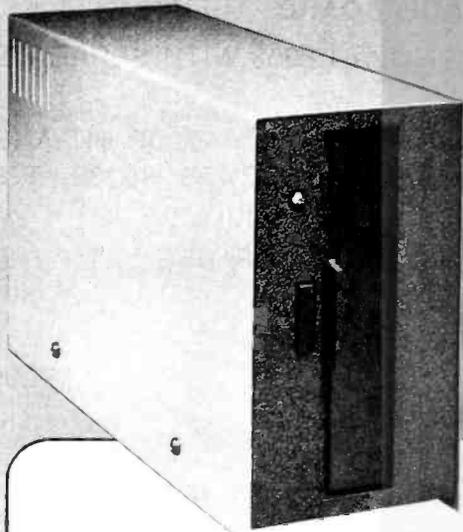
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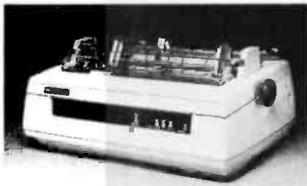
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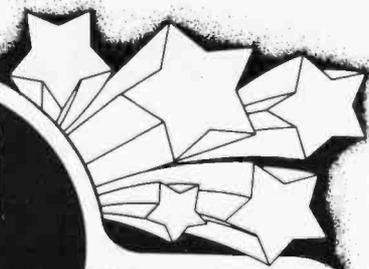
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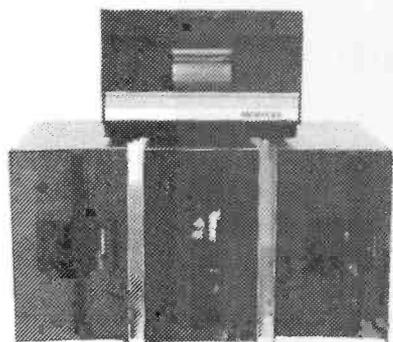
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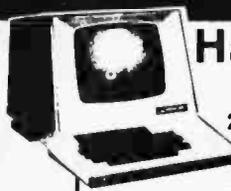
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Heath's third generation of computers is a compact, hi-style desktop unit which includes a complete terminal, a computer and a disk All-In-One! System includes Bootstrap in ROM, other programs available separately. HDOS operating system includes Heath's BASIC, an assembler and text editor along with important disk utilities. Microsoft language requires HDOS.

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Kynar precut wire. All lengths are overall, including 1" strip on each end. Colors and lengths cannot be mixed for quantity pricing. All sizes listed are in stock for immediate shipment. Other lengths available. Choose from colors: Red, Blue, Yellow, Orange, Black, White, Green and Violet. One inch tubes are available at 50¢. State second choice on colors when possible.

Length	100	500	1,000	Length	100	500	1,000
2.5 inches	1.04	2.98	5.16	6.5 inches	1.60	5.37	9.84
3	1.08	3.22	5.65	7	1.66	5.63	10.37
3.5	1.13	3.46	6.14	7.5	1.73	5.89	10.91
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4.5	1.23	3.95	7.12	8.5	1.82	6.41	11.97
5	1.28	4.20	7.61	9	1.87	6.76	12.51
5.5	1.32	4.48	8.10	9.5	1.92	6.93	13.04
6	1.37	4.72	8.59	10	1.99	7.26	13.57

Kit #1	\$7.95	Kit #2	\$19.95	KIT #3	\$24.95	Kit #4	\$44.95	#30 Spools
Less than 2.7¢/ft. (#30)		Less than 2¢/ft. (#30)		Less than 1.7¢/ft. (#30)		Less than 1.6¢/ft. (#30)		1-4 5-9 10+
250 3" 100 4"		250 2½" 250 5"		500 2½" 500 4½"		1000 2½" 1000 4½"		50 ft. 1.75 1.60 1.40
250 3" 100 5"		500 3" 100 5½"		500 3" 500 5"		1000 3" 1000 5"		100 ft. 3.00 2.75 2.50
100 4" 100 6"		500 3½" 250 6"		500 3½" 500 5½"		1000 3½" 1000 5"		250 ft. 4.75 4.50 4.25
		500 4" 100 6½"		500 4" 500 6"		1000 4" 1000 6"		500 ft. 8.50 8.00 7.50
		250 4½" 100 7"						1000 ft. 14.50 12.50 10.50

## Wire Wrap Tool

### BATTERY HOBBY TOOL\*

- Auto Indexing
- Anti-Overwrapping
- Modified Wrap

BW2630	Tool	.....	\$19.85
BT30	#30 Bit	.....	2.95
BT2628	#26 Bit	.....	7.95
BC1	Batteries & Charger	...	11.00

\*Requires 2 "C" Nicad Batteries

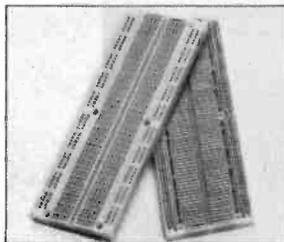


## Solderless Breadboarding

SK10 2/\$25.00 ~~\$16.60~~

The SK10's unique matrix configuration is embedded in a high temperature plastic molding. It gives you 64 pairs of 5 common spring contacts for principle circuit construction and a series of common buss strips (8) of 25 connections each.

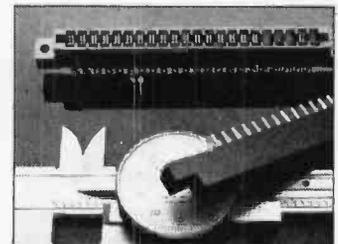
Dimensions: .33" h x 2.2" w x 6.5" l



## TI Edge Card Connectors

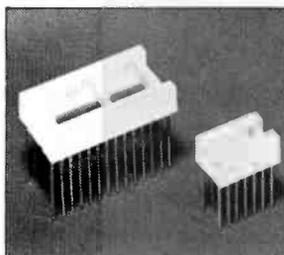
44 pin ST (.156" centers)	1.95
100 pin ST (.125" centers)	2.50
100 pin WW (.125" centers)	2.95

All connectors gold plated.



## RNIC Sockets

RN HIGH RELIABILITY eliminates trouble. "Slide-wipe" contacts make 100% greater surface contact with the wide, flat sides of your IC leads for positive electrical connections.



WIRE WRAP SOCKETS	Size	Quant./Tube	Price Ea.	Price/Tube
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Closed Entry Design	14 pin	60	.32	\$19.20
All prices include Gold	16 pin	52	.34	\$17.68
Also Available	18 pin	23	.50	\$11.50
Sockets sold at these prices by the tube only.	20 pin	21	.65	\$13.65
	22 pin	19	.70	\$13.30
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	28 pin	10	.95	\$9.50
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With Purchase of The INTEGRAL DATA 440

Your Choice, \$200 Value

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  - 2) Interface for APPLE II
  - 3) TRS-80 Printer Interface
- California Digital has recently researched the complete low cost printer market. It is our opinion that the IDS440 Paper Tiger is, without doubt, the most versatile and offers the best value of any printer costing under \$1,000.

This quality dot matrix printer incorporates such features as software selectable character size to allow print densities upto 132 characters per line. Full forms handling capabilities and tractor feed mechanism adjustable to 9.5". The Paper Tiger is engineered to accept either parallel or RS232 serial ASCII. 110/220V.50/60Hz.

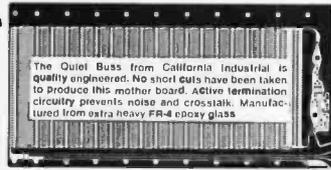
\*\*\*\*\* \$995.00 plus shipping \*\*\*\*\*

software selectable character size to allow print densities upto 132 characters per line. Full forms handling capabilities and tractor feed mechanism adjustable to 9.5". The Paper Tiger is engineered to accept either parallel or RS232 serial ASCII. 110/220V.50/60Hz.

## S-100 Mother Board

Quiet Buss

\$2995  
1803-18  
18 slot  
IMSAI



The Quiet Buss from California Industrial is quality engineered. No short cuts have been taken to produce this mother board. Active termination circuitry prevents noise and crosstalk. Manufactured from extra heavy FR-4 epoxy glass.

## TELETYPE MODEL 43

4320 KEYBOARD  
TTL ..... AAA \$1050  
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Friction ... AAE 1100 plus shipping  
103 Modem AAB 1575



## Minidisk Drive for TRS-80

your choice \$388.  
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Qty. fe. male hd.  
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GOLD 100 PIN  
IMSAI/ALTAIR

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36/72 wide post w/.156" \$1.95 3/4 5.00

## SYSTEM X-10

It's not often that California Digital ventures into the distribution of consumer products, but we have recently come across a product that appears so unique that we just had to add it to our product line. This is the System X-10 manufactured by the BSI turntable company. This space age system will remotely control any light or appliance in your home or office. Command signals are transmitted from the command console over your existing wiring. From your bed or easy chair you can control up to 16 different electrical devices inside and outside your home. Use the System X-10 to control your stereo, television or any light fixture on the premises.

The modular system is available in the following configurations:  
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## SPECIAL

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16K MEMORY  
COLOR • GRAPHICS • SOUND  
\$988  
PLUS SHIPPING \$1195

Authorized Distributor

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The most cost effective way to store data processing information, when random recall is a prime factor. The SA800 is fully compatible with the IBM 3740 format. Write protect circuitry, low maintenance & Shugart quality.

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ASCII ENCODED

KEYTRONIC ASCII & ASCII complement.  
\*Ten key data pad  
\*Cursor controls  
\*Six user switches  
\*Alpha Lock  
\*Auto repeat  
\*Single 5 volt.  
\*Class reed.

NEW

## MEMORY

### TRS-80 \$65

### APPLE II 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+
211.02 450nS.	1.19	.99	.95	.90	.85
211.02 250nS.	1.49	1.39	1.25	*	*
2114 1Kx4 450	5.95	5.50	5.25	4.75	4.50
2114 1Kx4 300	8.95	8.50	8.00	*	*
4044 4Kx1 450	5.95	5.50	5.25	*	*
4044 4Kx1 250	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

## Regent 25

\$850

through years of research the ASDI Corporation has evolved a low maintenance, extremely durable CRT terminal capable of withstanding an abusive 24 hour duty cycle. The Regent 25 features line 8081 microprocessor based control circuitry along with the Cherry Switch long life capacitor keyboard, 16 key cursor and numeric pad doubles to allow for user definable screen functions. Easy-drawing lower case characters along with a fully addressable cursor make the Regent 25 the ideal word processing terminal.

It also features a screen capable of displaying 80 upper and lower case ASCII characters and 32 control codes. This terminal is screen selectable to display six European languages.

All units shipped the Regent 25 offers the best value in today's CRT terminal market. Additional data upon request.

## The Imagination Machine

by BPF  
A BRILLIANT COMPUTER  
WHOSE TIME HAS COME

\$495

THE IMAGINATION MACHINE is brilliant in concept, design and engineering. It reads and processes information in a unique, non-linear fashion. It is a computer that can be used for personal and family use. It is a computer that can be used for business and industry. It is a computer that can be used for education and training. It is a computer that can be used for entertainment and recreation. It is a computer that can be used for everything.

## SPECIAL CIRCUITS

Z80A 4 Mhz.	24.95	AY5-1013A UART	4.95
8080A CPU	9.95	Floppy Disc Controllers	
8085	22.50	WD 1771 single D	39.00
8086 Intel 16 bits	85.00	WD 1781 Double D	65.00
TXIS9900 16 bits	49.95	WD 1791 D/D 3740	*

## PORTABLE DATA ENTRY SYSTEM

\$139.50

These used data terminals were originally designed for chain store inventory control and order entry systems. The operator enters the inventory control number, merchandise on hand and the unit price. After all pertinent data has been entered into the recorder, the main warehouse is telephoned, the handset is placed in the acoustic coupler and all the recorded information is transmitted back to the master computer. With a little imagination and one of these portable entry systems, you should be able to exchange programs and computer information with associates across the country. All units were removed from service in working condition. Original cost \$2,500. Each system comes complete with:

- \*Portable Cassette Drive Unit
- \*Removable Entry Keyboard with LED Display
- \*Five Gould "D" NICads
- \*Acoustical Coupler
- \*Battery Charger
- \*DB25 Cable
- \*Shoulder strap
- \*Full Documentation

## DISCOUNT Wire Wrap Center

IC SOCKETS

pin	Wire wrap ea.	low profile ea.	25	50	25	50
8					17	16 15
14	37	36	35	18	17	16
16	38	37	36	19	18	17
24	99	93	85	36	35	34
40	169	155	139	63	60	58

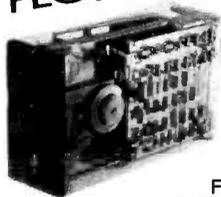
SPST DIP Switch  
\$1.29 ea. \$1.19 109 97 83 specify 4 for 8 pos.

KYNAR WIRE WRAP  
50ft. \$98  
500 1,000 11,000  
\$9. \$15. \$105.

## PROMS

	1-15	16-63	64+
1702A 2K	4.95	4.50	4.00
2708 8K	9.95	9.50	9.00
2716 3x16K	39.95	35.00	*
2716 T1	24.88	20.00	*
2532	85.00	*	*

# FLOPPY SYSTEMS



**8" Siemens FDD120-8D**  
All Siemens options included in this drive may be configured hard or soft and single or double density. We find this to be an extremely reliable drive. \$430.00

Fully Shugart compatible.



**5 1/4" BASF Magical Miniature Mini** drive only 2/3 the size of others is reliable and durable and quickly gaining in popularity with our customers. Single or dual density fast access times \$259.00

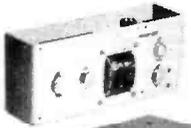


**Tarbell Controller** may be re-configured to control 5 1/4" drives and includes short cable for one drive. **KIT \$179.00, ASM \$265,** but only \$219 with purch. of 2 drives.



**Cable Kits For 8" Drives** with 10' 50 cond. cable and connectors. Also power cable and connectors. Flat cable assem if you wish. For one drive 27.50, two 33.95, three 38.95

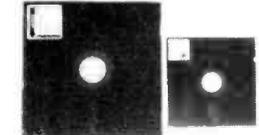
**Cable Kits for 5 1/4" Drives** as above, but 34 cond. For one drive 24.95, two 29.95.



**"Power One" Model CP206 Power Supply** adequate for at least two drives. 2.8A/24V 2.5A/5V, 0.5A/-5V beautiful quality. \$99.00



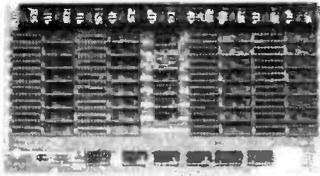
**CABINETS** for FDD120 and 801R drives, or CP206 supply. Matte finish in mar resistant black epoxy paint and stacking design 29.95



**DISKETTES**  
(3M, MRX, BASF, Georgia Magnetics, & Victor Borge)  
8" \$39.95/10  
5 1/4" \$29.95/10

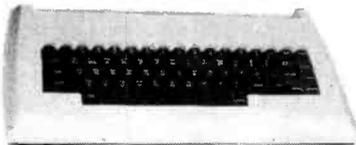
**32K - \$490.00 16K - \$290.00**

**NEW!! - CHRISLIN 64K Dynamic RAM \$750.00**  
(Showing Amazing Similarity to Tarbell's unit)  
(16K Shown in photo)

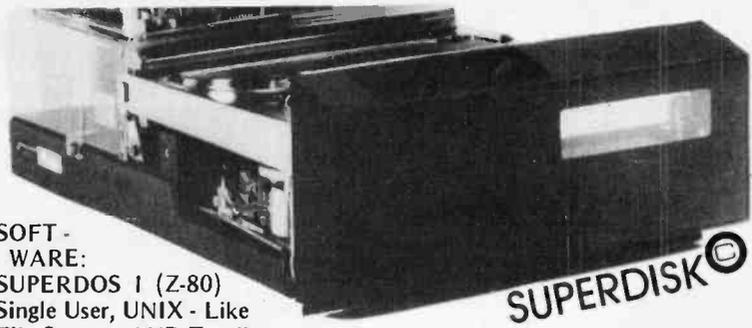


**32K - \$549.00 16K - \$349.00**

## "BACK TO SCHOOL" KEYBOARD SPECIAL



**CHERRY "PRO" Keyboard \$119.00**  
**Streamlined Custom Enclosure \$34.95**  
**BOTH ONLY \$124.95 !!!!!!!**



**10MB DRIVE \$3300**

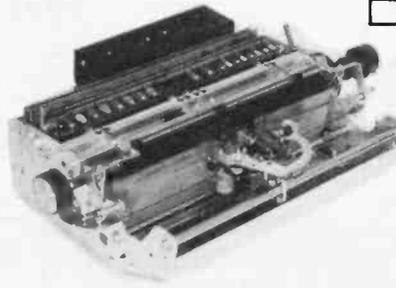
**S - 100 DMA CONTROL**

**POWER UNIT \$395.00**

**SOFTWARE:**  
**SUPERDOS 1 (Z-80)**  
Single User, UNIX - Like File System, AND Totally Upward Compatible From "XX/X" (What did you say, Digital Research??)

**PS: SUPERDOS-1 runs on the TRS-80,** and can transform it from a toy computer to a real business machine !!!

For the first time in something like 10 years, a new STANDARD in removable media has evolved. Selected by Datapoint, and others who have not yet announced, this drive is beautifully simple and easy, if not trivial to maintain. 920kBy/sec. transfer rate, 3600 RPM 39 lbs and only 125 Watts.



## Daisy Wheel Printers

### Qume Sprint 3\45

**PRINTER (factory warr.) \$1199.00**  
**POWER SUPPLY (Boschert) \$349.00**  
(shown mounted on rear of printer)  
**COMBINATION SPECIAL \$1699.00**

## DATA DISPLAY MONITORS

Used 12" Sylvania monitors. Composite Video, 15 MHz, 120VAC. Re-built with NEW P39 anti-glare tube \$119.00 New P4, 109.00, used P4 79.00. U-fix model, 10/\$300.00

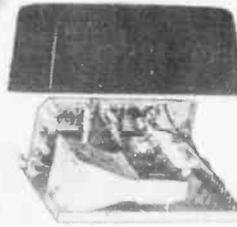


**"OEM STYLE"** as above, will fit any case. (Both versions serviced by qualified tech). Identical to above but subtract \$12.00



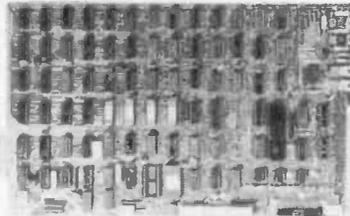
## Doppler Motion Sensor Intrusion Detector

Extremely effective microwave motion detector for detecting unwanted visitors. Ignores mice and other non-larcenous creatures. Operates on 12VDC or from small transformer supplied. Output is relay closure for alarm control interface, or to switch on lights annunciators. Will operate THROUGH door of closet or thin wall. Best application seems to be to turn on outside lights to help invited guests, and to intimidate unwanted ones. \$159.00  
Water Repellent Cover \$24.95



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Visa MC Am. Exp.



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**BI-LINGUAL 80x24 COMMUNICATING TERMINAL**

Scrolling, full cursor, bell, 8x8 matrix, 110 - 19,200 baud, Dual Font Applications. Arabic & Hebrew, Multilingual Data Entry Forms Drawing, Music, & Switchyards. \$349.00

## SOCKET SPECIAL

**BURNDY**



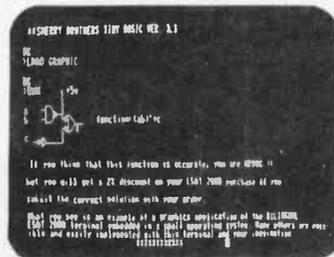
**"Won't Let Go"**

**Low Profile**

**Solder Tail**

**1 CENT/ Pin !! (0.75/1000's)**

8 14 16 18 20 22 24 28 40



CP/M\* Source Code -- FREE! when you purchase "OS-1"

Electrolab's new operating system for the Z-80 designed to have exactly the appearance of UNIX\*\*, including virtual I/O, "set TTY", a tree and a shell, filters and pipes PLUS total compatibility with CP/M software!

# OS-1

FEATURES

(Because OS-1 is truly a comprehensive "OS", and not merely a file handling "DOS", we have changed the name from "Superdos" to "OS-1")

**VIRTUAL I/O** - copy with a single command between floppy and hard disk, or from TTY to printer to tape to disk... etc., etc.

No messy I/O routines to write, & no awkward transfers.

**SECURITY** - 9 modes of file protection, user and login protection.

**MULTI-USER** - up to 256 passwords. (non-simultaneous users)

**16MBy FILE SIZE** - but no limit to no. of directories per device, thus allowing EASY implementation of gigantic storage devices.

**"SET TTY"** - for printer or crt: tabs, page width, buffer, cursor, UC/LC, fonts, formfeed, arbitrary control characters etc., etc.

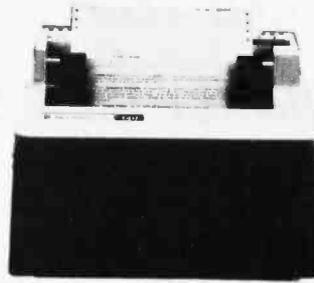
**"LOGIN"** - automatically executes user selected programs and "set TTY".

**OCCUPIES 12KBy** - only 50% larger than CP/M, but 500% more features.

**CP/M & CDOS COMPATABLE** - your library is guaranteed to run!

\* (Naturally, we are not giving away the version of CP/M written by Digital Research. Please pardon our pun, but they might object. What we ARE giving you is a greatly enhanced version of CP/M which resides on OS-1, and allows the user of OS-1 to run any and all of his programs, packages or system utilities which are already running on CP/M. We give you the source code at no charge so that you may modify any part of the CP/M to suit your own system requirements. At no charge, you also receive the enhancement allowing 4MBy files instead of 256K.)

OS-1 (with debugger, linker and screen oriented editor)	\$199.00
Update service, per year	29.00
Symbolic Debugger	150.00
MACRO-Assembler (Creates relocatable code)	150.00
"C" Compiler	660.00
FORTRAN Compiler	100.00
BASIC Compiler (very fast)	350.00



## PAPER TIGER

### IDS MODEL 440

- 8 Software Selectable Character Sizes
- Parallel & Serial Interface
- 98 ASCII Character set, upper & Lower case
- Forms length control
- Tractor Feed \$995.00
- Graphics option with 2K CRT screen buffer add \$199.00

## DYNAMIC DEVICES MODEM

- Acoustically coupled modem assembly set
- Asynchronous 0-300 Baud
- Switchable originate or answer modes
- Operates full or half duplex mode
- 15 minute assembly \$149.95



## NEW YEAR'S IC SPECTACULAR

(While Supply Lasts)	7001 (pull outs)	2.00	TMS2716	19.00
	4116 (set of 8, 16K)	69.00	2732	95.00
<b>MEMORY &amp; EPROM</b>			<b>CPU</b>	
2114-	\$ 3.00	5204	1802CD	\$19.95
2114-2	6.99	2708	6502	6.25
Pd411	2.50	2516	Z-80	9.95
2107 (pull outs)	2.00	2716	Z-80A	12.95
			8080A	8.99
			8085	22.00
			8741	79.00

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## FLOPPY CONTROLLERS

1771	\$26.95
1791	37.95
Pd372	39.00

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High Resolution 480 x 512  
for B&W and Color Imaging and Graphics

Light pen, A-D, D-A, TV synchro (needs no time base correction or adjustment with anything between random interface & NTSC commercial standard). T.V. single frame grabber ("snapshot"). Up to 1 Byte of attributions per pixel.

## LSI-100 & S-100 applied to:

**Graphic Presentation** - such as computer generated animation & other graphic displays up to 256 colors & up to 256 b&w gray scales. **Image Analysis** - using built-in FRAME GRABBER, for medical image enhancement, contour analysis, & pattern recognition. **Commercial TV Tilting & Advertising** - using synchronization capability. **Interactive graphics** - using light pen accessory.

## BASIC CONFIGURATION -

LSI-11 \$1995. S-100 \$1265.  
For TRS-80/Exidy Add \$595.00  
Includes: Data Board - 32K (480 x 512 x 1 pixel) D-A 16 level video generator. Video Synchronization Circuitry. Address Control & Timing Board.

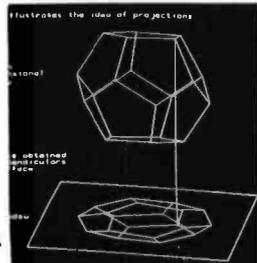
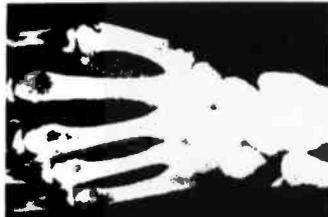
**FEATURES** - High speed. DMA or 2KBy window memory mapped interface. Full NTSC commercial color capability. Low power consumption. Excellent Software **Options - Accessories - Software**  
Options include: light pen, auxiliary outputs, text mode, memory and much more. Accessories include: b&w and color cameras and monitors. Software: "Plot" 2D or 3D, "Tilting", "Contour", "Image Enhancement", "Vector Curve Generation".

Call for price and details

\*CPM and \*\*UNIX

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Circle 206 on inquiry card.



## Electrolab's System Switcher Model SP04



Tames

RAW POWER

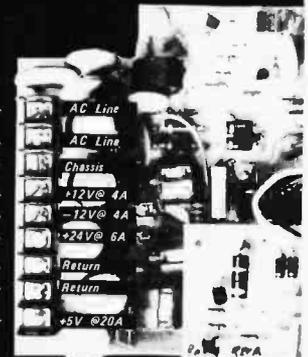
for the

# LSI-11/23

And Hard Disks

## FEATURES:

- \* Brown-Out Proof
- Line Frequency Indifferent
- Very Low EMI
- U.L. Approved
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- High Efficiency
- Soft Start
- Extremely Lightweight
- Open Frame Design
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- OV Protection
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- Adaptable to Un-Interruptable Power applications:
- and
- Low Cost!! (just look at DEC's price)



# Electrolabs

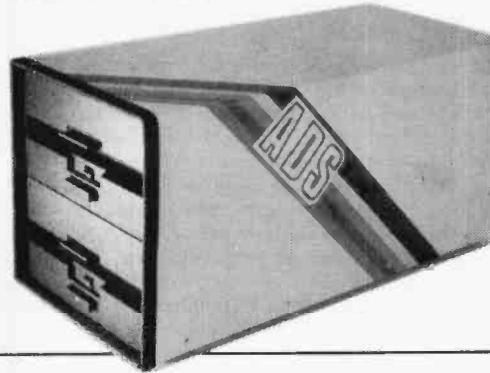


# MATCHMAKER TECHNOLOGY

## TURNKEY DISK SUBSYSTEMS

# DISK IS IN!!!

For those who wish to avoid the aggravation, fussing, irritation, annoyance etc., of assembling your own subsystem, plug in and GO!!!



✓ SORCERER

✓ TRS-80

✓ APPLE

✓ HPIB

✓ PET

### APPLE

#### FEATURES:

- 2 8" Floppy DISK DRIVES (Single Sided)
- Color Coordinated Cabinet with Power Supply
- Expanded version of APPLE-DOS
- Single Density Disk Controller
- Full Cabling, Connectors + Documentation
- Assembled and Tested
- Plug In and GO!!!

**\$1695.00**

#### OPTIONS:

- 2 8" Double Sided Drives (In place of Single Sided) **\$2395.00**
- 16K Internal Memory Expansion Kit **69.00**

### PET

Prices and specifications same as for APPLE except PET Operates via PET-DOS

### TRS-80

Prices and specifications same as for SORCERER with following exceptions:

- Expansion Interface necessary
- Space for up to 48K plug-in dynamic memory on Controller Card
- Software package as above **\$ 995.00**

### SORCERER

#### FEATURES:

- 2 8" Single Sided Floppy Disk Drives
- Single and/or Double Density
- Color Coordinated Cabinet with Power Supply
- Full RS-232 Interface
- OS-1 Disk Operating System (Fully CP/M compatible) CP/M is a registered trademark of Digital Research
- Full Cabling, Connectors + Documentation
- Assembled and Tested
- One S-100 Slot available for Memory Expansion
- Plug In and GO!!! **\$2195.00**

#### OPTIONS:

- 2 8" Double Sided Drives (In place of Single Sided) **\$2845.00**
- 32K Dynamic RAM Memory Board, Assembled and Tested **\$ 299.00**
- 16K Dynamic RAM Internal Memory Expansion Kit **\$ 69.00**
- Deluxe Business Software package includes:
  - C BASIC
  - WORD PROCESSING SOFTWARE
  - INTERACTIVE "Big 4":
    - General Ledger, Accts. Payable, Accts. Rec. and Payroll **\$ 695.00**
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9 - 15 VOLT D.C. Normally Open  
CONTACTS: 1 Amp Max Switch 2 Amps Max Carry  
BODY SIZE: Approx. 1 inch long 1/2 inch high

S.P.S.T. 1500 ohm coil \$1.15 each  
3.P.S.T. 750 ohm coil \$1.50 each

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**LARGE QUANTITIES AVAILABLE**

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**TANTALUM CAPS**  
1 MFD 35 VDC 20%

5 for \$1.00  
Large Quantities Available

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**22/44 EDGEBOARD CONNECTOR**  
TIN SOLDER TAIL .156" x .200"

**LARGE QUANTITIES AVAILABLE**

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1 1/2 AMP FULL WAVE BRIDGE RECTIFIER  
400 PIV  
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TO-3 HOUSE MARKED DARLINGTON TRANSISTOR  
16 Amps 80 Volts  
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Similar to: MJ4030 PNP  
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16 K X 1 DYNAMIC RAMS MK4116P3  
• 200 NSEC ACCESS/375 NSEC CYCLE TIMES  
• 16 PIN/TTL COMPATIBLE  
• ALL CHIPS BURNED IN AND FULLY TESTED  
• PRICE WITH DATA SHEET \$68.00 IN QTY OF 8/THAT'S \$8.50 EACH

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6800/6502 64K BYTE RAM & CONTROLLER SET  
MAKE 64K BYTE MEMORY FOR YOUR 6800 OR 6502  
THIS SET INCLUDES:  
• 32 MSK 4116-3, 16K X 1, 200 NSEC RAMS  
• 1 MC3480 MEMORY CONTROLLER  
• 1 MC3242A MEMORY ADDRESS MULTIPLEXER AND COUNTER  
• DATA & APPLICATION SHEETS. PARTS TESTED AND GUARANTEED.  
\$295.00 PER SET

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DYNAMIC MEMORY CONTROLLER MC3480L  
• GENERATES RAS/CAS & REFRESH TIMING FOR 16K TO 64K BYTE MEMORIES  
• PRICE WITH DATE SHEET: \$13.95 EACH

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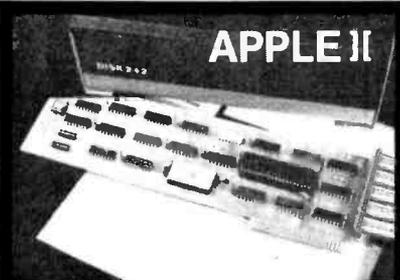
MEMORY ADDRESS MUX/COUNTER MC3242AP  
• MUX ADDRESS & REFRESH COUNTER FOR 16K TO 64K BYTE MEMORIES  
• PRICE WITH DATA SHEET: \$12.50 EACH

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**MEASUREMENT SYSTEMS & CONTROLS, INC.**  
MEMORY DEVICES DIVISION  
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# APPLE II

## 8" DISK CONTROLLER

**APPLE DOS COMPATIBLE**

- DOUBLES APPLE II™ STORAGE
- SHUGART 800/801 COMPATIBLE
- STANDARD IBM™ 3740 FORMAT
- CP/M™, UCSD PASCAL™ CAPABILITY

Available at your local APPLE Dealer: \$400.

**SVA** SORRENTO VALLEY ASSOCIATES  
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**CONTROL COMPUTER DEVELOPMENT SYSTEM**

6800 MPU, serial I/O, 48K RAM, dual 8" drives, WIZRD multitasking DOS, Editor, Assembler, 12K BASIC all for \$3995.

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Phone: (317) 742-8428

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Hardware/Software Systems

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**Cromemco**  
Incorporated

## 8K Bytesaver II

Memory Capacity: 8K Bytes  
Memory Type: 2708 PROM or equivalent  
Memory Access Time: 450 nanoseconds  
Wait States at 2MHz: none required  
Wait States at 4MHz: one per machine cycle  
Bus: S-100  
Power Requirements: +8V @ 0.8A  
                          +15V @ 0.2A  
                          -18V @ 0.4A  
Operating Environment: 0-55°C

Assembled  
**8KBS-W...\$245.00**

Cromemco's 8K BYTESAVER® card provides a built-in programmer for the popular 2708 PROM and has the capacity for a full 8K bytes of PROM memory storage. The BYTESAVER II also offers a number of new features including convenient switch selection of board address and Cromemco's powerful memory bank selection. The BYTESAVER II is assembled and tested (Model 8KBS-W) for \$245.

### DISCRETE LEDS

XC556R	red	5/51	.126" dia.	XC209R	red	4/51
XC556G	green	4/51		XC209G	green	4/51
XC556Y	yellow	4/51		XC209Y	yellow	4/51
XC556C	clear	4/51				

XC22Y	green	4/51	.185" dia.	XC252R	red	5/51
XC22G	green	4/51		XC252G	green	4/51
XC22Y	yellow	4/51		XC252Y	yellow	4/51
				XC252C	clear	4/51

MV10B	170° dia.	4/51	.190" dia.	XC111R	red	5/51
				XC111Y	yellow	4/51
MV50	085° dia.	6/51		XC111C	clear	4/51

INFRA-RED LED	1/4"x1/4"x1/16" flat	5/51				
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### DISPLAY LEDS

TYPE	POLARITY	HT	PRICE	TYPE	POLARITY	HT	PRICE
MAN 1	Common Anode-red	.270	2.95	MAN 6730	Common Anode-red ± 1	.560	.99
MAN 2	5 x 7 dot Matrix-red	.300	4.25	MAN 6740	Common Cathode-red-D.	.560	.99
MAN 3	Common Cathode-red	.125	.25	MAN 6750	Common Cathode-red ± 1	.560	.99
MAN 4	Common Cathode-green	.187	1.95	MAN 6760	Common Cathode-red ± 1	.560	.99
MAN 7G	Common Anode-green	.300	1.25	MAN 6780	Common Cathode-red	.560	.99
MAN 7	Common Anode-yellow	.300	.99	DL701	Common Anode-red ± 1	3.00	.99
MAN 72	Common Anode-red	.300	.75	DL704	Common Cathode-red	3.00	.99
MAN 74	Common Cathode-red	.300	1.25	DL707	Common Cathode-red	3.00	.99
MAN 82	Common Anode-yellow	.300	.49	DL728	Common Cathode-red	5.00	1.49
MAN 84	Common Cathode-yellow	.300	.99	DL741	Common Anode-red	6.00	1.25
MAN 3020	Common Anode-orange	.300	.39	DL745	Common Anode-red ± 1	6.30	1.49
MAN 3030	Common Anode-red ± 1	.300	.99	DL747	Common Anode-red	6.00	1.49
MAN 3040	Common Cathode-orange	.300	.99	DL749	Common Cathode-red ± 1	6.00	1.49
MAN 4610	Common Anode-orange	.300	.99	DL750	Common Cathode-red	6.00	1.49
MAN 4640	Common Cathode-orange	.400	.99	DL758	Common Cathode-red	1.10	.35
MAN 4700	Common Anode-red	.400	.99	FD700	Common Cathode	250	.69
MAN 4730	Common Anode-red ± 1	.400	.99	FD535	Common Cathode-red ± 1	6.00	1.50
MAN 4740	Common Cathode-red	.400	.99	FD539	Common Cathode	357	.75
MAN 4810	Common Anode-yellow	.400	.99	FD503	Common Cathode(FD500)	5.00	.99
MAN 4840	Common Cathode-yellow	.400	.99	FD507	Common Anode (FD505)	5.00	.99
MAN 6610	Common Anode-red-D.	.560	.99	S08-7720	Common Anode-red	3.00	.99
MAN 6630	Common Anode-orange ± 1	.560	.99	H08P-3400	Common Anode-red	6.00	1.50
MAN 6640	Common Cathode-orange-D.	.560	.99	H08P-3403	Common Cathode-red	8.00	1.50
MAN 6650	Common Cathode-orange ± 1	.560	.99	S082-7300	4 x 7 Sgl. Digit-LHDP	6.00	19.95
MAN 6660	Common Cathode-orange	.560	.99	S082-7304	Common character (±1)	6.00	15.00
MAN 6710	Common Anode-red-D.	.560	.99	S082-7340	4 x 7 Sgl. Digit-Hexadecimal	6.00	22.50

### RCA LINEAR

CA3012	2.15	CA3028N	2.00	MMS309	\$4.95	MC1408L1	\$4.95
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ASST. 6	5 ea.	390K	470K	560K	680K	820K	50 PCS	1.75
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XR1468CN	3.85	XR2211	5.25
XR1486	1.95	XR2212	3.45
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1N751	5.1	400m	1N4003	200 PIV 1 AMP	121.00	
1N752	5.6	400m	1N4004	600 PIV 1 AMP	101.00	
1N753	6.2	400m	1N4006	800 PIV 1 AMP	101.00	
1N754	6.8	400m	1N4007	1000 PIV 1 AMP	101.00	
1N756	6.8	400m	1N4010	50 200m	61.00	
1N757	9.0	400m	1N4148	75 100m	151.00	
1N758	12.0	400m	1N4154	25 100m	121.00	
1N959	8.2	400m	1N4733	5.1 1w	28	
1N965	15	400m	1N4734	5.6 1w	28	
1N932	6.5	500m	28	1N4735	6.2 1w	28
1N933	6.2	500m	28	1N4736	8.2 1w	28
1N934	6.8	500m	28	1N4737	8.2 1w	28
1N935	7.5	500m	28	1N4742	12 1w	28
1N936	12	500m	28	1N4744	15 1w	28
1N937	15	500m	28	1N1183	50 PIV 35 AMP	1.60
1N938	25	40m	61.00	1N1184	100 PIV 35 AMP	1.60
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## Function Generator Kit



Provides three basic waveforms: sine, triangle and square wave. Frequency range from 1 Hz to 100K Hz. Output amplitude from 0 volts to over 6 volts (peak to peak). Uses a 12V supply or a ±6V split supply. Includes chip, P.C. Board, components & instructions.

**JE2206B ..... \$19.95**

## Digital Thermometer Kit



Dual sensors — switching control for indoor/outdoor or dual monitoring. Continuous LED .8" ht. display. Range: -40°F to 199°F / -40°C to 100°C. Accuracy ±1° nominal. Set for Fahrenheit or Celsius. Simulated walnut case. AC wall adapter included. Size: 3¼" h x 6-5/8" w x 1-3/8" d.

**JE300 ..... \$39.95**

## Digital Stopwatch Kit



Use Intersil 7205 Chip. Plated thru double-sided P.C. Board. Red LED display. Times to 59 minutes, 59.59 seconds with auto reset. Quartz crystal controlled. Three stopwatches in one: single event, split (cumulative) and taylor (sequential timing). Uses 3 penlite batteries.

Size: 4.5" x 2.15" x .90"

**JE900 ..... \$39.95**

## 4-Digit Clock Kit



Bright .357" ht. red display. Sequential flashing colon. 12 or 24 hour operation. Black extruded aluminum case. Pressure switches for hours, minutes and hold functions. Includes all components, case and wall transformer. Size: 3¼" x 1¼" x 1¼"

**JE730 ..... \$14.95**

## 6-Digit Clock Kit



Bright .300 ht. common cathode display. Uses MM-5314 clock chip. Switches for hours, minutes and hold functions. Hours easily viewable to 20 ft. Simulated walnut case. 115VAC operation. 12 or 24 hour operation. Includes all components, case and wall transformer. Size: 6¼" x 3-1/8" x 1¼"

**JE701 ..... \$19.95**

## Jumbo 6-Digit Clock Kit



Four .630" ht. and two .300" ht. comm. anode displays. Uses MM5314 clock chip. Switches for hrs., mins., and hold functions. Hours viewable to 30 ft. Sim. walnut case. 115VAC operation. 12 or 24 hour operation. Incl. all components, case and wall transformer. Size: 6¼" x 3-1/8" x 1¼"

**JE747 ..... \$29.95**

## Regulated Power Supply Kit



Uses LM309K. Heat sink provided. PC board construction. Provides solid 1 amp @ 5 volts. Includes components, hardware & instructions. Size: 3½" x 5" x 2" h

**JE200 ..... \$14.95**

## Multi-Voltage Board Kit



ADAPTS TO JE200 SUPPLIES ±5V, ±9V and ±12V Independent load rating at single terminal. ±12V: 160mA, ±9V: 200 mA, -5V: 250mA. DC/DC converter with +5V input. Toroidal hi-speed switching XMFR. Short circuit protection. PC board construction. Piggy-back to JE200 board. Size: 3¼" x 2" x 9/16" h

**JE205 ..... \$12.95**

## Variable Power Supply Kit



Full 1.5 amp @ 5-10V output. Up to .5 amp @ 15V output. Heavy duty transformer. Three-terminal I.C. voltage regulator. Heat sink provided for cooling efficiency. PC board construction. 120VAC input. Size: 3½" x 5" x 2" h

**JE210 ..... \$19.95**

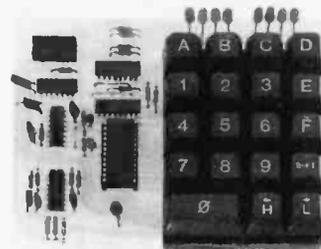
## 62-Key ASCII Encoded Keyboard Kit



The JE610 ASCII KEYBOARD KIT can be interfaced into most any computer system. The JE610 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 @ 10mA for operation. Features: 60 keys generate the full 128 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.

**JE610 ..... \$79.95**

## Hexadecimal Encoder Kit



### FULL 8-BIT LATCHED OUTPUT — 19-KEY KEYBOARD

The JE600 ENCODER KEYBOARD provides two separate hexadecimal digits produced from sequential key entries to allow direct programming for 8-bit microprocessor or 8-bit memory circuits. Three (3) 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.

**JE600 ..... \$59.95**

(Prices Subject To Change)



# 4 MHZ EXPANDORAM II KIT

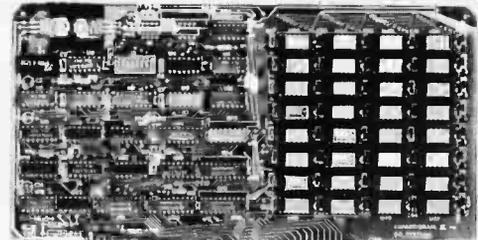
## The S-100 Memory Board for the 80's

SD SYSTEMS' ExpandoRAM II is a state-of-the-art dynamic RAM board with capacities from 16K bytes (4116) to 256K bytes (4164). It operates on the industry S-100 Bus. The ExpandoRAM II's design allows eight boards to operate from the same S-100 Bus. Page mode operation provides the system with the capability of servicing multiple users without RAM interference. Invisible refresh and synchronization with wait states provide greater reliability, and processing speeds up to 4 Mhz.

The ExpandoRAM II is compatible with most S-100 CPU's based on the Z80 microprocessor. When other SD SYSTEMS 200 series boards are combined with the ExpandoRAM II, they create a microcomputer with exceptional capabilities and features.

- S-100 Bus Compatible
- Up to 4Mhz Operation
- Expandable Memory from 16K to 256K
- DIP Switch Selectable Boundaries
- Uses 16K (4115) or 64K (4164) Memory Devices
- Page Mode Operation Allows up to 8 Memory Boards on Bus
- Operates with Z80 CPU's
- Phantom Output Disable
- Invisible Refresh (Synchronized with Wait States)

NEW



### SDS - EXPANDOPRAM II KIT (4116)

	List Price	Sale Price	List Price	Sale Price
16K . . .	\$460.00	\$295.00	48K . . .	\$960.00
32K . . .	\$710.00	\$370.00	64K . . .	\$1210.00
				\$520.00

**8803 MOTHER BOARD FOR S-100 BUS MICRO-COMPUTERS**

Includes 12 16-pin sockets for 4.5, 4.2, 12 buses and installed mounting sockets. Working solder shield. Copper plated bare epoxy glass with white markings for component locations. 610 epoxy glass board with 2 ounce copper, solder plated and 0.38 diam. pin holes for leads. Solder mask with copper windows on etched circuits to avoid accidental short circuits. Mounts 11 receptacles with 100 contacts (2 rows) on 125 centers with 250 foot spacing. Vector part number 8801-2, or mounts 10 receptacles plus interconnections to smaller mother board for expansion. Includes etched circuits and instructions for option of active, but not, or trailing terminations. Large buses, ±5V and GND (10 AMP), ±12V or 16V (17 AMP). Current ratings are per MIL-STD-275 with 100% avg. 6 pin Vector package enclosures. Fits in IBM S/4 8080 microcomputer as expansion board.

**Price: \$29.50**

**8800V Universal Microcomputer/processor plugboard, use with S-100 bus. Complete with heat sink & hardware. 5.3" x 10" x 1/16"**

1-4	5-9	10-24
\$19.95	\$17.95	\$15.95

**8801-1**

Same as 8800V except plain, less power buses & heat sink

1-4	5-9	10-24
\$15.22	\$13.79	\$12.18

**Plugboards**

3677 9.6" x 4.5" \$10.90  
3677-2 6.5" x 4.5" \$9.74

3682 9.6" x 4.5" \$12.97  
3682-2 6.5" x 4.5" \$9.81

Hi-Density Dual-In-Line Plugboard for Wire Wrap with Power & Gnd. Bus Epoxy Glass 1/16" 44 pin con. spaced .156

3677 9.6" x 4.5" \$10.90  
3677-2 6.5" x 4.5" \$9.74

Gen. Purpose D.I.P. Boards with Bus Pattern for Solder or Wire Wrap. Epoxy Glass 1/16" 44 pin con. spaced .156

3662 6.5" x 4.5" \$8.95  
3662-2 9.6" x 4.5" \$11.45

P pattern plugboards for IC's Epoxy Glass 1/16" 44 pin con. spaced .156

**CARD EXTENDER**

Card Extender has 100 contacts 50 per side on .125 centers-Attached connector is compatible with S-100 Bus Systems. \$25.83  
3690 6.5" 22/44 pin .156 ctrs. Extenders . . . \$13.17

**SALE S-100 BUS EDGE CONNECTORS \* SALE**

CO 1 (MSA) Style Card Guides \$11.00

14	5-9	10-24	1-4	5-9	10-24
\$4.75	\$4.00	\$3.75	\$4.10	\$3.80	\$3.50

100SE 50/100 Cont. 125 ctrs. PIERCED SOLDER EYELET TAILS GOLD

14	5-9	10-24	1-4	5-9	10-24
\$5.00	\$4.50	\$4.00	\$4.50	\$4.25	\$4.00

**Other Popular Edge Connectors**

D224-5WW 22/44 Cont. 156 ctrs. WIRE WRAP TAILS GOLD.	D224-5SE 22/44 Cont. 156 Ctrs. PIERCED SOLDER EYELET TAILS GOLD plated.
1-4 5-9 10-24 \$3.95 \$3.70 \$3.40	1-4 5-9 10-24 \$3.00 \$2.60 \$2.20

**RS232 & "D" TYPE CONNECTORS \***

P = Plug-Male S = Socket-Female C = Cover-Hood

PART NO.	DESCRIPTION	1-4	5-9	10-24
DE-9P	9 Pin Male	1.50	1.30	1.20
DE-9S	9 Pin Female	2.15	2.05	1.95
DE-9C	9 Pin Cover	1.50	1.30	1.15
DA15P	15 Pin Male	2.20	2.00	1.80
DA15S	15 Pin Female	3.20	3.00	2.80
DA15C	15 Pin Cover	1.80	1.45	1.30
DB-25P	25 Pin Male	2.80	2.60	2.50
DB-25S	25 Pin Female	3.75	3.65	3.40
DB51212-1	1 pc. Gray Hood	1.65	1.40	1.20
DB1225-1A	2 pc. Black Hood	1.80	1.60	1.50
DB110963-3	2 pc. Gray Hood	1.80	1.55	1.35
DC37P	37 Pin Male	3.95	3.80	3.80
DC37S	37 Pin Female	5.75	5.50	5.20
DC37C	37 Pin Cover	2.20	1.95	1.75
DD50P	50 Pin Male	4.95	4.75	4.50
DD50S	50 Pin Female	7.50	7.20	6.90
DD50C	50 Pin Cover	2.50	2.20	2.10
D20418-S	Hardware Set (2 pair) Connector for CENTRONICS 700 SERIES: Amphenol 57-30360 for back of Centronics 700 Series printers	1.4	1.9	5up-\$7.50

**1/16 Vector BOARD**

.042 dia holes on 0.1 spacing for IC's

Phenolic PART NO.	SIZE	PRICE
64P44XXXP	4.5x6.5"	\$1.56 \$1.40
169P44XXXP	4.5x17"	\$3.69 \$3.32

Epoxy Glass PART NO.	SIZE	PRICE
64P44	4.5x6.5"	\$1.79 \$1.61
84P44	4.5x8.5"	\$2.21 \$1.99
169P44	4.5x17"	\$4.52 \$4.07
169P84	8.5x17"	\$8.83 \$7.95

**3 LEVEL GOLD WIRE WRAP SOCKETS\***

Sockets purchased in multiples of 50 per type may be combined for best price.

	1-9	10-24	25-99	100-249	250-999
8 pin	.40	.36	.34	.31	.27
14 pin	.44	.43	.41	.39	.37
16 pin	.55	.47	.45	.41	.39
18 pin	.70	.60	.55	.50	.45
20 pin	.90	.80	.75	.65	.62
22 pin	.95	.85	.80	.70	.65
24 pin	.95	.85	.80	.70	.65
28 pin	1.25	1.15	1.00	.95	.90
40 pin	1.65	1.45	1.35	1.20	1.10

All sockets are GOLD 3 level closed entry. 2 level Tail Low Profile, Tin Sockets and Dip Plugs available. CALL FOR QUOTATION.

**3M SCOTCH® BRAND DISKETTES**

Part No.	Slides Density	Sectoring	Price Box of 10
740-OP	1/2single	Soft/HBM	\$39.95
740-2-OP	2/2single	Soft/HBM	\$75.00
740-3-2P	2/2single	32	\$39.95
740-3-2P	2/2single	32	\$75.00
741-0	1/2double	Soft	\$59.00
744-OK	1/2single	Soft-(TRS-80)	\$51.00*
744-10K	1/2single	Soft/10	\$51.00*
744-16K	1/2single	Soft/16	\$51.00*

\*Price Includes Kas-ette/10 Storage Box at \$5.00 Value (TRS-80) "DON'T SETTLE FOR ANYTHING LESS THAN SCOTCH"

**P.C. BOARD HOLDER** 315 PRICE: \$18.98

315-S same as 315 but with 14" bar to accommodate "S100" boards. PRICE: \$19.98

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**STANDARD VISE HEAD** 303 PRICE: \$13.49

**STANDARD VISE HEAD** 300 PRICE: \$13.49

**WIDE OPENING VISE HEAD** 380 PRICE: \$18.49

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**\$174.95** Regular \$198.00

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4116's RAMS from Leading Manufacturers (16Kx1 200/250ns)

**8 for \$75.00**

Add \$3.00 for programming Jumpers for TRS-80 Keyboard

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2708 8K 450ns EPROM	8/\$65.00 \$9.00
2716 16K 5 Volt Only EPROM	\$40.00

**Vector WRAP POST**

for .042 dia. holes (all boards on this page) T44/C pkg. 100 . . . \$ 2.34 T44/M pkg. 1000 . . . \$14.35 A-13 hand installing tool . . . \$ 4.19

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S D SYSTEMS SALE !!!

## OUR BEST SELLING MEMORY EXPANDORAM

EXPANDABLE TO 64K USING 4116 RAMS

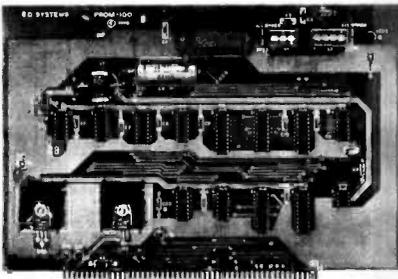


Interfaces with most popular S-100 boards  
Bank selectable; PHANTOM provision  
Draws only 5 watts fully populated  
Designed to work with Z-80, 8080, and 8085 systems  
No wait states required  
16K boundaries & protect via dip switches  
Kits come with sockets for full 64K  
Invisible refresh

MEM-16130K (16K KIT) .....	\$239.95
MEM-16130A (16K A&T) .....	\$289.95
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VERSATILE EPROM PROGRAMMER

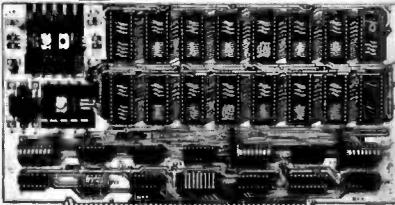


S-100 bus compatible (note: board height 7")  
Dip switch selects 2708, 2716, 2732, 2758, or 2516's  
25 VDC programming pulse generated on board  
Programming time only 100 seconds for 16K bits  
Support-software listing provided in manual  
Program and erasure verification  
Software provides for reading of object file from  
CP/M and programming into EPROM

MEM-99520K (KIT) .....	\$175.95
MEM-99520A (A&T) .....	\$225.95

## S D SYSTEMS EXPANDOPROM

EXPANDABLE TO 32K USING 2716 EPROMS



S-100 bus compatible, uses 2708 or 2716 EPROMs  
Dip switches allow selection of: each EPROM, 16K  
or 32K boundary, wait states

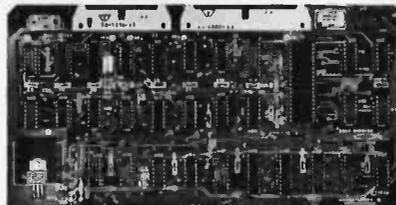
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Read/write single or double density, 8" or 5 1/4" drives  
On board Z-80 insures reliable operation  
CP/M compatible in either single or double density  
Density is software selectable  
Up to 4 single or double sided, single or double  
density drives may be mixed on the same system  
EIA level serial printer interface on board-up to 9600  
baud (perfect for despooling operations)  
All the hard work of disk access is done by the on  
board Z-80A and 2K memory, leaving your host  
CPU free for its normal duties  
Uses IBM standard formats for proven reliability  
**THIS BOARD REALLY WORKS !!!!!**

IOD-1200K (DOUBLE-D KIT) .....	\$285.00
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IOD-1200D (MANUAL ONLY) .....	\$15.00

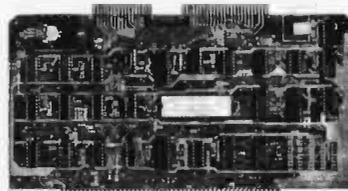
## S D SYSTEMS VERSAFLOPPY II DOUBLE DENSITY DISK CONTROLLER



Single or double density floppy disk controller  
985600 bytes on 8" double sided diskettes  
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S-100 bus (IEEE) standard compatible  
IBM 3740 format in single density  
8" and 5 1/4" drives controlled simultaneously  
Operates with Z-80, 8080, and 8085 CPU's  
Controls up to 4 drives  
Vectored interrupt operation optional

IOD-1160K (KIT) .....	\$335.95
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IBM 3740 soft sectored format  
S-100 Z-80 or 8080 compatible  
Controls up to 4 single or double sided drives  
Compatible with all popular disk drives  
CP/M compatible  
Listings for control software included

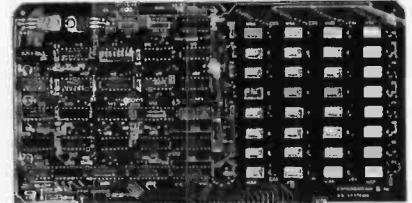
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Z-80 CPU BOARD WITH SERIAL I/O PORT  
2 or 4 MHz switchable, on-board 2708, 2716, or 2732  
EPROM useable in SHADOW mode (full 64K RAM)  
Automatic MWRITE generation if no front panel  
On-board USART for sync or async RS232

CPU-30201K (KIT) .....	\$159.00
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## S D SYSTEMS EXPANDORAM II 4 MHz RAM BOARD EXPANDABLE TO 256K

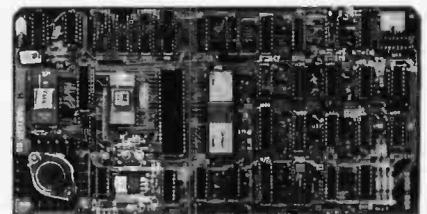


S-100 bus compatible, up to 4 MHz operation  
Expandable memory from 16K to 256K  
Dip switch selectable boundaries  
Page-mode allows up to 8 boards on the same bus  
Invisible refresh; PHANTOM output disable  
Designed to operate in Z-80 based systems

MEM-16631K (16K KIT) .....	\$295.95
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MEM-32632A (32K A&T) .....	\$419.95
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MEM-48632A (48K A&T) .....	\$494.95
MEM-64632K (64K KIT) .....	\$519.95
MEM-64632A (64K A&T) .....	\$569.95

## S D SYSTEMS VDB-8024

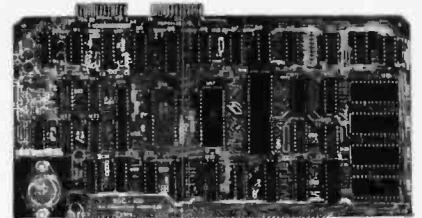
80 X 24 I/O MAPPED VIDEO BOARD



80 character by 24 line display, 7 X 10 dot matrix  
Composite or separate TTL video outputs  
On-board keyboard interface with power  
On-board Z-80 and 2K RAM  
Blink, underline, reverse, protect, up/down scroll  
Upper/lower case characters, 32 special characters  
Optional 128 user-programmable characters

IOV-1020K (KIT) .....	\$329.95
IOV-1020A (A&T) .....	\$389.95

## S D SYSTEMS SBC-100/200 2 OR 4 MHz SINGLE BOARD COMPUTER



S-100 bus compatible Z-80 CPU  
1K of on-board RAM  
4 EPROM sockets accommodates 2708, 2716, or 2732  
One parallel and one serial I/O port  
4-channel counter timer chip (Z-80 CTC)  
Software programmable serial baud rates

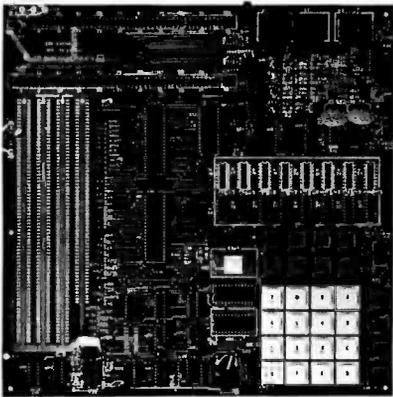
CPC-30100K (2 MHz KIT) .....	\$249.95
CPC-30100A (2 MHz A&T) .....	\$299.95
CPC-30200K (4 MHz KIT) .....	\$289.95
CPC-30200A (4 MHz A&T) .....	\$339.95

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## S D SYSTEMS Z-80 STARTER KIT COMPLETE Z-80 MICROCOMPUTER



On-board keyboard, display, EPROM programmer, and cassette interface  
On-board S-100 interface  
Wire-wrap area and room for 2 S-100 connectors  
Two 8-bit parallel I/O ports, 4-channel CTC, 5 programmable breakpoints  
Examine and change memory, I/O ports, or register  
CPS-30010K (KIT) ..... \$279.95  
CPS-30010A (A&T) ..... \$349.95

## CP/M 2.0

Digital Research has done it again! This new release of their industry standard disk operating system is bound to be an even bigger hit than the original version. All of the fundamental file-size restrictions of release 1 have been eliminated, while maintaining full compatibility with the earlier versions. This new release can be field-configured by the user for a single mini-disk up through a multiple drive hard-disk system with 128 megabyte capacity. Field configuration can be accomplished easily through use of the Macro Library (DISKDEF) provided with CP/M 2.0.

A powerful operating system for only ... \$150.00

## JADE'S NEW MOTHERBOARDS THE ISO-BUS

WE'RE PROUD OF OUR MOTHER !

### 6-SLOT

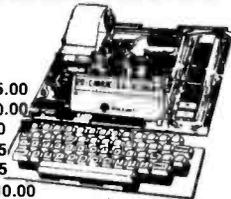
BARE BOARD	.....	\$24.95
KIT	.....	\$49.95
ASSEMBLED & TESTED	.....	\$59.95
<b>12-SLOT</b>		
BARE BOARD	.....	\$39.95
KIT	.....	\$89.95
ASSEMBLED & TESTED	.....	\$99.95
<b>18-SLOT</b>		
BARE BOARD	.....	\$59.95
KIT	.....	\$129.95
ASSEMBLED & TESTED	.....	\$149.95

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KIM-1 compatible  
On-board printer  
Full ACSII keyboard

AIM-65 w/1K RAM..\$375.00  
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POWER SUPPLY..\$59.95  
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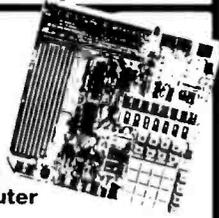
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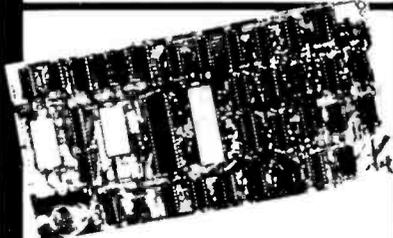
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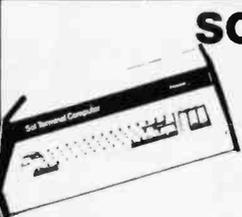


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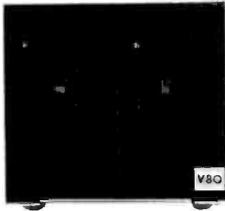


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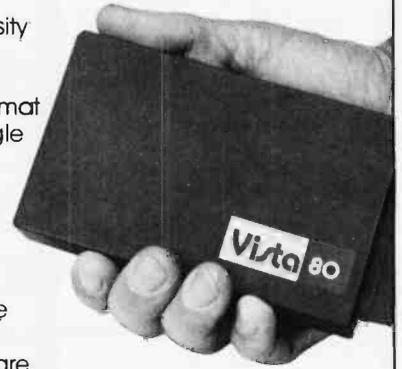
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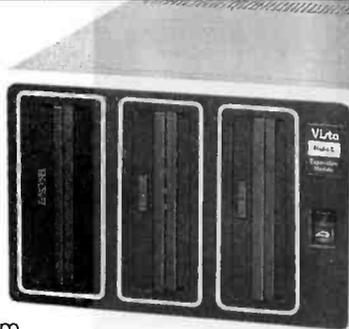
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**FOR SALE:** Magazine sets: BYTE issue #1 to issue #16, *Creative Computing* volume 1 #4 to volume 2 #6, *Kilobaud* issue #1 to issue #12, *Microtek* volume 1 #1 to volume 1 #2, and *Personal Computing* volume 1 #1 to volume 1 #6. Excellent condition. Please quote offer. F J Scavo, 1811 Court St, Syracuse NY 13208.

**FOR SALE:** Three Digital Group 8 K memory boards. 450 ns. Very reliable. \$140 each. M S Judy, 6401 Hamilton Av, Cincinnati OH 45224, (513) 542-2787.

**FOR SALE:** Heathkit computer system. Includes H9 video terminal, H8 computer with 8 K memory, serial input/output (I/O) cassette interface, all manuals and cables. Less than one-year-old. \$900 for entire system. B Hiesel, POB 35, Cudahy WI 53110.

**FOR SALE:** Heathkit factory assembled and working H11 system (equivalent to LSI/PDP-11), with I/O memory and interfaces plus H10 paper-tape reader punch. Total cost over \$3400, best reasonable offer accepted. Mr Block, POB 231, Hallandale FL 33009, (305) 456-6209.

**TRS-80 USERS:** Tiny-c and Assembler programming bulletin. Send SASE for information. Rob Varty, 2193 Haygate Cr, Mississauga Ontario, CANADA L5K 1L7.

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**FOR SALE:** Line printer, Tally T-2200, 200 lines per minute, 132 columns, 5 by 7 matrix, up to six copies, adjustable tractors, 6/8 lpi, 8-channel VFU, parallel interface. Cost \$5000, asking \$1600. Also available: warranty, service contract, other interfaces. John Marshall, POB 242, Renton WA 98055, (206) 226-0981.

**FOR SALE:** Poly 88 system. 32 K programmable memory, 3 K erasable read-only memory, 16 by 64 video with graphics and hardware scroll, keyboard, real-time clock, serial port, high-speed cassette, 9 inch monitor, documentation, and software; \$1700 Canadian. North Star FPB; \$275 Cdn. input/output (I/O) board with 2708 programmer, three parallel ports, two digital-to-analog (D/A) converters, 16-channel analog-to-digital (A/D) converter, sockets for 8 K programmable memory; \$100 Cdn. Michael Dunn, 45 Livingston Rd #501, West Hill Ontario, CANADA M1E 1K8, (416) 266-1635.

**FOR SALE:** TRS-80 Level 1 microcomputer. Only seven months old. Voice synthesizer and manual included. Eighteen popular software and game programs also included. Computer in great condition. Keyboard, cassette recorder, and video display are also included. Demonstration tape included with voice synthesizer. \$1211. Rob Wiley, 1009 S Sterling Av, Tampa FL 33609.

**FOR SALE:** ELF II system with two 4 K memory boards (factory tested), Giant Board (factory tested), ASCII keyboard, AP-1 5 A power supply ( $\pm 8$  V DC, 20 V AC/PP), RF modulator, Tiny BASIC cassette, complete documentation. Main board may have one or more defective integrated circuits. Will sell for \$275. R C Saunders, 8902 River Rd, Richmond VA 23229, (804) 740-8071.

**WANTED:** TRS-80 business software disks. I want to purchase programs for business applications at an affordable cost. They can also be in TRS-CPM version or TRS-Microsoft-FORTRAN. Douglas Gilson, Rua Sambaiba 516 Leblon, Rio de Janeiro, BRAZIL.

**FOR SALE:** Digital Group system. 30 K random access memory, 4 K erasable-programmable read-only memory with custom monitor/debugger, dual Phi-Decks, CDC floppy, Sylvania 12-inch video display, custom front panel, paper-tape reader, interfaces for audio cassette, Tally printer, and programmer; \$2200. Optional electronic pinball machine; \$400. Bought a larger system. J Kalafatas, 483 Park St, N Reading MA 01864, (617) 275-1800 ext 446 days.

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**FOR SALE:** SOL-20 in original box complete with monitor and cassette recorder; \$1495. 8 K random-access-memory board; \$100. GPM programmable-read-only-memory board; \$60. Uses 2708 programmable read-only memories. Mountain Hardware 100,000 day clock; \$100. Bob Haworth, POB 92, Boring OR 97009, (503) 663-6206.

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**FOR SALE:** Friden Flexowriter Model SPD. Includes parallel interface, but circuit needs minor work. Relays have been stripped, but will be included in the package. Friden schematics included. \$100. John Kane, 2193 Charles Dr, Stevensville MI 49127, (616) 429-8353.

**WANTED:** Any or all copies of Processor Technology's ACCESS newsletter. Peter Wayner, 37 Grandview Dr, Latham NY 12110.

**FOR SALE:** SwTPC 6800 computer system assembled. Includes: MP-68 processor, 8 K random access memory, MP-S, MP-L, AC-30, CT-1024, two Superscope C-101A cassette decks, 4 K and 8 K BASIC tapes, Motorola K9TS-460Q video monitor/TV, Expander Model 123P Black Box printer, custom walnut, leather, and acrylic case, complete system documentation. Asking \$1950 plus shipping. R H Gay, 48 Maine St, Brunswick ME 04011, (207) 725-5835.

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Please note that it may take three or four months for an ad to appear in the magazine.

**FOR SALE:** RCA Cosmac VIP assembled with video modulator. All in good working condition. All documentation. \$160. Philip Best, 19 Brookside Ln, Mansfield Center CT 06250, (203) 429-5633.

**FOR SALE:** Centronics Micro Printer, RS-232, electrographic printing, 4.6 inches wide; 20,400 characters per line; with twenty rolls of paper, \$350 or offer. C Looney, 3406 Notre Dame St, Hyattsville MD 20783.

**FOR SALE:** Electronic Systems Apple II serial input/output (I/O). Assembled and tested. RS-232 input and output; up to 30,000 bits per second (bps). Plugs into Apple. Software routine included. \$45. Bill Carlquist, 6253 Hollywood Blvd Suite 202, Hollywood CA 90028, (213) 461-4643.

**FOR SALE:** Heathkit IG-102 signal generator 100 KC to 110 MC, \$60 or best offer. Bell and Howell O-Scope single trace with Heathkit probes, \$150 or best offer. Heathkit how to use programs for signal generator and VTM, \$30 each or best offer. Full documentation with above. Brian Hummerl, 96 Hollywood Dr, Middletown PA 17057, (717) 939-7646 Mon-Wed 5:00-9:00 ET.

**FOR SALE:** Four Phi-Decks dress cabinets and Digital Group controller. Asking \$700. Peter Bornstein, 120 Ocean Pky, Brooklyn NY 11218, (212) 438-0949.

**WANTED:** Early issues of BYTE up to September 1976. Please send invoice (needed for Exchange Control) stating price. R L Bissessar, 52 Joyeau St, Curepe Trinidad, TRINIDAD AND TOBAGO, West Indies.

**FOR SALE:** Very large personal book collection. Subjects include electronics (engineering and technical levels), microcomputers, reference books, college texts, self-study courses, aviation, etc. Send 25c and SASE for complete listing. Also for sale, all new parts and chassis for unregulated power supply. +5 V at 25 A, -5 V at 3 A, +1-12 V at 3 A. Worth over \$60. You pay \$25 plus shipping. William Blair, POB 81042, DMAFB AZ 85707.

**SWAP:** OSI Challenger II owner willing to swap programs and information. Have a variety of programs from *101 Computer Games*, *24 Tested, Ready-To-Run Programs In Basic*, etc. Most 8 K but some will run in 4 K. (I have Assembler and Extender Monitor so I can run and to some extent modify machine-language programs.) Barry L Beal, RFD #1 POB 160, Machias ME 04654.

**WANTED:** Computerized options markets (C B O E, etc) and their underlying stocks are my interest, including multiple regression analysis, simulation, trading systems development, and computer interface with a securities quotation machine. I would like to correspond with those interested in trading ideas, programs, data bases, etc. J Spillane, Rd 1 POB 138, Sicklerville NJ 08081.

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## Ciarcia - Highlight of November Games

It was a close race, but Steve Ciarcia won by a nose in the last lap of the November BOMB for his article "The Intel 8086," (page 14). But so close behind were Macdonald and Gursel with "Solving Soma Cube and Polyomino Puzzles," (page 26) that the judges decided to award first place to both teams. Amazingly enough, the same close race was run for second place which will be awarded both to Gary S Sivak for "A Special Spacecraft Simulator" (page 104) and "Alpha-Beta Pruning" by Dr Maurer, (page 84). Standard deviations for all four articles were between 1.12 and 1.10. ■

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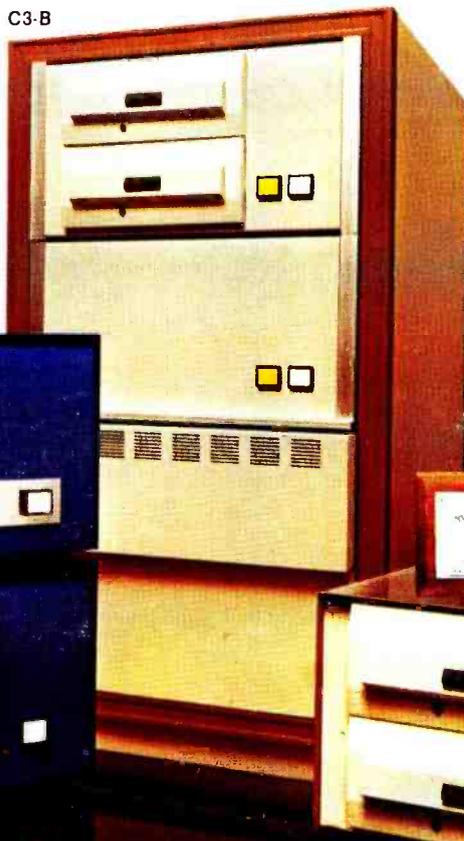
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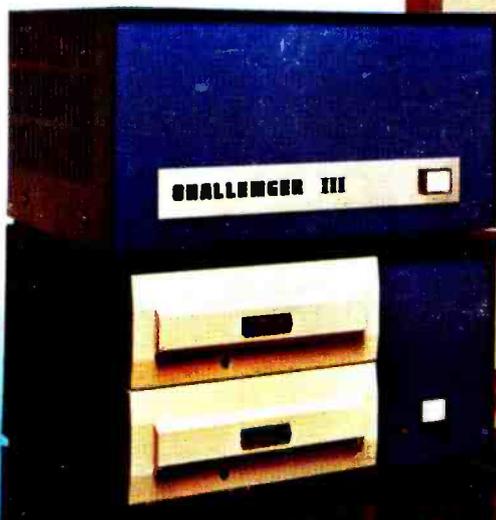
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