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BYTE®

the small systems journal

A McGRAW-HILL PUBLICATION

COMPUTERS IN THE LABORATORY

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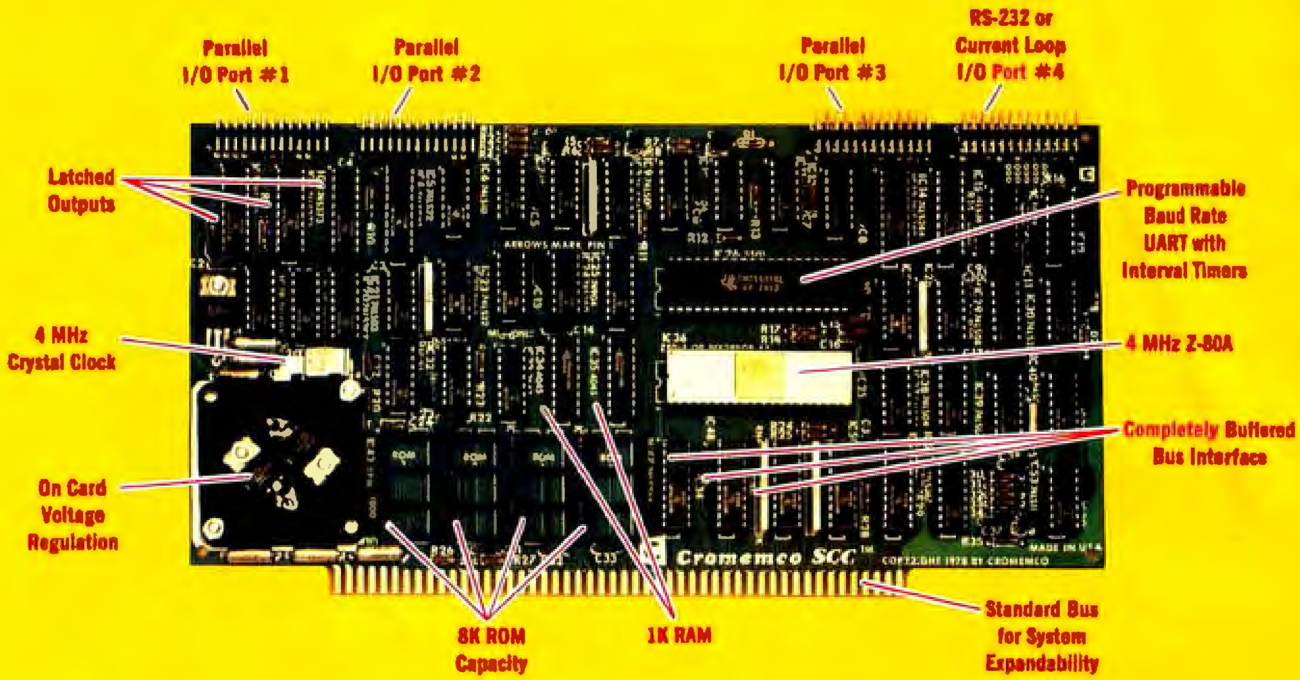

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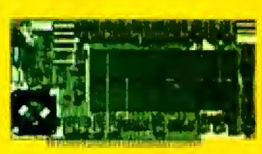

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Circle 1 on inquiry card.

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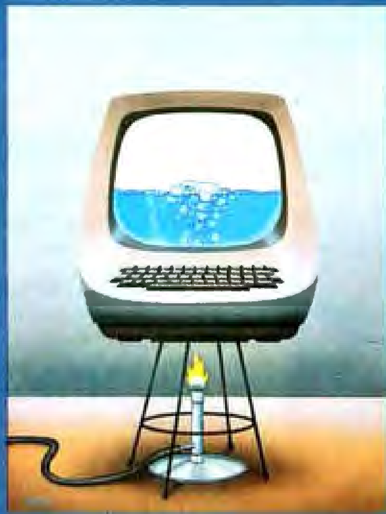
Nucleus



ON THE COVER

This month's cover theme is "Computers in the Laboratory." Personal computers can be employed as a tool of analysis and control in scientific applications. We celebrate this theme with a fantasy suggestive of one area of scientific application: an advanced color-graphics-oriented personal computer is shown over a Bunsen burner on a beaker stand. On the terminal is a high-resolution image of some liquid boiling. This computer, without floppy-disk drives, certainly suggests a future direction: built-in, permanent mass storage with sufficient capacity to eliminate any need for removable media. We might even conjecture that a pattern is shown here being "boiled" into a bubble memory.

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Editorial

Hunting the Computerized Eclipse

by Carl Helmers

As noted last month, the subject of this editorial is completing some technical details of a project that has consumed all my spare time during the closing months of 1979. This project is the practical execution of what was really a pipe dream last March when the July 1979 editorial ("Computers and Eclipses") was written. The July editorial was inspired by my travels the previous February to see my first total solar eclipse from a roadside near Roundup, Montana. During that event, which took place in cold wintry weather, all my pictures were taken manually using the telephoto lens on my Nikon F2A camera. I knew there had to be a better way of controlling my camera during an eclipse event, and set about concocting a suitable first approximation of a computer-control method.

As a result of writing about the problem, I received a letter from and eventually met one of our readers, Norm Whyte, of Monte Rio, California. In the course of the ensuing correspondence and telephone calls, we developed a degree of friendship based on mutual interests in matters scientific and technological. The result was that since there were a couple of berths left in the travel plans for Norm's eclipse trip to Kenya during February 1980, I was able to become more serious about making a real version of the fantasy sketch outlined in last July's editorial.

With the decision to go made, the next decision was how to implement the system. The number one step, of course, was to order a motor drive and a magazine back for the Nikon camera. I quickly came to the conclusion that if I were going to travel all the way to Kenya to watch 4 minutes of celestial follies, more than thirty-six exposures would be appropriate. The Peterborough Camera Shop did their job, so by September I had the motor drive, and I had the magazine-back and bulk-loading accessories by mid-October. The camera system and methods of developing a 250-frame roll in a small batch tank were debugged at the camera store in November, through the efforts of its owner Wayne Esty and lab technician Skip DeLiquori.

At about this time, I began testing my refined concept of electrical control for the motor-drive/shutter mechanism. It took about 15 minutes to verify what I wanted to know: applying an ohmmeter and a miniature Phillips screwdriver to the detachable control head of the motor drive, I was able to determine the proper wiring of the four-wire MC-1 remote-control cable I had purchased. In the normal use of a Nikon motor drive, this cable serves as the electrical equivalent of a mechanical cable release.

In my application, I simply cut off and set aside the extension socket for the control head. In its place I wired an electronic simulation of the control head. This electronic simulation is the circuit of figure 1 (see page 10), which acts like the push-button switch of the motor drive head. One silicon diode is required in the logic which distinguishes between single shot and continuous firing of the motor drive.

The relatively machine-independent, Pascal language interface to the machine-dependent absolute addresses of the annunciator output ANO is provided through a variant record technique. This technique works in UCSD Pascal implementations such as Apple Pascal, but may not work in all implementations since it definitely "bends" the formal definition of the language.

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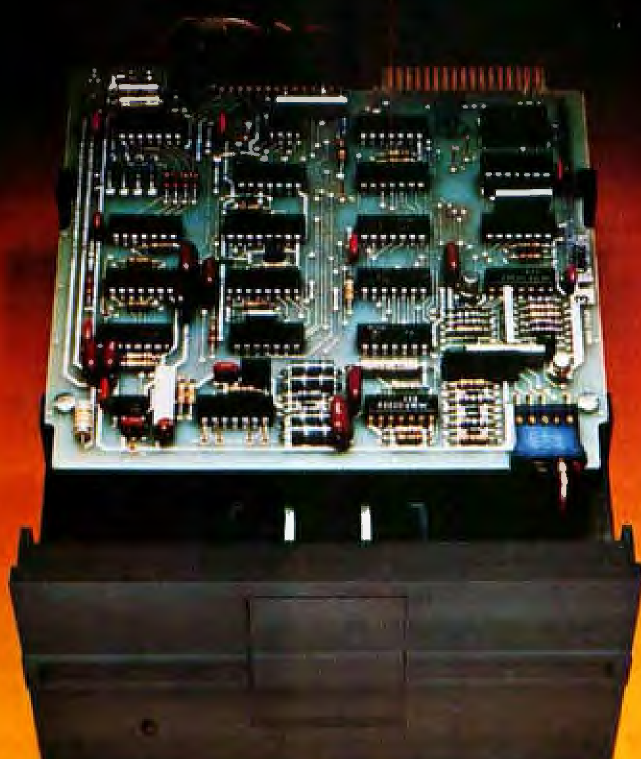

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Photo 1: *The Camera. The camera equipment has slightly expanded since originally conceived. The method of interfacing has also been greatly simplified. The camera now has a 250-exposure magazine back, which will be loaded with ASA 64 Kodak Ektachrome slide film. It turns out that the Nikon MD-2 motor drive allows direct computer control of camera operation, through a single bit interface (see figure 1). When the shutter speed control is in the "bulb" position, this single bit out of the computer controls exposure time and motor drive action.*

A transition from 0 to 1 opens the camera shutter after flipping the reflex mirror out of the way; a transition from 1 to 0 closes the shutter and causes the motor drive to advance the film to the next frame. The optically isolated two-transistor interface is wired to the four conductors in the Nikon MC-1 remote shutter extension cable. Readers should refer back to the July 1979 BYTE editorial for a much more elaborate and probably unworkable mechanical kludge suggestion.

Photo 2: *Field computer equipment. My original plan was to take a small, single board computer for use in the field. However, as the winter solstice of 1979 was fast approaching, it became obvious that it would be far easier to simply take along the Apple II Pascal machine which has the complete simulation of the event written in a high-level form. Thus, I went hunting at a local computer store, where I came upon a truly elegant Apple II traveling case. (Contact Bob McGuffie, Computerland of Nashua, New Hampshire, if you want one. I paid $108 for this product.) The case will accept two floppy-disk drives, the Apple, and the Sanyo miniature television which will be used as my field display. (At the eclipse field site, we will have 110 V AC power provided by a small gasoline generator.)*

All one needs to do is reference the appropriate address. One address, if referenced, sets the ANO output line; the second address, if referenced, resets the ANO line. I could have used the Apple-dependent, machine-language routine called TTLOUT, but decided instead to use the variant record escape of setting a pointer to an integer address value. The test program of listing 4 was used to verify the operation of the circuit in figure 1.

At the stage of this editoral's writing during December 1979, I had created a Pascal program shown in listing 1 (with execution shown in listings 2 and 3 photographed from my terminal). This program represents the most difficult part of the model, allocating the detail exposure times for all the shots of the eclipse.

The advantages of using this high-level language become obvious whenever such an elaborate program is even contemplated. I started out with a first version of the program that defined the application-specific data types of "seconds," "milliseconds," "absolute-time," "exposures," and "an-exposure-detail." The records "absolute-time" and "an-exposure-detail" give examples of how Pascal may be used to create conceptually oriented data types for specific purposes.

In this real-time simulation, I chose to use the millisecond as the basic unit of time, with actual time values on the order of seconds expressed as a two-part record with an integer value 0 thru 999 of milliseconds and an integer value of 0 thru 32,767 of seconds. I chose to express time in this manner as a part of my original intention to use a small, single-board computer programmed in assembly language. Such an expression of the data would have made it easy to translate the high-level language simulation into a hand-crafted small program.

(After time started growing short and I had not yet received the small computer I had intended to use, I started asking skeptical questions like: "Why should I flagellate myself with a macroassembly language expression of a perfectly good program written in Pascal?" After all, this "big machine" with its new suitcase is certainly portable and has the single-bit output needed.)

The variables needed by the program are declared with long, explanatory names immediately following the TYPE declarations. Thus, whenever I need a variable which is intended to be an "absolute-time" value, I declare it using the application-specific type of that name.

Text continued on page 12

Circle 2 on inquiry card.

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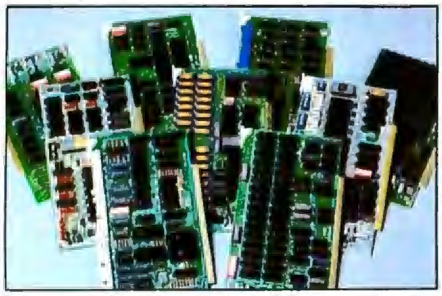

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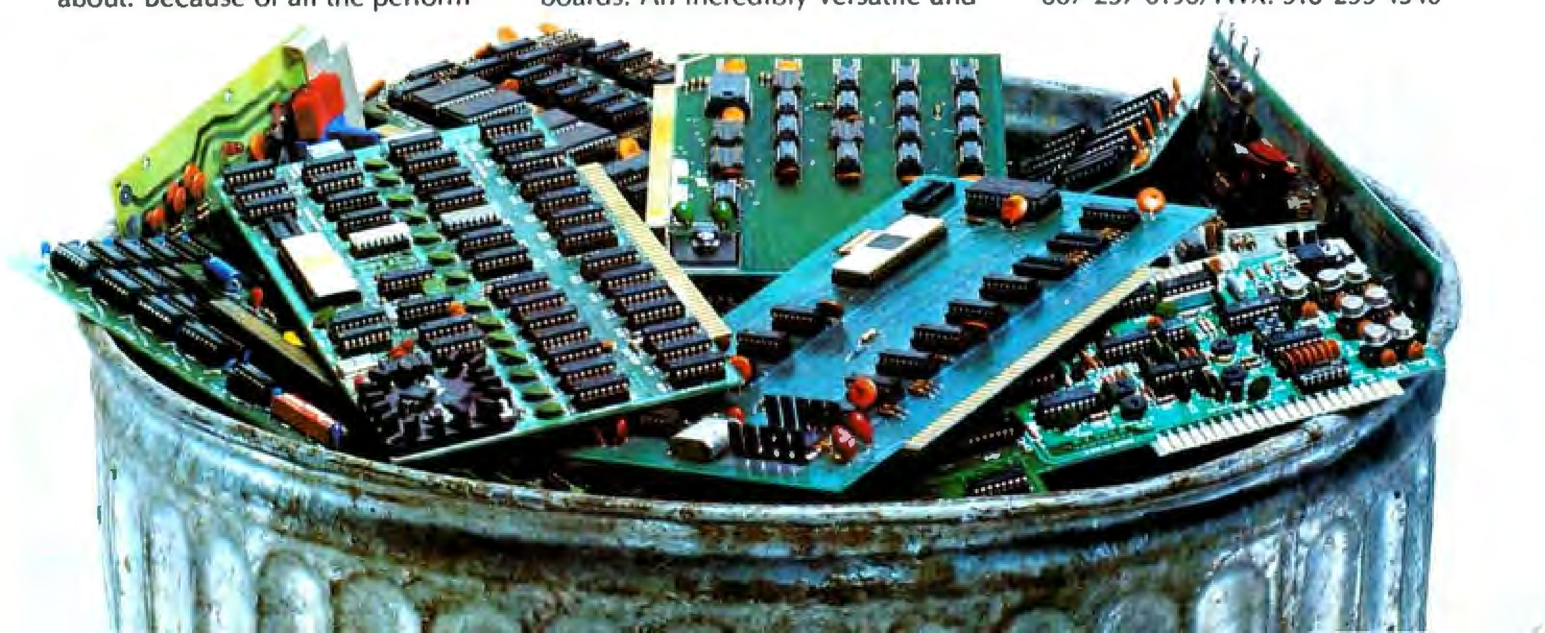
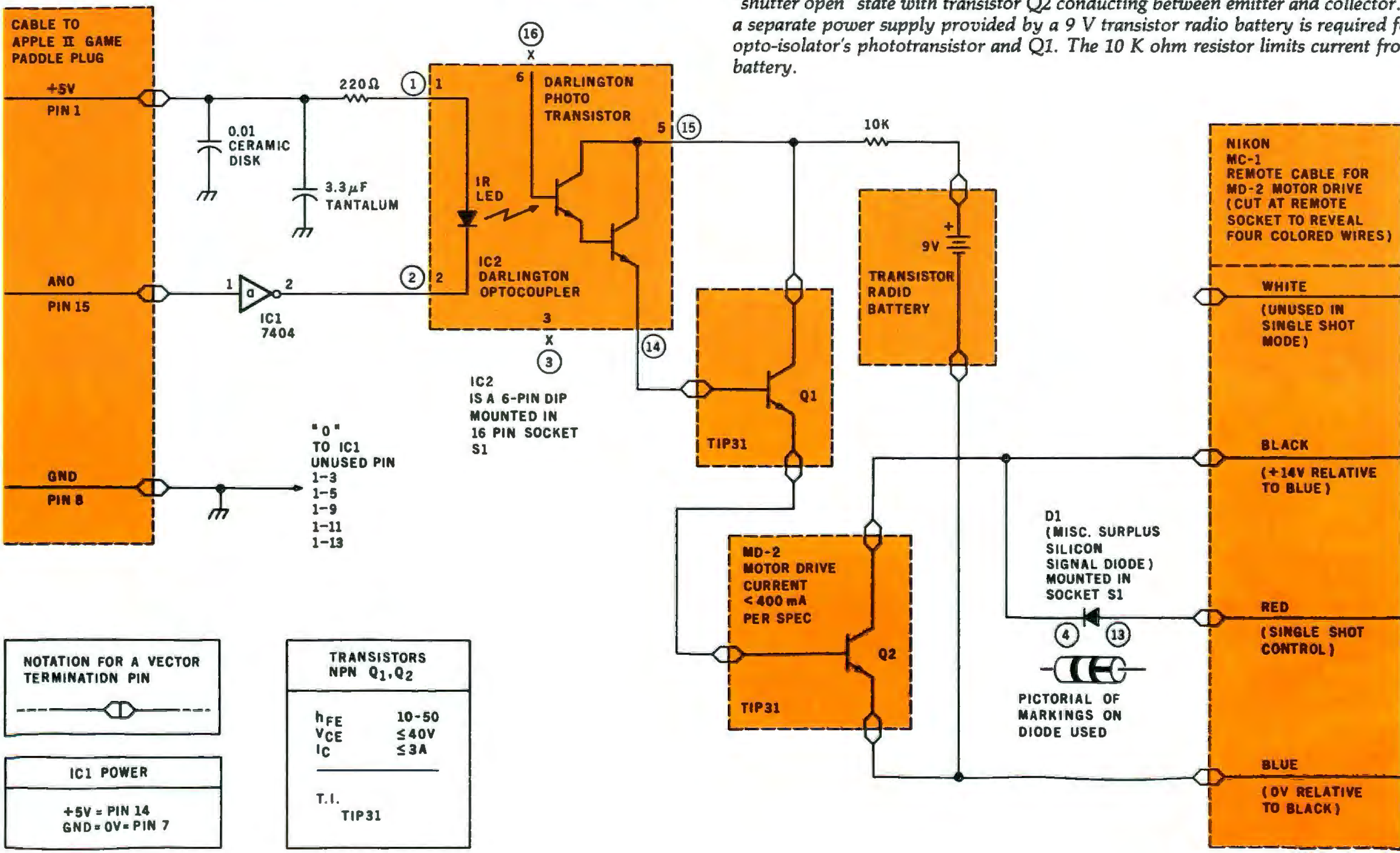


Figure 1: *The schematic of the Apple II/Nikon interface. The two transistors (Q1 and Q2) and diode D1 simulate a switch and a diode found inside the original Nikon MD-2 motor drive shutter-control head. The colors noted at the right in this figure correspond to the colors found in the four-wire cable of the Nikon MC-1 remote shutter extension cable. An opto-isolator with Darlington phototransistor was required in order to isolate the Apple II from the noisy transients of the motor drive.*

Before this final optically isolated version was devised after much frustration (and productive suggestions from Steve Ciarcia and Chris Bancroft), three different versions were tried in which switching transients propagated back to the Apple II via a common ground. The first unsuccessful version simply had a 7404 gate driving a reed relay. Then a 75450 peripheral driver was tried because the surplus relay proved to require a higher voltage (12 V) than the 5 V available from TTL. The peripheral driver made the relay flip state. But at random times when operating the motor drive, the ANO output bit would refuse to stay in the state defined by my program. So, I then tried eliminating the relay entirely and using both output transistors of the 75450 in parallel.

The random state changes remained. The lack of a 100 MHz storage scope prevented me from seeing what had to be there: short (order of magnitude: nanoseconds) high voltage, inductive transients occurring during the time when the LS Schottky TTL latch in the Apple was having its state redefined by the program. After a trip to a Radio Shack store to buy two transistors and two packages of random assorted opto-isolators, the present circuit resulted.

The opto-isolator darlington phototransistor and transistor Q1 provide drive to an output transistor Q2. If all of the transistor collectors are wired to a common supply provided by the "black" lead of the MC-1 cable, then the circuit will latch into the "shutter open" state with transistor Q2 conducting between emitter and collector. Thus a separate power supply provided by a 9 V transistor radio battery is required for the opto-isolator's phototransistor and Q1. The 10 K ohm resistor limits current from the battery.



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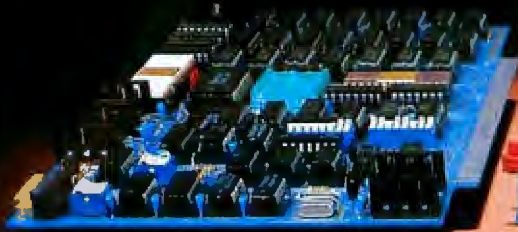

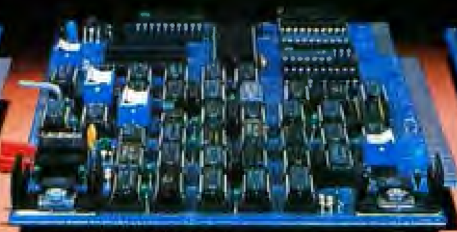

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Photo 3: *The Apple II/Nikon interface. The interface of figure 1 was wired on a framework of "P" pattern Vector perforated board. Vector terminal pins were used to provide anchorage for the Apple II cable (left edge), the cable from the Nikon MC-1 shutter extension (right edge), the connector for a 9 V transistor radio battery (bottom edge), and mountings for the two NPN transistors. Wiring was done using number 20 guage copper wire for most connections; wire-wrap connections were used for one or two signal buses.*

Text continued from page 8:

The model I am using for exposure control is a table-driven one, with two tables of the data type "an-exposure-detail." The table "ten-shot-grouping" is initialized (in procedure "initialize," naturally) with a set of ten exposures bracketing a range from 2 milliseconds to about 4 seconds. The second table "transient-shots" is used to specify the exposures that will be taken during the transient diamond ring events at the beginning and the end of the eclipse.

The exposure control details are provided by two numbers in my model: the number of milliseconds devoted to the open camera shutter state, and the number of milliseconds of waiting time which will be used to separate the shot from the next shot. This waiting time is initialized to an "overhead-duration" figure set by a Pascal constant of that name. The present value of "overhead-duration" is set at 200 milliseconds, corresponding to the motor drive's maximum speed of 5 frames per second. This initial value of the time required for each frame is used for the first pass through the procedure "sum-up-eclipse" in order to calculate the minimum time needed for all the exposures in the total phase.

The procedure "normalize-timing" is the main portion of the simulation program as it stands in listing 1. After some initialization dialog in listing 2, the procedure "alloc-exposures" is used to assign an equal number of exposures to each diamond ring sequence (second contact and third contact) given the number of exposures during totality and the total number of exposures available in the bulk film cassette.

Then the procedure "preliminary-allocation" is used to total up the time requirements of the diamond ring exposures, totality exposures, and an arbitrary amount of slack time entered to allow a hand-coordinated cuing of the third contact diamond ring sequence. The margin

Text continued on page 102

Listing 1: *A Pascal eclipse interval-allocation program. This listing contains the first cut at a Pascal camera-control program for the 1980 solar eclipse. The program's name is "eclipse-monitor-simulation" in order to emphasize that the entire process is a conceptual simulation of an actual detailed sequence of events. At this stage in the design, most of the model details have been selected in order to produce a detailed time line specified by tables. The input parameters to the program are the number of exposures, the number of exposures during totality, the time expected for totality at the site of observation, and the time to be reserved at the end of totality for manual cuing of the second diamond ring/Baily's beads (so-called third contact) exposure sequence. Listings 2 and 3 were made photographically from the terminal during a run of the program. The program as shown here has the time allocation portion completed, with the details of the actual time line simulation represented by dummy procedures, which were written in late December 1979.*

```
{     N O T E S   A B O U T   T H E   D E S I G N   P R O C E S S  }
{}
{     Step 1: High Level Description  - begun November 22, 1979     }
{          This is a first cut at a program to simulate the eclipse }
{        photography process, and define some of the necessary global }
{        data of the problem.                                       }
{                        COMPLETED 11/24/79                         }
{}
{     Step 2: Fill in allocation details -                          }
{          Achieve a complete allocation of the eclipse camera con- }
{        trol function as evidenced by calculation of a detailed time }
{        line for the eclipse event given various conditions:       }
{               Given:                                              }
{                  n   = number of totality exposures               }
{                  m   = number of diamond ring exposures           }
{                  t   = totality time                              }
{                  s   = slack in allocated totality time           }
{               Then let us seek the following...                   }
{                * d2  = diamond ring time at 2nd contact           }
{                * d3  = diamond ring time at 3rd contact           }
{                * z   = extra slack (one half of diamond ring total)}
{                * p   = anticipation time (half first diamond ring) }
{                * A   = required time for exposures during totality }
{                * a   = allocated totality time for exposures      }
{                * x   = margin per frame in totality               }
{               Theorems:                                           }
{                  d2,d3 derived from table of diamond ring frames  }
{                  A   derived from table of totality frames        }
{                  z = (d2 + d3)/2                                  }
{                  p = d2 / 2                                       }
{                  a = t - s - z                                    }
{                  x = (a - A) / n                                  }
{                                                                   }
{             PROCEDURES Detailed Here Are...                       }
{               initialize                                          }
{               normalize                                           }
{                        COMPLETED 12/16/79                         }
{}
{     Step 3: Fill in the simulated details...                      }
{          Create a program which uses the results of step 3 to     }
{        go through a detailed time line of the experiment on paper }
{        (or terminal screen).  Each event (shutter transition      }
{        open-->close or close-->open will be marked by a report of }
{        its nature and time of execution relative to <start> signal }
{                                                                   }
{             PROCEDURES Detailed Here Are...                       }
{               await_cue                                           }
{               diamond_ring_burst                                  }
{               totality                                            }
{}
{     Step 4: Adapt to real time control -                          }
{          Put in augmentations of the software to actually demon-  }
{        strate operation with the Nikon F2A camera via a relay     }
{        plugged into the Apple II Game Paddle Socket               }
{        THIS IS THE FINAL FORM OF THE PROGRAM TO BE USED IN THE    }
{        FIELD CONTROLLING THE EXPERIMENT...                        }
{          Necessary step: determining a method of measuring time   }
{        intervals from the CPU clock which is consistent with UCSD }
{        Pascal.  Possibly use assembly language subroutine.        }
{}


PROGRAM eclipse_monitor_simulation;


    CONST
       overhead_duration = 200 {milliseconds};

    TYPE
       seconds      = INTEGER;
       milliseconds = INTEGER;
       absolute_time =
          RECORD
             units       : seconds;
             thousandths : milliseconds
          END;
       exposures    = INTEGER;
       an_exposure_detail =
          RECORD
             duration    : milliseconds;
             wait_after  : milliseconds
          END;
       string_pointer = ↑STRING;


    VAR
       s                    : STRING[128];
       crash_ahead          : BOOLEAN;
```

Listing 1 continued on page 96

MORE CAPABILITIES THAN ANY OTHER PERSONAL COMPUTER UNDER $1,000*

Compare the built-in features of the ATARI™ 800™ with other leading personal computers. Whether you program it yourself or use pre-programmed cartridges or cassettes, the ATARI 800 gives you more for your money.

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Your way or our way, you'll find that the ATARI 800 is probably the most powerful computer that $999.99* can buy.

And with that power, you get dependability. Dependability built into Atari's custom designed and fully-tested LSI circuitry and lower component count, (less components, less chance for failure).

But if anything ever does go wrong, you'll find a complete network of computer-connected Atari service facilities waiting for you throughout the country.

Make your own comparison. Hands on. Anywhere computers are sold. Or, send for a free chart that compares the features of the ATARI 800 to other leading fully-programmable computers.

*Suggested retail price $999.99, includes computer console, program recorder and BASIC language cartridge.

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Letters

Needed: Software and/or Computers in Rhodesia

In the Faculty of Engineering at the University of Rhodesia, we have a critical shortage of computing facilities, and we do not have the foreign currency or the monies to purchase even simple systems like the Apple II or Cromemco. We are therefore obliged to build our own microcomputer systems. Unfortunately, we do not have the necessary expertise at the University or in the country to write the necessary BASIC interpreters, assemblers, and editors to make our systems useful or suitable for teaching purposes. I would appreciate it if one of your readers could put me on to someone who could possible supply the BASIC interpreter and/or compiler; assembler, with loader if required; and a text editor for the Intel 8080 or 8085 microprocessors.

I have been through BYTE magazine, but no one seems to offer the above software in the form which we could adapt for our own homebrew computers, and, therefore, we would appreciate it if one of your readers could advise us of anyone who may be able to sell or donate such software to enable us to offer a more effective computer teaching facility.

W B Green
Projects Engineer
POB M P 167
Mount Pleasant
Salisbury
RHODESIA

The Bare Necessities

I enjoyed the article "Budget Building on a Bare Board" by Dan S Parker (October 1979 BYTE, page 206). As he points out, there are large savings in building up only the parts of a circuit board that are needed. For instance, I have built only one serial input/output (I/O) port (for my Teletype) from the two serial and four parallel ports available on the SSM IO-4 circuit board. I have also applied this technique to a Z80 processor board, an 8 K-byte memory board, an erasable programmable-read-only memory board, and a cassette interface board.

Mr Parker's article did not go on to describe what you can do using these partially built-up boards. I am using the Integrand Research mainframe box, the SSM Monitor VI.0 (in the erasable programmable-read-only memory), and Palo Alto Tiny BASIC (Extended), which I typed into my system from the May 1976 and February 1977 issues of *Dr Dobb's Journal of Computer Calisthenics and Orthodontia*. This BASIC interpreter fits in only 2 K bytes of memory and is amazingly powerful.

I am writing a program to store a mailing list of 1000 names and addresses in main memory. The program should be able to add, delete, alphabetize, sort by ZIP code, and compress the list to free space from deleted entries. Just how far *can* one go without a floppy disk drive?

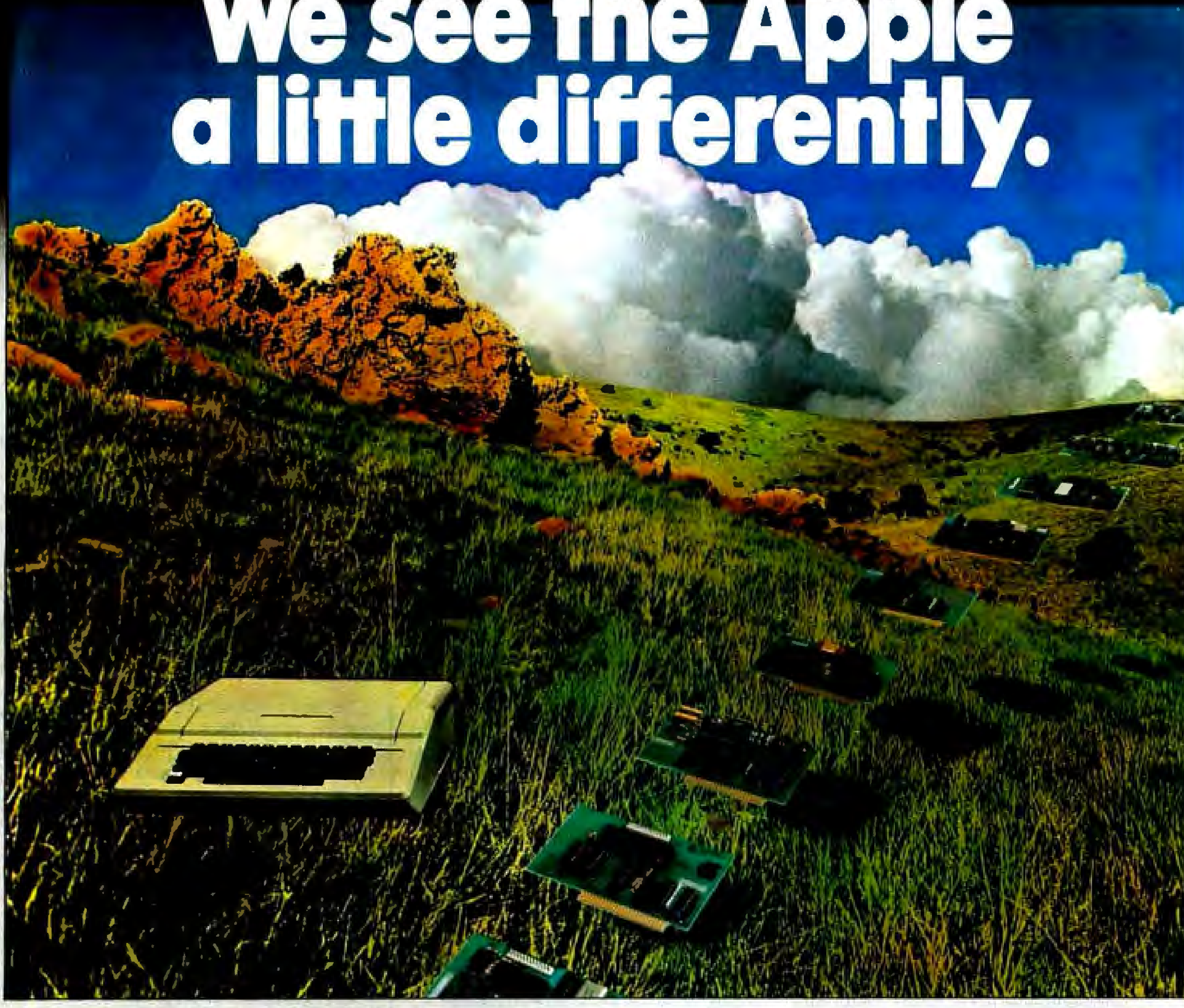
Readers of BYTE can obtain copies of the software I have written from me for either a small copying charge or in exchange for other software. I use the Intel hexadecimal checksum format on either paper tape or Kansas City cassette tape.

I have found that the Jade Serial/Parallel/Cassette I/O board is not software-compatible with the SSM monitor, but it can be made so through a process that involves cutting conductor etches on the board. You must reverse the port address bits 0 and 7, invert the transmitter-buffer-empty signal, invert the read-data-available signal and move to bit 7, and cut the control bits for the universal asynchronous receiver/transmitter (UART) from the data bus. Following this, you rewire these in the desired format.

Ralph Johnston
35 Groveland St
Newton MA 02166

Biological Rhythms and Biased Data

Regarding the editorial ". . . Pseudoscience Done . . ." (November 1979 BYTE, page 6): I totally agree with Carl Helmers' comments on the "science of biorhythms." At many times I have also been curious about the apparent cyclical nature of my physical and mental processes — such as, a few occasional nights of especially weird dreams; or several days of running slower and more painfully than usual (I run for exercise); days of great mental energy filled with



great plans, etc. . . . But each time I think about "taking data" on these phenomena, I realize the strong possibility that such data would be biased by my expecting that cycles do exist. We know how powerful our subconcious minds are. I feel my subconcious mind is easily capable of keeping track of days and thus creating (or at least influencing) the very cyclical data I am searching for.

If this is the case, perhaps the data gathering would only be valid for someone who had never heard of biorhythms. Or, maybe the human-behavior guys can figure a way around the bias.

Anyway, thanks for a good magazine.

Sid G Knox
4621 South G St
Oxnard CA 93030

Correspondence Regarding "Curve Fitting with Your Microcomputer"

"Curve Fitting with Your Microcomputer" (October 1979 BYTE, page 150) has resulted in interesting mail correspondence, some of which has enough general value to merit discussion in BYTE.

Several readers have requested information on reference books which relate to least-squares curve fitting in more than one dimension. I have yet to find a book which has a good, balanced discussion on this subject. Perhaps a reader has. One useful book is *Applied Regression Analysis*, by Norman Draper and Harry Smith (John Wiley and Sons, 1966). Another more detailed and complicated discussion appears in *Computational Geometry for Design and Manufacture*, by I D Faux and M J Pratt (John Wiley and Sons, 1979).

Dr Titus (of Tychon) has informed me of a convolution technique for least-squares smoothing of equally spaced data. The mechanics of the method are very similar to those involved in nonrecursive digital filters, and reminiscent of Akima's approximation to the cubic spline fit. The reference Dr Titus supplied was "Smoothing and Differentiation of Data by Simplified Least-Squares Procedures," by A Savitsky and M J E Golay (*Analytical Chemistry*, volume 36, number 8, July 1964).

As a final note, it has been noted that program line 800 in listing 1 has an error in it. The correct statement is S = S/(I-3), instead of S = S/(I-1). This does not affect the curve fit or relative comparisons, but influences the printed value of the standard deviation by several percent.

F R Ruckdeschel
Xerox Corp
Xerox Square
Rochester NY 14644■

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Follow the dotted line and cut out the transfer image above.

Preheat iron (dry-wool setting) for 3 minutes. Slip garment on ironing board over scrap material. Remove wrinkles. Position transfer face down and pin edges to ironing board cover. Iron transfer slowly for one minute. If paper browns, iron is too hot. Let transfer cool for one minute, then unpin and slowly pull transfer straight up. Results are best when t-shirt is at least 50% polyester.

Pascal by the package.

Our high-level, full feature Language System consists of a plug-in 16K RAM language card, five diskettes containing Pascal as well as Integer BASIC and Applesoft extended BASIC, plus seven manuals documenting the three languages.

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Apple's Pascal language takes full advantage of Apple high resolution and color graphics, analog input and sound generation capabilities. It turns the Apple into the lowest priced, highest powered Pascal system on the market. With Pascal, programs can be written, debugged and executed in just one-third the time required for equivalent BASIC programs. With just one-third the memory.

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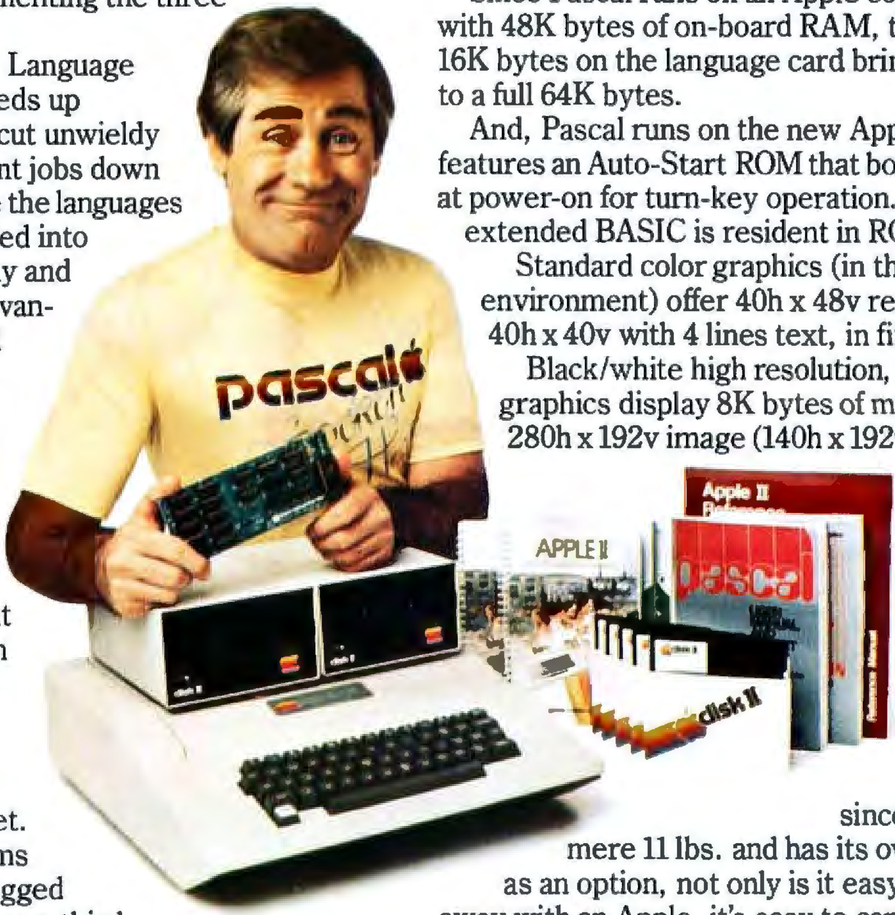
Because Apple uses UCSD Pascal,™ you get a complete software system: Editor, Assembler, Compiler, and File Handler. And because we adhere to the standard, your programs run on any UCSD Pascal system with minimum conversion. Which is really something an enthusiast can get enthusiastic about.



To be more specific.

The Apple II's specs are tempting enough without the Language System and Pascal. With them, they're downright irresistible.

The text screen, a 24x40-line window, can display an entire 80-column Pascal line, thanks to Apple's unique horizontal scrolling feature.

Characters are normal, inverse or flashing, 5x7, upper case. Full cursor control is standard.

Since Pascal runs on an Apple computer with 48K bytes of on-board RAM, the additional 16K bytes on the language card bring the total to a full 64K bytes.

And, Pascal runs on the new Apple II Plus. It features an Auto-Start ROM that boots the Disk II at power-on for turn-key operation. Applesoft extended BASIC is resident in ROM.

Standard color graphics (in the BASIC environment) offer 40h x 48v resolution, or 40h x 40v with 4 lines text, in fifteen colors.

Black/white high resolution, bit-mapped graphics display 8K bytes of memory as a 280h x 192v image (140h x 192v in six colors).

Fully buffered peripheral connectors provide access to all system buses, for complete interface freedom.

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If you'd like more information on the advantages of owning an Apple personal computer, he can fill you in. Personally.

apple computer

Ease into 16-Bit Computing:

Get 16-Bit Performance from an 8-Bit Computer

Steve Ciarcia
POB 582
Glastonbury CT 06033

Stopping for coffee at the local doughnut shop has become a morning ritual. I am quite capable of making coffee at home, but I am not what you would call a "morning person." Even though I have culinary talents that include the preparation of eggs Benedict and strawberry crepes, it had better be evening when you request them around our house.

This morning started out like any other. I pulled my car into the doughnut shop's parking lot only after carefully examining all the potential hazards. I carefully avoided the broken glass, the beat-up 1962 Chevy and the large black van with a "Tax the Rich!" bumper sticker.

After entering the shop, I sat down and spread my reading material, the latest issue of BYTE, on the counter. As my coffee and bran muffin were delivered, I could not help but overhear the conversation of two other people at the counter.

"Dave, have you been reading any of the magazines lately? It looks like everyone is going 16-bit crazy."

"I've read a lot of descriptive articles, but I suppose it'll take a while before we see any real hardware."

"Actually, I'm a little hesitant to just jump on the bandwagon. My 8085 works just fine."

"I know what you mean, Ed. The Z80 system I built from scratch is still cranking along. I'd like to do something with the 16-bit chips, but I sure don't want to throw out my 8-bit system."

"What about building a small system to experiment with? Didn't I see an article a few months ago on a single-board 8086?"

"Yeah, I remember. It was in BYTE. Wasn't it written by that guy who lives around here someplace, in his cellar or something?"

Upon hearing that last statement, I nearly choked on my muffin. I thought it would be prudent to remain anonymous until I learned whether or not they enjoyed the article. I carefully closed the magazine and placed it face down on the counter.

One way to ease yourself into the world of 16-bit computers is with the Intel 8088. This microprocessor is an 8086 on the inside with an 8-bit data bus on the outside.

"Maybe, but anyway, the article wasn't too bad," said Ed. I'm sure they didn't hear the sign of relief from across the counter. Then he continued, "But it just seemed like a larger computer than I have time to build. It's obviously oriented toward guys who don't have any other development system. I'd prefer a minimal hardware configuration to start with. If I want large programs, I'll run a macroassembler on my 8085 system, write the object code into an EPROM, and then plug it into the test board."

"Eliminating all the keys and displays will help, but how small a computer can we end up with and still be 16-bit? You'll need 16-bit address and data buses, and what's 1 K words of memory—four chips? All the EPROMs I know are 8-bit output. That means at least two of them."

"Wait a minute," said Ed. "I didn't say I had all the answers. The minimal configuration may be twenty chips, but isn't this closer to something we could afford to experiment with?"

This was the perfect opportunity to express my point of view concerning the things that I write and consult about. "Excuse me," I said. "I couldn't help but overhear your conversation. Had you considered using an 8088?"

The two young men looked up at me, paused, and harmonized, "An 80 what?"

"I know a little about microprocessors. Have you considered using an Intel 8088?"

"Is it 16-bit?" asked Dave.

"Well, yes and no," I replied. "It uses an 8-bit data bus, but, internally it's an 8086. Essentially it's an 8-bit chip that's completely 8086-software-compatible."

Should they listen to this doughnut and coffee philosopher? "That sounds tremendous, but won't it still require quite a few chips to make an operational computer?"

I sensed that this was a good time for my exit. Staying any longer would involve my designing a computer for them on the back of a napkin. Ordinarily I probably would have stayed, but I had just completed a similar task in my latest article, so I decided to let them wait a few more weeks. I rose to leave, carefully rolling up the copy of BYTE, cover page inside, and stopped behind them on my way out. "My recollection is that while four chips is a possibility, a five-chip computer is quite a reality. I've even seen how a BASIC interpreter could be written to run on it. In case you're interested, the next issue of BYTE has an article all about it."

I excused myself to attend an important meeting. As I opened the door I heard, "Thanks, I'll look forward to reading it." They watched me intently as I drove out. I could only speculate on their final conversation.

The 16-Bit Generation

The exciting items in microcomputing these days are the 16-bit microprocessors made by companies such as Intel (the 8086), Zilog (the Z8000) and Motorola (the M68000). All of these devices, although they differ in internal architectures, commonly claim to have compressed the power of a minicomputer within a single chip of silicon. Most notably are the 16-bit data bus and increased addressing space. A 20-bit address can directly address a megabyte of memory.

There seems to be little doubt in the minds of microcomputer-system designers that the 16-bit processors are the wave of the future. Already some major manufacturers are designing the new processors into intelligent terminals, word-processing systems, and other equipment. The day when this revolution within a revolution will affect the personal and small-business computer marketplace is not too far away.

But if it is obvious that the 16-bit machines will be the trend of future product technology, it is equally obvious that it is relatively difficult for the designer to make a leap from the 8-bit world of the 8080, Z80, 6800 and 6502 to the emerging 16-bit world. The 16-bit instruction sets are more complex. The 8086, for instance, has a repertoire of some 133 instructions, as compared to seventy-eight for the 8080. Simply because of the larger range of memory that can be addressed and because of address segmentation, addressing of memory is more advanced. Also, the register set is more complicated, and the types of operands with which the processor can work are more extensive.

As complex as the 8086 or any other 16-bit microprocessor is from a software viewpoint, it is in the design of hardware circuits to work with the 16-bit processors where the real complexities arise. Peripheral interfaces and existing hardware systems are generally based on an 8-bit data bus. When your whole design is built to make efficient use of an 8-bit data bus, converting to a 16-bit architecture is not a simple matter of replacing the processor. This incompatibility dictates substantial design changes to take advantage of the new 16-bit microprocessor.

A Gradual Approach to 16-Bit Computing

There is an alternative to converting abruptly to 16-bit architecture. Look at photo 1 and observe the Intel 8088 microprocessor. This device uses an 8-bit data bus, so all of your present hardware system components will work with it from the standpoint of getting information between the processor and the peripheral-support devices or memory, but the 8088 features a common internal architecture and complete software compatibility with the 16-bit 8086 processor.

As a result, the 8088 provides an excellent way for designers, engineers, hobbyists, and students to ease into the world of 16-bit computing. Its 8-bit-compatible bus structure makes it the logical choice for upgrading 6800, 6502, Z80 and 8080 designs to 16-bit capability without

I've finally found a personal computer I respect. Compucolor II.

It's not surprising that professionals get excited about the Compucolor II. It's a totally-integrated 8080A system with full color graphics display, built-in 51K mini-disk drive, and the best cost performance ratio available in a personal computer.

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Circle 9 on inquiry card.

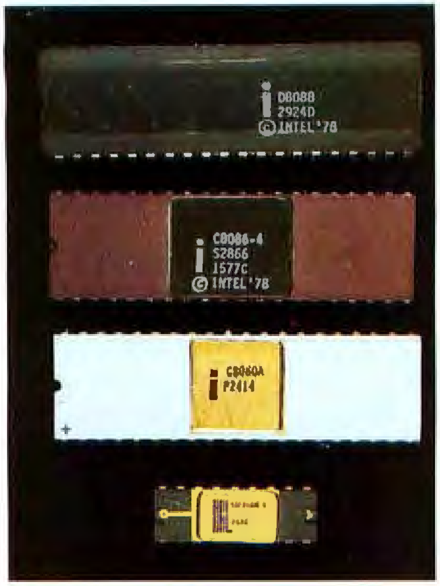


Photo 1: *An exhibit of advancing microprocessor technology. Here are four integrated circuits produced by Intel Corporation. From bottom to top, we have the 8008, the first 8-bit general-purpose microprocessor; the 8080A, one of the breed of 8-bit devices that helped ignite the microcomputing boom; the 8086, the advanced 16-bit processor; and the 8088, the subject of this article—a component that contains 16-bit computing capability in a package that can communicate with the outside world through an 8-bit data bus.*

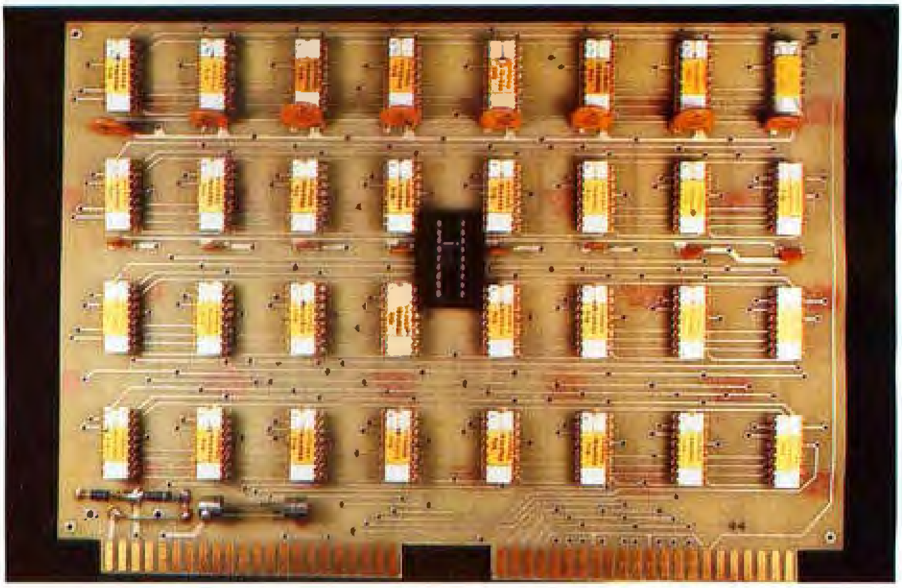


Photo 2: *An exhibit of advancing memory technology. The single black integrated circuit at the center can replace the entire board of components. The center component is the Intel 8185 1 K-byte static programmable memory. The board is a 1 K-byte memory board from a Scelbi 8B microcomputer system, which used the 8008 microprocessor (circa 1975).*

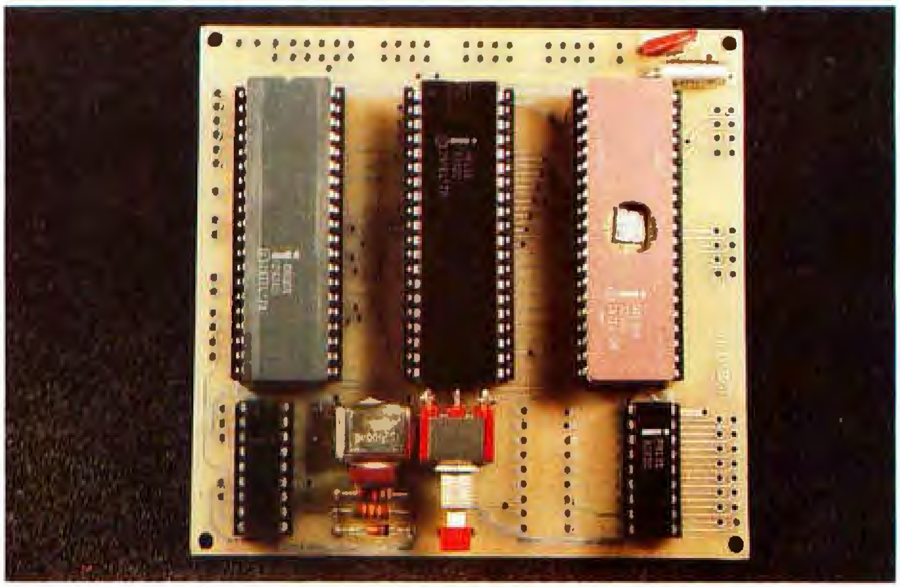


Photo 3: *Using the 8088 and other components of kindred technology, it is possible to build a functional microcomputer system with only five integrated circuits. Part 2 of this article (in the April 1980 BYTE) will present more detailed information about this system.*

alteration of existing 8-bit hardware.

The 8088 can be used in projects such as a low-cost system that employs multiplexed peripherals such as the 8155, 8755A and 8185. Or, fully expanded, it forms a system that allows a full megabyte of address space and compatibility with the 8086 family of coprocessors and multiprocessors.

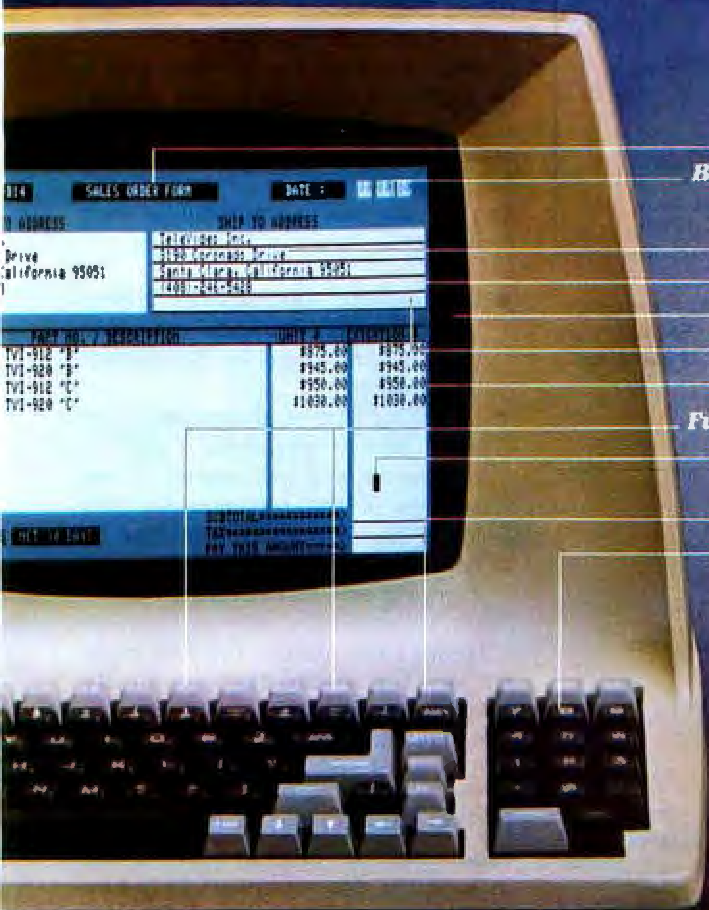
This two-part article is designed to give you a glimpse of the 8088. This month in Part 1, I shall attempt to familiarize you with the instruction set of the 8088 and the hardware of a microcomputer that is made from an 8088 and only four other integrated circuits. The power of this five-chip circuit will be emphasized by illustrating, among other examples, how it can be configured to support a multi-user Tiny BASIC.

Architecture of the 8088

Anyone comparing the internal architectures of the 8088 and the 8086 processors will realize that they are identical. Even though I have previously discussed the 8086, a brief explanation of this architecture is necessary since the capabilities of our five-chip computer depend directly upon it. However, if you wish to read a more detailed description, you should refer to a previous Circuit Cellar article, "The Intel 8086" (November 1979 BYTE, page 14).

A diagram of the internal structure of the 8088 is shown in figure 1. The 8088 contains two logical "units", the bus-interface unit (BIU) and the execution unit (EU), and a 4-byte instruction queue.

COMPARE SMARTS.



Reverse video
Blinking/blank fields
Upper/lower case char.
Protected fields
Non-glare screen
Underlining
12 × 10 char. res.
Function/editing keys
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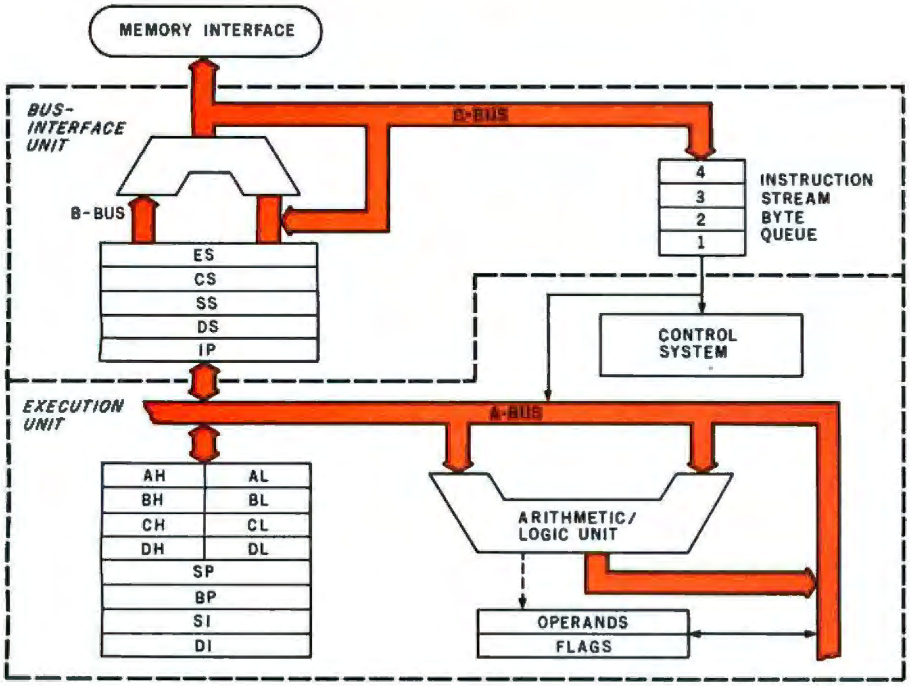

Figure 1: *Diagram showing internal operational principles of the 8088 microprocessor. The 8088 (and the 8086) use a pipelined architecture that increases performance by overlapping instruction execution with memory-fetch operations. The 8088 can directly execute any 8086 software.*

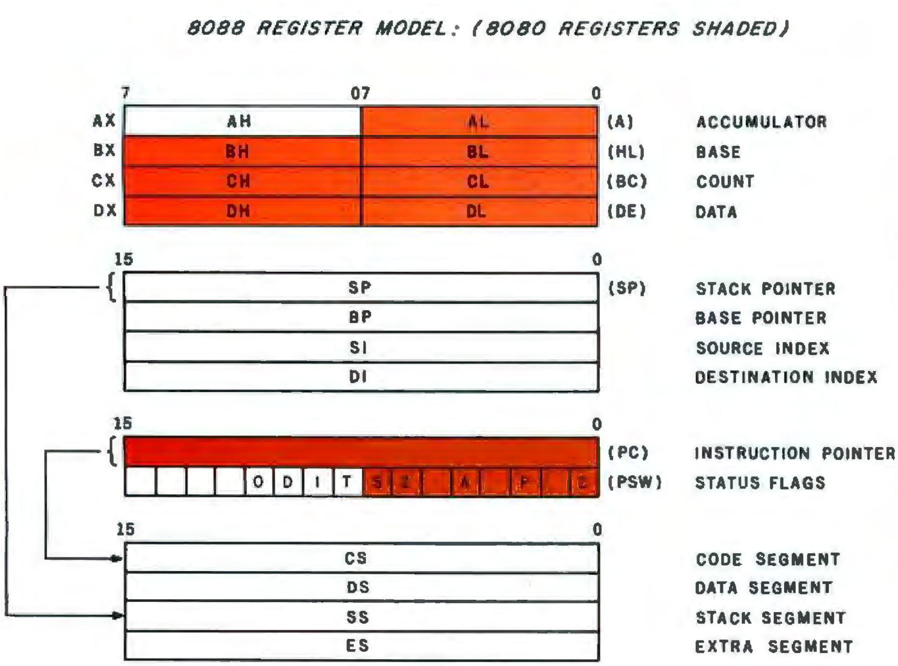

Figure 2: *The 8088 contains fourteen 16-bit registers. The shaded registers are those common to the 8088 and the 8080.*

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

The role of the *bus-interface unit* is to maximize bus-bandwidth utilization, (that is, to speed things up by making sure that the bus is used to its full capacity). The bus-interface unit carries out this assignment in two basic ways:

- by fetching instructions *before* they are needed by the execution unit, storing them in the instruction queue
- by taking care of all operand fetch and store operations, address relocation, and bus control (These actions of the bus-interface unit leave the execution unit free to concentrate on processing data and carrying out instructions.)

Figure 2 summarizes the 8088 register set. The shaded registers are the 8080 register subset, that is, the registers that are common to the 8088 and its 8-bit predecessors.

The *general registers*, also called the HL group because they can be subdivided into *H*igh and *L*ow bytes, include the accumulator (AX), base (BX), count (CX) and data (DX) registers. The AX register may be addressed as a 16-bit register, AX, or the high-order byte can be addressed as the register AH and the low-order byte as AL. The same holds true of the other three general registers (BX, CX, and DX).

Another group of registers is the *pointer and index* (or P and I) group. This set contains the stack pointer (SP), base pointer (BP), source index (SI), and destination index (DI)

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The new Series 5000 is mighty for its size. In more than several thousand ways!

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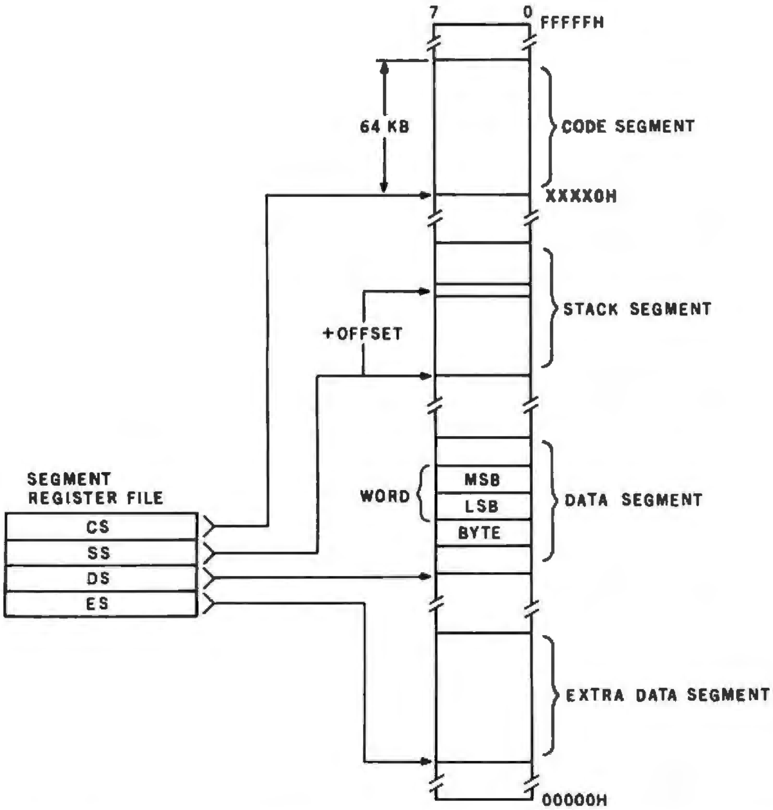

Figure 3: *Memory organization. The 8088 uses a memory-segmentation technique to address up to 1,048,576 bytes (1 M byte) of memory. The user can use attributes of the memory-addressing system to dynamically relocate a program anywhere within the entire address space.*

registers. Generally speaking, these registers hold offset addresses used for addressing within a segment of memory. They can also participate, along with the general register group, in arithmetic and logical operations of the 8088.

The 8088 uses memory segmentation to address this large memory space efficiently. At any one time, the 8088 can deal with memory as a set of four 64 K-byte segments. The total memory is organized as a linear array of 1,048,576 bytes, addressed as hexadecimal 00000 to hexadecimal FFFFF. The 8088 creates a 20-bit address by combining a 16-bit offset and a segment boundary value stored in one of the segment registers. Figure 3 demonstrates how this works.

Each of the 16-bit-segment registers, the code segment (CS) register, the stack segment (SS) register, the data segment (DS) register, and the extra data segment (ES) register, contains a value that is added to a 16-bit offset address, forming a 20-bit address. The memory is thus divided into a maximum of four 64 K-byte segments that are active at any single time. The *code segment* of memory is where instructions are stored, the *stack segment* of memory is where the pushdown stack is located, the *data segment* is where data to be operated on is found in memory, and the *extra segment* is an additional 64 K-byte data area.

When fetching an instruction from memory, the location accessed is given by a 20-bit address that is the sum of two numbers. The first number is the value of the 16-bit instruction pointer. The second number is a 20-bit value that is the 16-bit code-segment register with four low-order zero bits appended. This forms the 20-bit address required to specify any location in the megabyte-sized address space.

In the case of a memory-reference operation for a transfer of data, the absolute memory address referenced by a given memory-access instruction is calculated by adding the given 16-bit address to the base address. The base address is given by the contents of the data-segment or extra-segment register and is followed by four low-order zero bits.

In the case of a stack operation, the memory location referenced is similarly offset from the value contained in the stack-segment register.

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

Small System Applications

The 8088 can be used in a broad range of applications, from systems requiring use of a minimum number of components to systems requiring maximum performance. The component-count-sensitive applications include point-of-sale terminals and simple controllers, which require that system cost be kept low, but need substantial processing power. A big reason for this design flexibility is the ability of the 8088 to operate in a minimum-hardware mode.

The minimum-mode, multiplexed configuration, as shown in figure 4, is an effective way of building a powerful system around the 8088, while using the smallest number of parts. The processor is connected in the minimum mode by wiring its Mn/Mx pin in the high-logic state (at V_{cc} potential). The multiplexed bus is directly compatible with the Intel 8085A-family peripheral components (8155, 8355, 8755A, and the new 8185).

A four-chip system can be designed using the following components: an 8088 microprocessor; an 8284 clock generator; an 8155 memory, input/output (I/O), and timer device; and an 8755A EPROM and I/O device. A fifth component, the 8185, is a simple

♦♦♦ ALERT ♦♦♦
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1100
1000
900
800
700
600
CELLS# 1 2 3 4 5 6 7 8 9 10
WARNING: CHECK COOLANT TEMP.

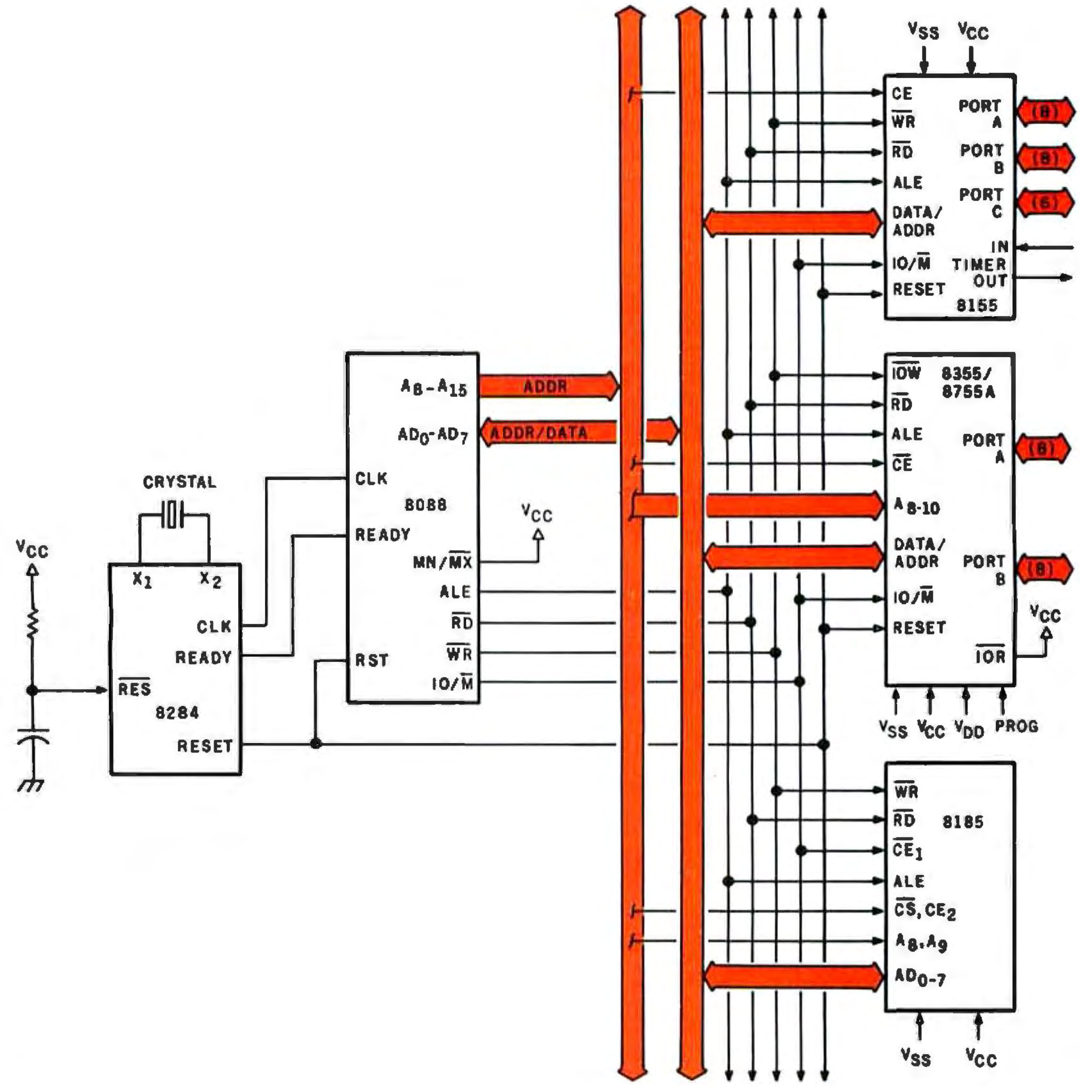

Figure 4: *When used in the minimum mode (MN/ $\overline{MX}$ line held high), the 8088 interfaces directly with the multiplexed address and data components in the 8085A-support family to form a functional microcomputer system using only five integrated circuits. Detailed information concerning this circuit will be given in Part 2.*

addition to the system and provides an extra 1 K bytes of user memory.

In the minimum-mode configuration, the 8088 provides all necessary bus-control signals, including $\overline{RD}$, $\overline{WR}$, IO/ $\overline{M}$ and ALE. It further provides HOLD and HLDA (hold-acknowledge) signals to allow direct-memory-access (DMA) data transfer, INT and $\overline{INTA}$ to interface the 8259A interrupt controller, and $\overline{DEN}$ and DT/ $\overline{R}$ to control transceivers on the data bus.

The power of the 8088 can be extended in large-system applications by wiring it into the maximum-mode configuration. However, a discussion of maximum-mode features is beyond the scope of this article.

The 8088 Instruction Set

A complete discussion of the 8088's instruction set is also beyond the scope of this article. Rather than attempt it, I shall concentrate on some specific features of the 8088 instruction set that facilitate the specific application discussed next month in Part 2 of this article. These features include extended arithmetic instructions, direct use of ASCII-encoded data, multiprocessing features, string-manipulation instructions, and table-translating aids. The 8088 instruction set includes single-instruction multiplication and division instructions, along with five different types of addition and seven types of subtraction operations.

These multiply and divide instructions greatly facilitate "number crunching." This numerical ability saves much time in such applications as data sampling, signal processing, and scientific calculation. Not only are fewer machine instructions needed to perform a given task, with corresponding savings in memory usage and execution time, but the versatility of the instructions and the

Text continued on page 30

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Listing 1: *An example of the efficiency of the 8088 and 8086 instruction set. This short routine accepts input of five values from an input port, and then calculates and sends a running-average value to an output port. Compare this listing with listing 2.*

```
        XOR     BX, BX          ;CLR BX
        MOV     CX, 5           ; Set loop counter

Average INC     BL              ;Increment data counter
        IN      AL, Port #      ;Input data
        ADD     BH, AL          ;Update running total
        MOV     AL, BH
        DIV     BL              ;Divide running total by
                                ;data counter.

        OUT     Port #, AL      ;Output running average.

        LOOP    Average         ;Return unless fifth pass
                                ;is completed.

        HLT
```

Listing 2: *A routine that performs the same task as the routine given in listing 1. This code, however, was written for the older 8080 processor. As you can see, it is longer and more tedious to write.*

```
        MVI     H,00            ;Clear H register
        MVI     E,00            ;Clear E register

Average INR     E               ;Increment data counter

        MOV     C, H
        IN      A, Port #       ;Input data
        ADD     H               ;Add data to running total

Divide  XRA     A               ;Clear accumulator
        MOV     B, A            ;Clear B register
        MOV     L, A            ;Clear L register
        MVI     C, 80           ;Initialize bit counter

Loop    MOV     A, C            ;Shift B and C as
        RAL                     ;a 16-bit unit—
        MOV     C, A            ;one bit left
        MOV     A, B
        RAL
        MOV     B, A

        CMP     E               ;Compare data
        JC      Next            ;counter (divisor) with
                                ;dividend; if divisor is larger,
                                ;bypass subtract.
        SUB     E               ;Divisor is smaller; subtract.
        MOV     B, A
        MOV     A, D            ;Set current bit of
        ORA     L               ;L to 1
        MOV     L, A

Next    MOV     A, D            ;Shift D right and check carry
        RRC
        JNC     Loop            ;If no carry, return for next bit.

        MOV     A, L            ;Outport running average
        OUT     Output #

        MVI     A, 05           ;Return unless fifth pass is
        CMP     E               ;completed.
        JNZ     Average

        HLT
```

Text continued from page 26
ability of the 8088 to deal with several types of data remove the usual necessity of handling messy conversions from one type of data representation to another and back again.

Two program listings demonstrate the saving of effort. Listing 1 gives the 8088 code for the skeleton of a subroutine that accepts data from a specified input port and calculates a running average of the values entered. The same subroutine section coded for the older 8080 microprocessor is shown in listing 2.

Direct Use of ASCII and Decimal Data

The direct use of unpacked binary-coded decimal (BCD) or ASCII-encoded data in a microcomputer has a number of obvious advantages. Since many I/O devices present data to the processor in American Standard Code for Information Interchange (ASCII) format and expect responses in the same format, microcomputer-system designers have for years faced the necessity of putting their input and output through a translation process (usually involving a table look-up operation) before processing the input or responding with output.

With the 8088's instruction set, such manipulation is no longer necessary. All four mathematical instruction types (add, subtract, multiply, and divide) provide for ASCII adjustment of the accumulator contents by a single instruction. This feature is obviously of great use in everyday microprocessor applications. Equally interesting (and useful) are the two instructions that adjust the results of addition and subtraction to *packed* decimal form.

Table-Translating Aid

Despite the availability of single instructions to convert accumulator contents from one type of data representation to another, it may still be necessary from time to time to translate data by means of the traditional look-up table. This might, for example, be necessary if the data is being received or transmitted in EBCDIC (Extended Binary-Coded-Decimal Interchange Code) rather than in ASCII form.

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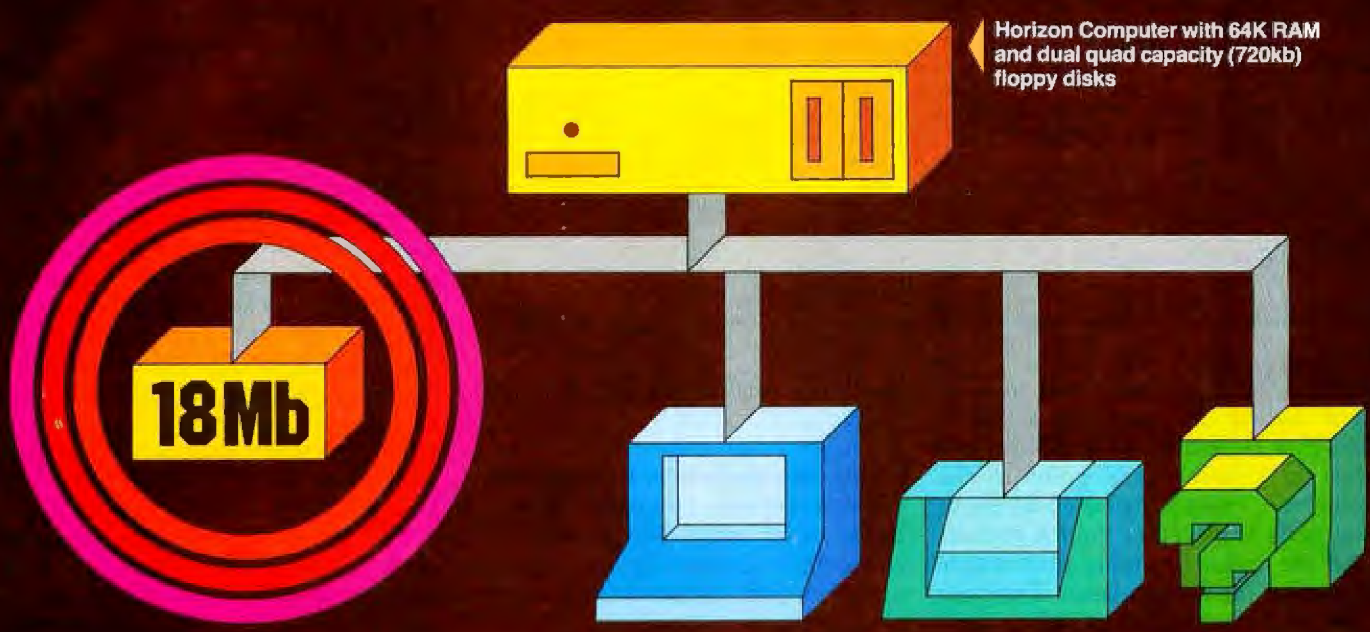

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Listing 3: *A segment of 8088 code that translates characters from Extended Binary-Coded-Decimal Interchange Code (EBCDIC) to American Standard Code for Information Interchange (ASCII) form. The 8088 instructions for manipulating and translating strings of characters are put to good use.*

```
        MOV     SI, FFFE    ; Source index register contains start of EBCDIC Buffer
        MOV     BX, 0100    ; B register points to translate table
        MOV     DI, ASCBUF  ; Destination index points to ASCII buffer
        MOV     CX, 528     ; C register contains length of buffer
        CLD
        JCXZ    EMPTY       ; Skip if input buffer empty
NEXT:   LODS    EBOBUF      ; Get next EBCDIC character
        XLAT    TABLE       ; Translate to ASCII
        STOS    ASCBUF      ; Transfer ASCII character to buffer
        CMP     AL, EOT     ; Test for EOT character
        LOOPNE  NEXT        ; Continue if no EOT received (CX decrements first)
        .
        .
        .
EMPTY:  (Program continues)
```

The XLAT (ie: translate) instruction allows the user to define a 256-byte table of correspondence and then to reference any point in the table very easily. The base address of the table is placed in the BX register and the index (ie: table position) is stored in the accumulator. Then the single instruction code XLAT is used to refer to the proper point in the table, pick out the translation, and store the result in the accumulator.

This is useful particularly when data that has been entered from a port comes into the accumulator for disposition or transfer. If you are dealing with a stream of incoming characters in EBCDIC format, for example, the translation proceeds thusly. You begin by storing the beginning memory address of your 256-byte translation table in the BX register. If you set up the table so that the base address of the table corresponds to an incoming EBCDIC value of 00, the next address to an incoming value of 01, etc, all you must do is simply accept a byte of data and execute the XLAT instruction.

This simple procedure lets us obtain the correct translation of that byte into the proper format for handling by the 8088 or some other processor. A MOV instruction will then store the result of translation until it is needed; the translation process can then be repeated with the next incoming byte. Setting up the necessary instruction sequence requires one instruction: a MOV to the BX register of the base address of the table. The loop for handling the translation requires only three basic instructions: the input instruction, XLAT, and MOV.

String-Manipulation Instructions

Since typical computer applications often deal with strings of characters consisting of letters, numbers, and special symbols, easy-to-use string-manipulation instructions are a welcome enhancement to 8-bit processors. The 8088 addresses this need by providing five powerful primitive string operators that may be preceded by a single-byte repetition prefix.

For a byte-for-byte or word-for-word comparison of two data strings (as you might use in verifying the accuracy of data loaded into memory from a mass-storage device, for example), the 8088 offers the CMPS instruction. This also allows termination of a program segment upon occurrence of a predetermined equality or inequality condition, as well as automatic incrementing or decrementing.

You can scan through a string of data for an occurrence or for an absence of occurrence of a specific string or character by using the SCAS instruction. This operation subtracts the byte or word operand in memory (or elsewhere) from the accumulator and changes the logic state of the flags; it does not, however, return a result. Again, decrementing or incrementing is automatic.

The STOS instruction allows you to fill a string of arbitrary length with a single value (eg: a string of zeros or nulls for a floppy disk initialization routine), once more with automatic incrementing or decrementing of a predetermined count.

Putting Some Things Together

Let's take a quick look at a small but powerful example that employs both the string manipulation and the XLAT instructions to solve a very practical problem.

You are designing an input routine that must translate a buffer filled with EBCDIC characters into ASCII form, continuing the transfer until one of several possible EBCDIC characters is received. The transferred ASCII string should be terminated with an EOT (end-of-transmission, hexadecimal value 04) character. Assume that the buffer starts at hexadecimal memory location FFFE, the table to translate the EBCDIC form to ASCII begins at hexadecimal location 0100 and the CX register is to contain a value giving the length of the buffer containing EBCDIC characters. The buffer may, of course, be empty.

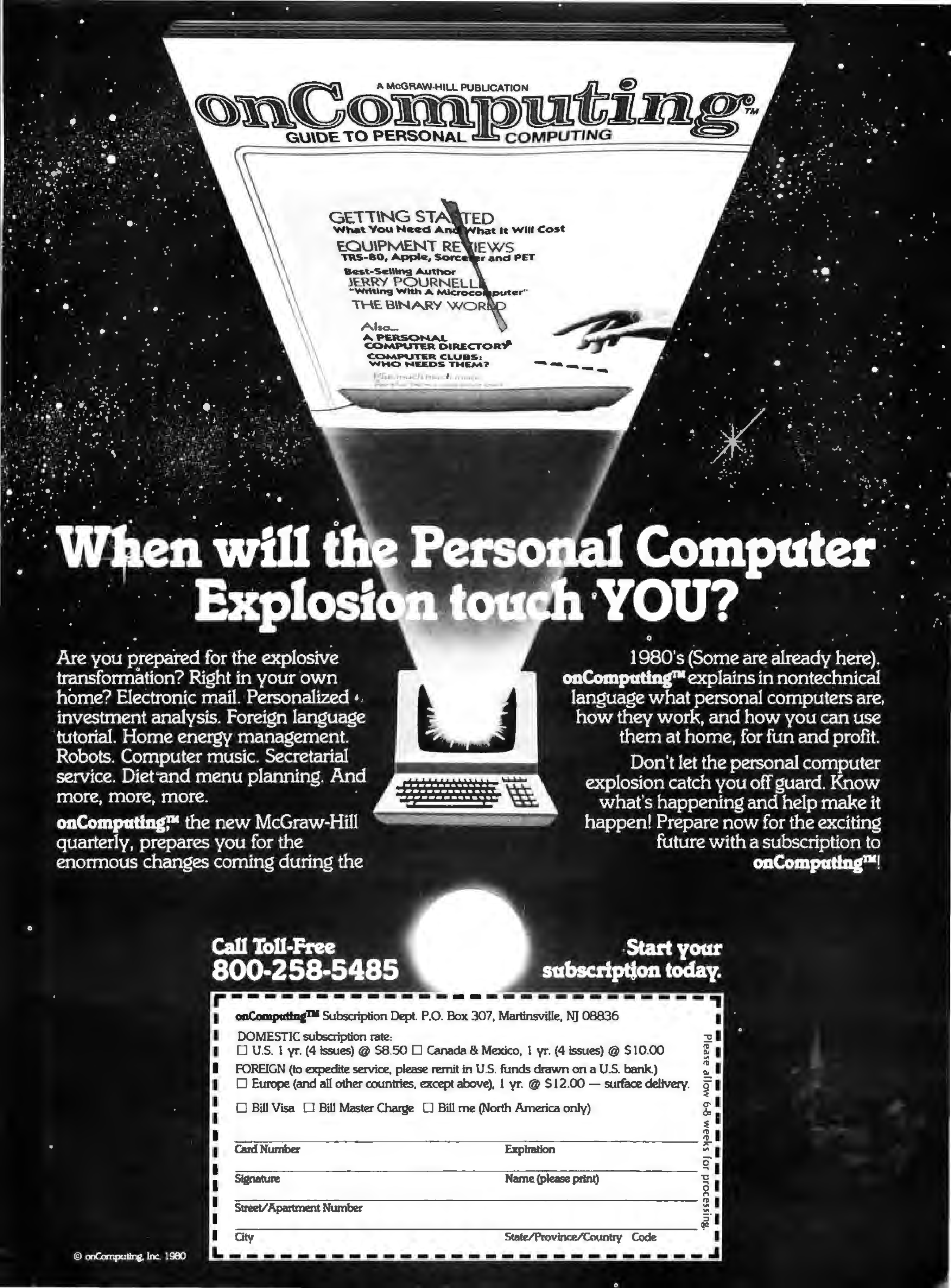
The small 8088 program segment shown in listing 3 accomplishes this task in a small number of instructions and handles a great deal of overhead work with little effort or concern on the part of the system designer and programmer.

By now you should have an understanding of the power of the 8088 microprocessor. Even in a minimal-mode, five-component circuit, our little computer will have the following attributes:

- 5 MHz 8088 8-bit processor (completely 8086 software-compatible)
- 1280 bytes of static user memory
- 2048 bytes of erasable, programmable read-only memory (EPROM)
- 38 parallel I/O lines
- a 14-bit counter/timer
- power-on reset and nonmaskable interrupt.

Next month, in Part 2, we will deal with some key features of the 8088 which make it particularly suited to multiprocessing situations. We will investigate the operating system of a multi-user, Tiny BASIC language system on our minimal-configuration computer. ■

These figures are provided through the courtesy of Intel Corporation.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Electron Behavior in a Chemical Bond

Michael Liebl, OSB
Mount Michael High School
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Years spent subconsciously gathering and sifting data in our daily lives gives each of us a common sense intuition for the laws of nature. But our intuitive understanding of how nature works often fails when we explore worlds beyond the realm of common experience. In the submicroscopic world of atoms and molecules, matter exhibits unexpected behavior attributable to its dual nature as particle and wave. Scientists interpret this world with the aid of quantum mechanics, a discipline that more often than not involves long and complicated mathematical operations.

The computer, by virtue of the ease and speed with which it handles such operations, has become an invaluable tool in the quantum-mechanical study of atoms and molecules. This article describes a program written in BASIC which allows anyone with an elementary understanding of quantum mechanics to investigate the behavior of an electron in the bond formed between two atoms in a diatomic molecule.

Electronic Potential Well

A chemical bond is the result of attractive, electric interaction between the atoms' electrons which are negatively charged and the nuclei which are positively charged. Opposite charges attract; like charges repel. In the vicinity of the nucleus of an atom, an electron feels an attractive force. The environment in which the electron is subject to this force is described as a *potential.* A rectangular *potential well,* as shown in figure 1, is an approximate model of the relation between an electron and its nucleus. The depth of this rectangular well determines the extent to which the electron is confined to the region about the nucleus. If the well is deep, it is difficult for the electron to cross the boundaries of the high walls. If, on the other hand, the well is shallow, then it is relatively easy for the electron to escape the nucleus.

A molecular bond can form when two atoms exchange or share an electron. For example, table salt is composed of two elements, sodium, an alkali metal, and chlorine, a halogen. Sodium, like all alkalis, can arrive at a stable electronic configuration by giving away one of its electrons to form a positively charged sodium ion. This element has a *shallow* potential well. Chlorine, like all halogens, can arrive at a stable electronic configuration by accepting an extra electron to form a negatively charged chloride ion. Chlorine has a *deep* potential well.

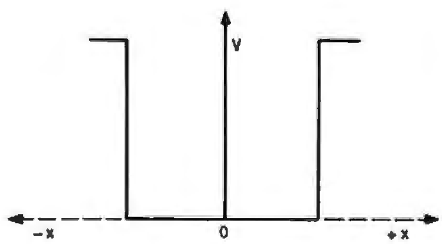

Figure 1: *Rectangular potential well model that approximates the relation of an electron to the nucleus of an atom. The depth of the well indicates the extent to which the electron is confined to the region about the nucleus.*

A bond can form between a sodium atom and a chlorine atom, and between any alkali and any halogen, when the former donates an electron to the latter. The result is a molecule, the positively charged sodium ion bound to the negatively charged chloride ion. We will use the potential well model to study different elements and the bonds that they make.

No two elements are exactly alike either in their ability to receive or in their ability to donate an electron. Thus the behavior of the electron in a chemical bond depends upon certain properties of the two elements involved. To determine the depth of the rectangular potential well for a given element, we will refer to two characteristic properties of the elements: ionization potential and electron affinity.

Ionization potential is a measure of the amount of energy required to remove an electron from a neutral atom of some element X: $X \rightarrow X^{+} + e^{-}$. For alkalis this number is small, for halogens large. *Electron affinity* is a measure of the amount of energy released when a neutral atom acquires an extra electron: $X + e^{-} \rightarrow X^{-}$. For alkalis this number is 0, for halogens the number is large. (For values of ionization potentials and

electron affinities see the *Handbook of Chemistry and Physics* published by the Chemical Rubber Company.) The depth of the potential well of any element, that is, its ability to hold on to an electron, can be estimated by averaging the element's ionization potential and electron affinity.

Composite Potential Model

When two atoms form a *diatomic* molecule, each of the atoms brings its potential well to the bond. The electron exchanged or shared by the two atoms can be pictured as being confined to a composite rectangular well that consists of the two potential wells placed side by side, as shown in figure 2. Unless the two atoms are of the same element, one side of the composite well will be deeper than the other. The difference in height between the two levels of the well is the essential feature of the bond which determines how much time the electron spends in the vicinity of one atom's nucleus as compared to the other.

Because the *difference* in height is the crucial factor, the lower level of the potential well can always be assigned as the origin on the potential axis of a Cartesian coordinate system. The upper level of the well is located at the point that represents the difference between the averages of the ionization energies and electron affinities of the two elements. Finally, it is also convenient to assume that the walls of the potential well at the endpoints of the bond are infinitely high. Given this assumption, it is impossible for the electron to escape the confines of the molecule. This potential model of the bond in a diatomic molecule simplifies the equations that describe the behavior of the electron in the bond.

Schrödinger Wave Equation

In 1926, Erwin Schrödinger formulated a differential equation to describe the behavior of a submicroscopic particle such as an electron. This equation incorporates both the particle and wave nature of the electron. Fundamentally, Schrödinger's equation is a restatement of the basic energy relation; the kinetic energy, $p^2/2m$ (derived from momentum and mass), plus the potential energy, V, yields the total energy, E, of any particle:

$$p^2/2m + V = E$$

Schrödinger's equation takes the form:

$$\frac{-\hbar^2}{2m}\frac{d^2\psi}{dx^2} + V\psi = E\psi$$

for a single-dimension model.

In the equation, $\hbar$ is read as "h-bar," and stands for a value equal to Planck's constant divided by 2π. Planck's constant, h, is an empirically determined value equal to 6.6256×10^{-34} Joule-seconds. The mass of the particle is shown as m. The Greek psi (ψ) is the notation for the wave function. In Schrödinger's formulation, the energy equation has been multiplied by a wave function, ψ, to account for the wave-like behavior of submicroscopic particles, and the square of the momentum has been replaced by the differential operator, $-\hbar^2\, d^2/dx^2$.

When the Schrödinger equation is solved for a particular set of circumstances, called *boundary conditions*, it yields as a solution the form of ψ, the wave equation. ψ^2 gives the relative probability, for the conditions assumed, of finding the particle it describes at some point in space. It is known as the *probability distribution* function.

In our model, the depth of the rectangular potential well is a measure of the magnitude of the potential energy, V, which acts on the electron and affects its location. In a split-level well the deeper side exerts a greater force on the electron. Therefore we

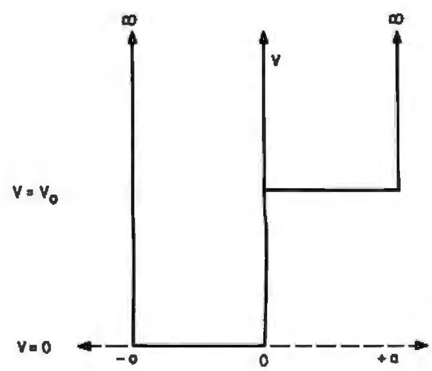

Figure 2: *When a diatomic molecule is formed, the relationship between the two atoms may be considered as a combination of two potential wells.*

m	mass of an electron; 9.109×10^{-31} kilograms
q	charge on an electron; 1.602×10^{-19} Coulombs
$\hbar$	Planck's constant divided by 2π; 0.658×10^{-15} electron-volt-seconds
p	momentum of the electron
a	length of chemical bond
V_0	potential difference between elements
E	total energy of the electron
A	coefficient of the wave equation, ψ_L, for the left side of the potential well
B	coefficient of the wave equation, $\psi_{R,I}$, for the right side of the potential well when $E>V_0$
C,D	coefficients of the wave equation, $\psi_{R,II}$, for the right side of the potential well when $E<V_0$

Table 1: *Symbols and constants that are used throughout this article.*

would expect the probability distribution function, ψ^2, to be skewed toward the deeper side of the well.

Two-Part Equation Solution

For the potential well pictured in figure 2, the Schrödinger equation is solved in two parts, corresponding to the lower or left side and to the upper or right side of the well. The potential in the left side of the well is equal to zero. The potential in the right side of the well is equal to the difference between the potentials of the two elements, V_0.

The wave-equation solution, ψ, must meet four requirements:

- At the left boundary of the well, the potential wall is infinitely high. There is no possibility for the electron to pass beyond this point. Therefore at $x = -a$, the value of the function ψ_L must be zero.
- Similarly, the wall at the right boundary is infinitely high. There is no possibility for the electron to pass beyond this point. Consequently at $x = +a$, ψ_R must also be equal to zero.
- We are studying a single electron. Although we attack the solution in two parts that correspond to the two sides of the potential well, a

Text continued on page 44

Listing 1: *BASIC program that solves the Schrödinger equation to simulate the behavior of an electron in a diatomic chemical bond. The program finds αa, βa, and γa in terms of V_0.*

The correspondence of variables in the program to terms in the equations is as follows: A1 stands for αa; B1 stands for βa; G1 stands for γa; V0 stands for V_0.

```
10 REM PROFILE OF A CHEMICAL BOND IN A DIATOMIC MOLECULE
20 REM WRITTEN BY MICHAEL LIEBL
30 REM CALCULATION OF N AND VO
40 REM PROGRAM LINES 10-1000
50 PRINT : PRINT : PRINT
60 DIM S$(10),R(10),IP(10),EA(10)
70 PRINT TAB(20);"-PROFILE OF A CHEMICAL BOND--"
80 PRINT
90 PRINT"      THE ELECTRON DENSITY IN THE CHEMICAL BOND OF A DIATOMIC MOLECULE"
100 PRINT"DEPENDS UPON THE POTENTIAL DIFFERENCE (VO) BETWEEN THE TWO ELEMENTS"
110 PRINT"WHICH ARE BOUND TOGETHER AND UPON THE LENGTH OF THE BOND (A).  THE"
120 PRINT"AVERAGE OF THE IONIZATION ENERGY AND THE ELECTRON AFFINITY OF AN"
130 PRINT"ELEMENT OFFERS A MEASURE OF THE POTENTIAL OF THE ELEMENT."
140 PRINT
150 PRINT"      THIS PROGRAM CALCULATES A PROFILE OF A CHEMICAL BOND BASED"
160 PRINT"UPON THIS INFORMATION.  FROM THE LIST OF ELEMENTS BELOW, SELECT TWO"
170 PRINT"WHICH WILL MAKE UP THE MOLECULE.  ENTER THE SYMBOLS FOR THESE"
180 PRINT"ELEMENTS AT THE REQUEST OF THE PROGRAM."
190 PRINT : PRINT
195 F=0
200 PRINT TAB(10)"HYDROGEN  -  H"
210 PRINT TAB(10)"LITHIUM   -  Li";TAB(40)"FLOURINE   -  F"
220 PRINT TAB(10)"SODIUM    -  Na";TAB(40)"CHLORINE   -  Cl"
230 PRINT TAB(10)"POTASSIUM -  K";TAB(40)"BROMINE    -  Br"
240 PRINT TAB(10)"RUBIDIUM  -  Rb";TAB(40)"IODINE     -  I"
250 PRINT TAB(10)"CESIUM    -  Cs"
260 PRINT
270 PRINT
280 INPUT"ENTER ELEMENT NUMBER ONE - ";A$
290 FOR I=1 TO 10
300 READ S$(I),R(I),IP(I),EA(I)
310 IF S$(I)<>A$ THEN NEXT I
320 IF I<>11 THEN 350
330 GOSUB 800
340 GOTO 280
350 RESTORE
360 INPUT"ENTER ELEMENT NUMBER TWO - ";A$
370 FOR J=1 TO 10
380 READ S$(J),R(J),IP(J),EA(J)
390 IF S$(J)<>A$ THEN NEXT J
400 IF J<>11 THEN 430
```

Listing 1 continued on page 38

Listing 1 continued:

```
410 GOSUB 800
420 GOTO 360
430 RESTORE
440 PRINT : PRINT : PRINT
450 M=9.109E-31
460 Q9=1.602E-19
470 H=0.658E-15
480 A=(R(I)+R(J))*1E-10
490 V1=(IP(I)+EA(I))/2
500 V2=(IP(J)+EA(J))/2
510 VO=V2-V1
520 IF VO<O THEN VO=-VO
530 N=SQR(2*M*VO/Q9)*A/H
540 N2=N^2
550 PRINT"VO = ";
560 PRINT USING"##.###";VO
570 PRINT" N = ";
580 PRINT USING"##.###";N
590 PRINT : PRINT : PRINT
600 INPUT"WHEN READY TO CONTINUE TYPE A CARRIAGE RETURN. ";A$
610 GOTO 1010
800 REM SYMBOL ENTRY ERROR
810 PRINT
820 PRINT"THE CHEMICAL SYMBOL ENTERED DOES NOT MATCH ANY IN THE FILE.  CHECK"
830 PRINT"THE LIST AND TRY AGAIN."
840 PRINT
850 RESTORE
860 RETURN
900 REM DATA FILE
910 DATA H, 1.54, 13.595, 0.80
920 DATA Li, 0.68, 5.39, 0
930 DATA Na, 0.97, 5.138, 0
940 DATA K, 1.33, 4.339, 0
950 DATA Rb, 1.47, 4.176, 0
960 DATA Cs, 1.67, 3.893, 0
970 DATA F, 1.33, 17.418, 3.448
980 DATA Cl, 1.81, 13.01, 3.613
990 DATA Br, 1.96, 11.84, 3.363
1000 DATA I, 2,20, 10.454, 3.063
1010 REM CALCULATION OF A1 AND B1 OR G1, LINES 1010-1780
1020 PRINT
1030 PRINT"GRAPHICAL SOLUTION OF"
1040 PRINT"TRANSCENDENTAL EQUATION"
1050 PRINT
1060 PRINT TAB(6);"-30";TAB(36);"0";TAB(64);"+30"
1070 FOR A=1 TO 60
1080 PRINT TAB(A+6);"-";
1090 NEXT A
1100 PRINT
1110 PRINT " -A1-";TAB(36);"!"
1120 FOR A1=.1 TO 3.2 STEP .1
1130 PRINT USING " #.##";A1;
1140 PRINT"-1";
1150 A2=A1^2
1160 GOSUB 1530
1170 IF INT(Y1)=INT(Y2) THEN GOTO 1290
1180 IF Y2<Y1 THEN GOTO 1240
1190 IF ABS(Y1)<=30 THEN PRINT TAB(36+Y1);"+";
1200 IF ABS(Y2)<=30 THEN PRINT TAB(36+Y2);"*" ELSE GOTO 1220
1210 GOTO 1300
1220 PRINT""
1230 GOTO 1300
1240 IF ABS(Y2)<=30 THEN PRINT TAB(36+Y2);"*";
1250 IF ABS(Y1)<=30 THEN PRINT TAB(36+Y1);"+" ELSE GOTO 1270
1260 GOTO 1300
```

Listing 1 continued on page 40

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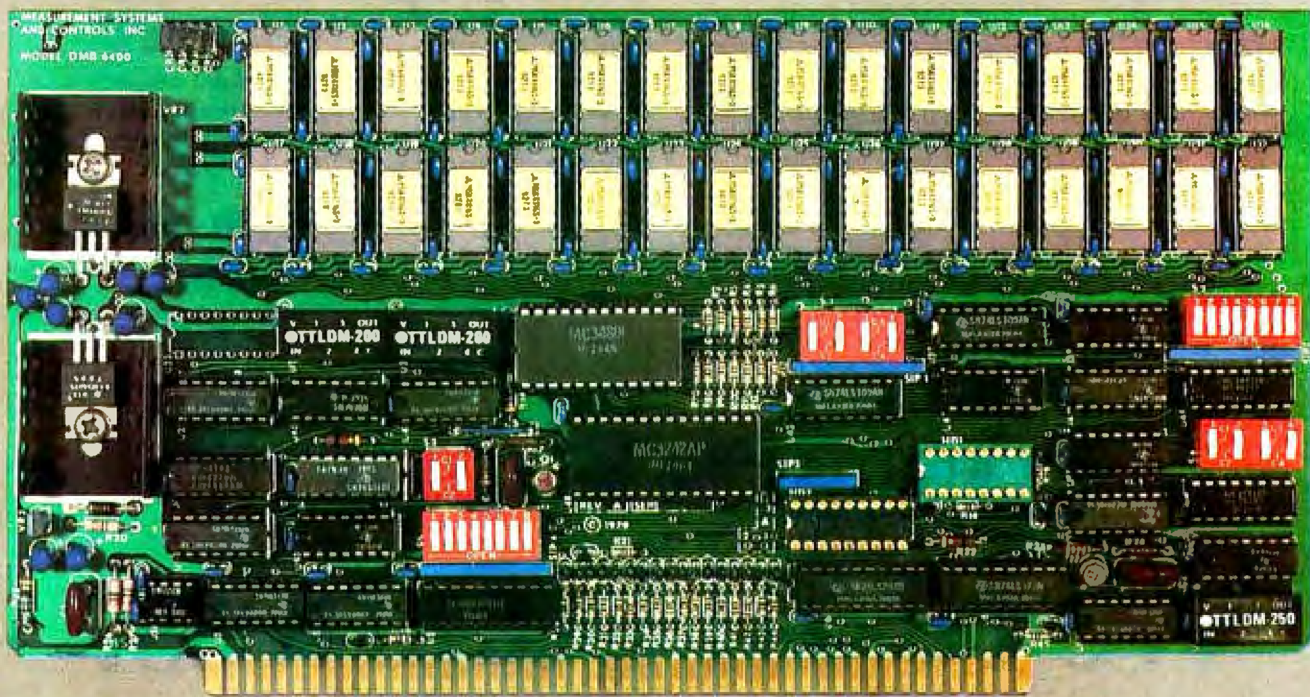
Listing 1 continued:

```
1270 PRINT""
1280 GOTO 1300
1290 PRINT TAB(36+Y1);"x"
1300 NEXT A1
1310 FOR A=1 TO 60
1320 PRINT TAB(6+A);"-";
1330 NEXT A
1340 FOR A=1 TO 3
1350 PRINT
1360 NEXT
1370 PRINT"AT WHAT VALUE OF A1 DO THE LINES SEEM TO INTERSECT?"
1380 PRINT"A1=  ";
1390 INPUT A1
1400 IF N=0 THEN A1=1.57079
1410 G9=1000
1420 A1=A1+.0004
1430 A2=A1^2
1440 GOSUB 1530
1450 IF S<G9 THEN G9=S ELSE GOTO 1480
1460 IF A1=3.1416 THEN PRINT"DID NOT FIND POINT OF INTERSECTION"
1470 GOTO 1420
1480 PRINT
1490 PRINT"THE POINT OF INTERSECTION IS:"
1500 PRINT"A1=  ";
1510 PRINT USING "##.###";(A1-.0004)
1520 GOTO 1670
1530 REM SUBROUTINE FOR TRANSCENDENTAL EQUATION
1540 IF N>A1 THEN GOTO 1560 ELSE GOTO 1610
1550 REM PAIR OF EQUATIONS FOR N>A1
1560 Q1=SQR(N2-A2)
1570 Y1=Q1*SIN(A1)/(A1*COS(A1))
1580 Y2=-(EXP(Q1)-EXP(-Q1))/(EXP(Q1)+EXP(-Q1))
1590 S=(Y1-Y2)^2
1600 RETURN
1610 REM PAIR OF EQUATIONS FOR N<A1
1620 Q2=SQR(A2-N2)
1630 Y1=Q2*SIN(A1)/(A1*COS(A1))
1640 Y2=-SIN(Q2)/COS(Q2)
1650 S=(Y1-Y2)^2
1660 RETURN
1670 REM END SEARCH
1680 A2=A1^2
1690 IF N>A1 THEN G2=N2-A2 ELSE B2=A2-N2
1700 G1=SQR(G2)
1710 B1=SQR(B2)
1720 IF N<A1 THEN GOTO 1760
1730 PRINT"G1=  ";
1740 PRINT USING "##.###";G1
1750 GOTO 1780
1760 PRINT"B1=  ";
1770 PRINT USING "##.###";B1
1780 PRINT
2000 REM CALCULATION OF PSI
2010 PRINT"-CALCULATION OF PSI-"
2020 PRINT
2030 REM CHOICE OF OUTPUT
2040 PRINT"DO YOU WANT OUTPUT AS TABLE OF VALUES (1) OR IN GRAPHICAL FORM (2)?"
2050 PRINT"ENTER A 1 OR 2"
2060 INPUT Z9
2070 IF Z9=1 THEN GOTO 2090
2080 IF Z9=2 THEN GOTO 2310 ELSE GOTO 2050
2090 REM TABLE OF VALUES
2100 PRINT TAB(9);"TABLE OF VALUES"
2110 PRINT TAB(8);"-----------------"
2120 PRINT
```

Listing 1 continued on page 43



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Listing 1 continued:

```
2130 PRINT TAB(4);"A";TAB(17);"PSI";TAB(26);"(PSI)^2"
2140 FOR P=-16 TO 0
2150 GOSUB 2610
2160 GOSUB 2830
2170 NEXT P
2180 FOR P=1 TO 16
2190 GOSUB 2680
2200 GOSUB 2830
2210 NEXT P
2220 PRINT
2230 IF F=1 THEN 3000
2240 PRINT"WOULD YOU LIKE TO SEE THE GRAPHICAL FORM?"
2250 PRINT"ENTER A YES OR NO"
2260 F=1
2270 INPUT A$
2280 IF A$="YES" THEN GOTO 2310
2290 IF A$="NO" THEN 3000
2300 GOTO 2250
2310 REM GRAPHICAL FORM
2320 PRINT
2330 PRINT TAB(9);"GRAPHICAL FORM"
2340 PRINT TAB(8);"--------------------"
2350 PRINT
2360 PRINT TAB(10);"(PSI)^2"
2370 PRINT
2380 FOR A=1 TO 50
2390 PRINT TAB(12+A);"_";
2400 NEXT A
2410 PRINT
2420 FOR P=-16 TO 0
2430 GOSUB 2610
2440 GOSUB 2900
2450 NEXT P
2460 FOR P=1 TO 16
2470 GOSUB 2680
2480 GOSUB 2900
2490 NEXT P
2500 IF F=1 THEN 3000
2510 PRINT
2520 PRINT"WOULD YOU LIKE TO SEE THE TABLE OF VALUES?"
2530 PRINT"ENTER A YES OR NO"
2540 F=1
2550 INPUT A$
2560 IF A$="YES" THEN GOTO 2090
2570 IF A$="NO" THEN 3000
2580 GOTO 2530
2590 PRINT
2600 GOTO 3000
2610 REM SUBROUTINE FOR PSI FROM -16 TO 0
2620 W=P/16
2630 X=W*A
2640 A9=1
2650 P1=A9*SIN(A1*(X+A)/A)
2660 P2=P1^2
2670 RETURN
2680 REM SUBROUTINE FOR PSI FROM 0 TO 16
2690 W=P/16
2700 X=W*A
2710 IF N>A1 THEN GOTO 2720 ELSE GOTO 2790
2720 D=A9*SIN(A1)
2730 C=-D*(EXP(G1)+EXP(-G1))/(EXP(G1)-EXP(-G1))
2740 E5=EXP(G1*X/A)
2750 E6=EXP(-G1*X/A)
2760 P1=C*(E5-E6)/2+D*(E5+E6)/2
2770 P2=P1^2
```

Listing 1 continued on page 44

Listing 1 continued:

```
2780 GOTO 2820
2790 B=A9*SIN(A1)/SIN(B1)
2800 P1=B*SIN(B1*(A-X)/A)
2810 P2=P1^2
2820 RETURN
2830 REM SUBROUTINE FOR TABLE OF VALUES
2840 PRINT USING "##.###";W;
2850 PRINT TAB(14);
2860 PRINT USING " #.###";P1;
2870 PRINT TAB(26);
2880 PRINT USING " #.###";P2
2890 RETURN
2900 REM SUBROUTINE  FOR GRAPHICAL FORM
2910 P9=INT(50*P2)
2920 PRINT TAB(5);
2930 PRINT USING"##.###";W;
2940 PRINT "I";
2950 FOR F9=0 TO P9
2960 IF F9+13<>13 THEN PRINT TAB(F9+13);"=";
2970 NEXT F9
2980 PRINT
2990 RETURN
3000 REM CONTINUE OR FINISH
3010 PRINT : PRINT
3020 PRINT"WOULD YOU LIKE TO STUDY ANOTHER PAIR OF ELEMENTS?"
3030 PRINT"ENTER A YES OR NO"
3040 INPUT A$
3050 IF A$="YES" THEN 190
3060 IF A$<>"NO" THEN 3030
3070 END
```

Text continued from page 37:

single function, ψ, must describe a single particle. Thus at the junction of the two sides of the well, the solution for the left side must take on the same value as the solution for the right side:

$$\psi_L = \psi_R \text{ at } x = 0$$

- In addition, the solutions for the left and the right sides must fit together smoothly at the junction of the two sides.

Mathematically, this fourth requirement is met if the first derivatives of the solutions for the left and the right sides of the well take on the same value at the junction:

$$\frac{d\psi_L}{dx} = \frac{d\psi_R}{dx}$$

at $x = 0$.

There is a further complication in the solution for the right side of the potential well. Two cases must be distinguished. The total energy of the electron, E, may be greater than the potential difference between the elements, V_0, or E may be less than V_0. According to classical theory, if E were less than V_0, the electron would never be able to pass into the region of the bond that is represented by the upper level of the potential well. But such is not the case in quantum mechanics.

Because of the wave-like nature exhibited by submicroscopic particles, it is possible for an electron to enter an area where its total energy is less than the potential of that area. If $E > V_0$, ψ_R is a sine function designated $\psi_{R\,I}$ similar in form to the solution for the left side of the potential well. But if $E < V_0$, then ψ_R is a linear combination of hyperbolic functions designated $\psi_{R\,II}$. The Schrödinger equation and these boundary conditions lead to the equations listed in table 2. The program in listing 1 portrays electron behavior in a chemical bond based on these equations.

Algorithm for Simulation

To simulate the behavior of the electron in a chemical bond, the program executes the following steps:

1. determine the potential difference, V_0, between the two elements that make up the molecule
2. determine the bond length, a
3. determine the parameter, n, which is a function of V_0 and a
4. determine αa (where α is equal to the momentum of the particle divided by $\hbar$ when the particle is in the left, low side of the well) by solving the appropriate transcendental equation depending upon whether $E > V_0$ or $E < V_0$
5. determine βa or γa (where β and γ correspond to α, but for the right, high side of the well) depending upon whether $E > V_0$ or $E < V_0$
6. determine the coefficients B or C and D in terms of A depending upon whether $E > V_0$ or $E < V_0$
7. evaluate ψ_L and, depending upon whether $E > V_0$ or $E < V_0$, evaluate either $\psi_{R\,I}$ or $\psi_{R\,II}$
8. list the values of ψ and ψ^2 in tabular form or display ψ^2 in graphical form

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Table 2: *Equations and definitions for solving Schrödinger's equation. The author is indebted to Lars Melander for the potential-well model described in this article and the equations listed in this table. For a complete description of the problem and its solution see Melander's article "Rectangular Box Model of the Polar Bond" in the* Journal of Chemical Education, *October 1972, pages 686 thru 688. Melander's article was the inspiration for the program of listing 1.*

A $\frac{d^2\psi}{dx^2} = \frac{-2mE\psi}{\hbar^2} = -\alpha^2\psi\ ;\ \psi_L = A\sin(\alpha(x+a))$

The Schrödinger equation and its solution for the left side of the potential well. The solution can be verified by differentiating ψ_L twice.

B i) $\frac{d^2\psi}{dx^2} = \frac{-2m(E - V_0)\psi}{\hbar^2} = -\beta^2\psi\ ;\ \psi_{R,I} = B\sin(\beta(a - x))$ for $E > V_0$

ii) $\frac{d^2\psi}{dx^2} = \frac{2m(V_0 - E)\psi}{\hbar^2} = \gamma^2\psi\ ;\ \psi_{R,II} = C\sinh(\gamma x) + D\cosh(\gamma x)$ for $E < V_0$

The Schrödinger equations and their solutions for the right side of the potential well. There are two possible solutions depending upon whether E is greater than or less than V_0. The solutions can be verified by differentiating ψ_R twice.

C $n^2 = \frac{2mV_0a^2}{\hbar^2}$

Definition of n, a parameter which is a function of V_0 and a. It is introduced for reasons of convenience.

D i) $\beta^2a^2 = \alpha^2a^2 - n^2$ for $E > V_0$
ii) $\gamma^2a^2 = n^2 - \alpha^2a^2$ for $E < V_0$

Identities that can be verified by combining the appropriate definitions from A, B and C.

E i) $\frac{\sqrt{\alpha^2a^2 - n^2}}{\alpha a}\tan(\alpha a) = -\tan(\sqrt{\alpha^2a^2 - n^2})$ for $E > V_0$

ii) $\frac{\sqrt{n^2 - \alpha^2a^2}}{\alpha a}\tan(\alpha a) = -\tanh(\sqrt{n^2 - \alpha^2a^2})$ for $E < V_0$

Pair of transcendental equations that derive from the boundary conditions. They determine the value of αa given n. The equation used depends upon whether E is greater than or less than V_0.

F i) $B = A\sin(\alpha a)/\sin(\beta a)$ for $E > V_0$
ii) $C = -D/\tanh(\gamma a)$, $D = A\sin(\alpha a)$ for $E < V_0$

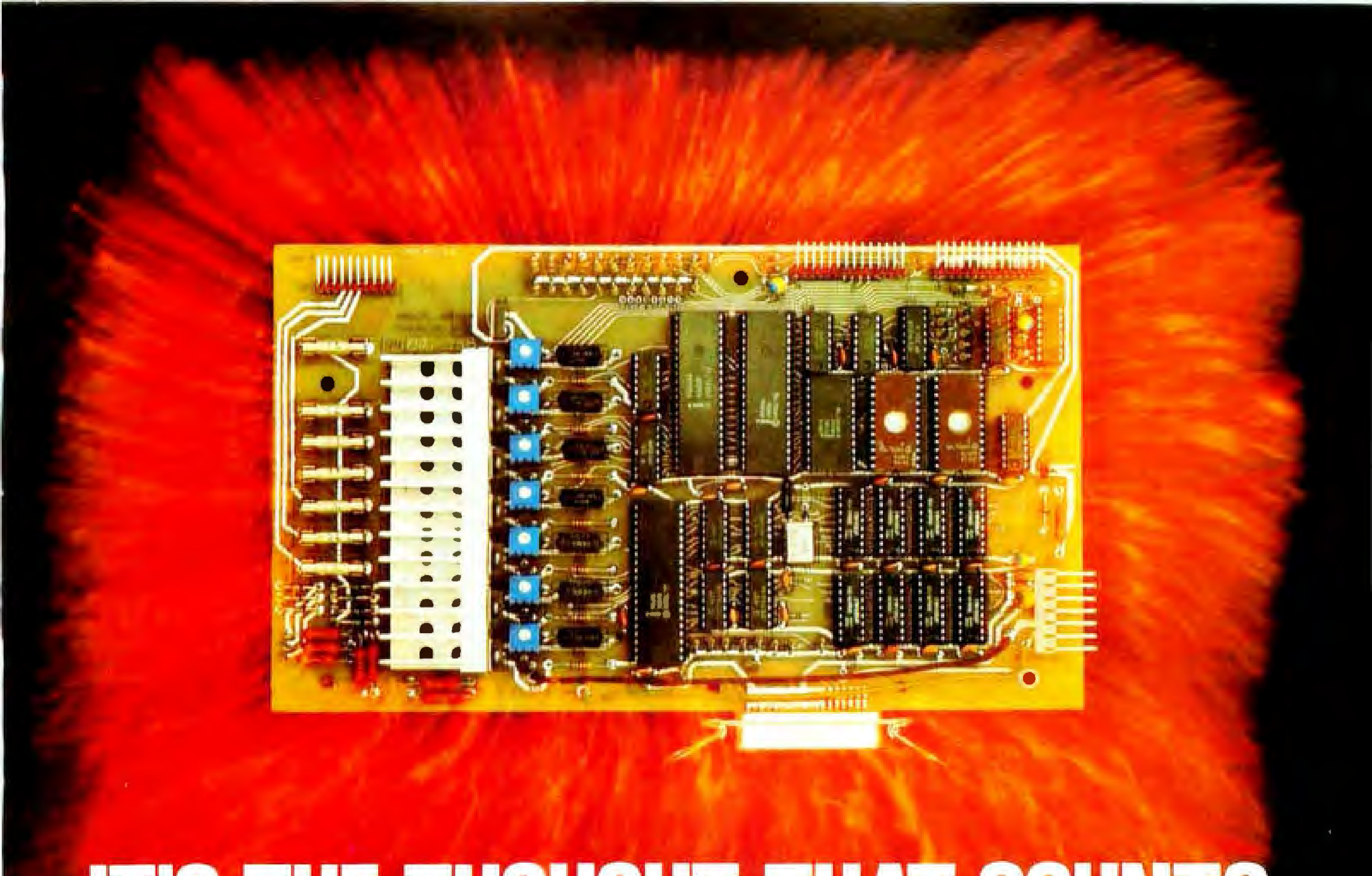
Equations which define the coefficients of the solutions for the right side of the potential well in terms of the coefficient (amplitude), A, of the solution for the left side of the potential well. These equations also derive from the boundary conditions.

A small data file is created. The file contains a list of elements capable of forming a diatomic molecule by exchanging or sharing a single electron with another element. The file contains the following information: the chemical symbol of the element, its ionic radius, ionization potential, and electron affinity. [Note: *The ionic radius of an element depends upon whether the molecule is a single unit, as in the gas phase, or whether it belongs to a larger group as in the crystalline or solid phase. The crystalline ionic radii used in this program may be found in the* Handbook of Chemistry and Physics, *Chemical Rubber Company, 18901 Cranwood Parkway, Cleveland OH 44128.*]

The program lists the elements by name and symbol after a short introduction. The operator enters the symbols for the two elements to be involved in the bond. The program determines potential energy, V_0, and the bond length, a, then solves for and prints out the parameter, n. Then the product of the momentum and the bond length, αa, must be determined. If the diatomic molecule is in a state of lowest energy, the *ground state,* then αa must lie in the interval between 0 and π.

Theoretically, the best method of solving the appropriate transcendental equation for αa would be to evaluate each side of the equation separately for all values of αa between 0 and π, and find the point at which the two sides of the equation are equivalent. It is possible for a computer to find the correct value of αa by stepping αa from 0 to π in very small increments. In practice, this is far too time-consuming, especially on a small computer.

The program of listing 1 determines the value of αa in two stages. In the first stage, αa is increased from 0 to π by steps of 0.1. A graph of each side of the transcendental equation is plotted on the same axis. The point where the two lines generated by the two halves of the equation intersect gives a rough approximation to the proper value of αa. The operator then enters the value of αa immediately before the point of intersection. The program begins with this value of αa and increments it in steps of 0.0004. When



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the difference between the two sides of the transcendental equation (squared so that negative numbers are inconsequential) is a minimum, the program prints out the value of αa. Depending upon the relative size of αa and n, the program then evaluates and prints out either βa or γa.

Next the coefficients of the equations for the right side of the potential well are determined in terms of A, the amplitude of the wave equation for the left side of the potential well. The value of the coefficient A could be determined by normalization, making the probability that the electron is at some point between $-a$ and $+a$ equal to 1. In this program, the wave equation is left unnormalized.

The equations defining the relationship among these coefficients are the result of application of the boundary conditions. Finally, numerical values of ψ and ψ^2 can be determined. The program evaluates ψ for each side of the potential well at fractional intervals along the bond length according to the appropriate equation. The data is available to the operator either in tabular or in graphical form. As might be expected, the graphical form gives a better impression of how the electron behaves in the bond.

Characteristics of the Program

The program of listing 1 was written in AlphaBASIC to run on an AlphaMicro Systems AM-100 computer. The hyperbolic trigonometric functions, sinh(x) and cosh(x), do not appear in AlphaBASIC. But these functions can be defined in terms of the natural exponential function, which appears in most versions of BASIC:

$$\sinh(x) = \frac{e^x - e^{-x}}{2}$$

$$\cosh(x) = \frac{e^x + e^{-x}}{2}$$

In these equations, e is the base of the Napierian natural logarithm and has a value of approximately 2.71828. Otherwise there are no unusual statements or functions in the program. The processing of mathematical variables is carried out in floating-point notation with eleven-digit accuracy.

The formatted output rounds off all results at the third decimal place.

Text continued on page 56

Listing 2: *A sample execution of the program of listing 1.*

```
RUN CHMBND


                     -PROFILE OF A CHEMICAL BOND-

     THE ELECTRON DENSITY IN THE CHEMICAL BOND OF A DIATOMIC MOLECULE
DEPENDS UPON THE POTENTIAL DIFFERENCE (VO) BETWEEN THE TWO ELEMENTS
WHICH ARE BOUND TOGETHER AND UPON THE LENGTH OF THE BOND (A).  THE
AVERAGE OF THE IONIZATION ENERGY AND THE ELECTRON AFFINITY OF AN
ELEMENT OFFERS A MEASURE OF THE POTENTIAL OF THE ELEMENT.

     THIS PROGRAM CALCULATES A PROFILE OF A CHEMICAL BOND BASED
UPON THIS INFORMATION.  FROM THE LIST OF ELEMENTS BELOW, SELECT TWO
WHICH WILL MAKE UP THE MOLECULE.  ENTER THE SYMBOLS FOR THESE
ELEMENTS AT THE REQUEST OF THE PROGRAM.


        HYDROGEN  -  H
        LITHIUM   -  Li               FLOURINE   -  F
        SODIUM    -  Na               CHLORINE   -  Cl
        POTASSIUM -  K                BROMINE    -  Br
        RUBIDIUM  -  Rb               IODINE     -  I
        CESIUM    -  Cs


ENTER ELEMENT NUMBER ONE - Na
ENTER ELEMENT NUMBER TWO - Cl



 VO =   5.743
  N =   3.414

WHEN READY TO CONTINUE TYPE A CARRIAGE RETURN.

GRAPHICAL SOLUTION OF
TRANSCENDENTAL EQUATION
```

Listing 2 continued on page 50

MicroDaSys Software™ - CP/M™ Compatible

The Pencil Sharpener™ - Now with subscripts and superscripts! The form letter merge utility for the Electric Pencil II™. $195. Order Code: PS1.

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The "millie" is the smartest buy a small business can make. It comes with the most powerful **accounting, word processing** and **applications software** available. And to take advantage of that power, the "millie" uses the S-100 bus, eight inch disk drives and the universal CP/M‡ operating system. It can be programmed in BASIC, FORTRAN, Pascal and dozens of other languages. Best of all, "millie" prices start at **under** $3000. The one illustrated includes a **reproduction-quality printer** and **full accounting and word processing software** for just $6995. "Millie" has been in use for over a year in the US, Europe, South America and Australia. It is a **proven design**, regularly updated as the state-of-the-art advances.

But an international company can't knock on doors. Without branch offices in every city of the US (and the world) we have the same problem as dozens of other computer manufacturers. **We simply can't contact all of the small businessmen who could benefit from our "millie".** That's where **you** come in.

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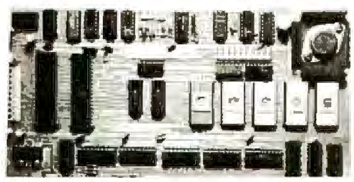
Circle 22 on inquiry card.

6809!
Single Board Computer



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$299 Assembled
$239 Kit

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MD690bK

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		Shipping Total	$5	

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Dept B1 Phone: (213) 935-4555 TWX: 910-321-2378

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COMPANY ___
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CITY ___
STATE ___ ZIP ___
Calif. residents add 6%

Check here for: ☐ Millie Sales Package

Listing 2 continued:

```
     -30                            0                            +30
      --------------------------------------------------------------
-A1-                                !
0.10-I                             *   +
0.20-I                             *   +
0.30-I                             *   +
0.40-I                             *   +
0.50-I                             *   +
0.60-I                             *   +
0.70-I                             *    +
0.80-I                             *    +
0.90-I                             *    +
1.00-I                             *     +
1.10-I                             *     +
1.20-I                             *      +
1.30-I                             *        +
1.40-I                             *            +
1.50-I                             *                             +
1.60-I                             *
1.70-I                +            *
1.80-I                       +     *
1.90-I                         +   *
2.00-I                          +  *
2.10-I                           + *
2.20-I                            +*
2.30-I                            +*
2.40-I                             X
2.50-I                             X
2.60-I                             X
2.70-I                             X
2.80-I                             X
2.90-I                             X
3.00-I                             X
3.10-I                             X
3.20-I                             *+
      --------------------------------------------------------------

AT WHAT VALUE OF A1 DO THE LINES SEEM TO INTERSECT?
A1 = ? 2.3

THE POINT OF INTERSECTION IS:
A1 =  2.378
G1 =  2.449

-CALCULATION OF PSI-

DO YOU WANT OUTPUT AS TABLE OF VALUES (1) OR IN GRAPHICAL FORM (2)?
ENTER A 1 OR 2
? 1
```

TABLE OF VALUES

A	PSI	(PSI)^2
-1.000	0.000	0.000
-0.938	0.148	0.022
-0.875	0.293	0.086
-0.813	0.431	0.186
-0.750	0.560	0.314
-0.688	0.677	0.458
-0.625	0.778	0.606
-0.563	0.863	0.744
-0.500	0.928	0.861

Listing 2 continued on page 52

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

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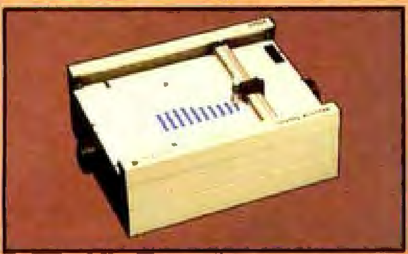

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Listing 2 continued:

```
       -0.438              0.973           0.947
       -0.375              0.996           0.993
       -0.313              0.998           0.996
       -0.250              0.977           0.955
       -0.188              0.935           0.875
       -0.125              0.872           0.761
       -0.063              0.790           0.625
        0.000              0.691           0.477
        0.063              0.591           0.350
        0.125              0.506           0.256
        0.188              0.432           0.186
        0.250              0.368           0.135
        0.313              0.313           0.098
        0.375              0.265           0.070
        0.438              0.223           0.050
        0.500              0.187           0.035
        0.563              0.155           0.024
        0.625              0.127           0.016
        0.688              0.101           0.010
        0.750              0.078           0.006
        0.813              0.057           0.003
        0.875              0.037           0.001
        0.938              0.018           0.000
        1.000              0.000           0.000

       WOULD YOU LIKE TO SEE THE GRAPHICAL FORM?
       ENTER A YES OR NO
       ? YES

   GRAPHICAL FORM
   --------------
     (PSI)^2
            ----------------------------------------------------
-1.0001
-0.9381  =
-0.8751  ====
-0.8131  =========
-0.7501  ================
-0.6881  =======================
-0.6251  ================================
-0.5631  =======================================
-0.5001  ==============================================
-0.4381  ==================================================
-0.3751  ====================================================
-0.3131  ====================================================
-0.2501  ==================================================
-0.1881  ==============================================
-0.1251  ========================================
-0.0631  =================================
 0.0001  ========================
 0.0631  ==================
 0.1251  =============
 0.1881  ==========
 0.2501  ======
 0.3131  ====
 0.3751  ===
 0.4381  ==
 0.5001  =
 0.5631  =
 0.6251
 0.6881
 0.7501
 0.8131
 0.8751
 0.9381
 1.0001
```

Listing 2 continued on page 54

Chief Relief

For years many small business system buyers thought that in order to get "real" performance and enough storage to be a "real" business system they would have to sacrifice the family jewels.

But with the introduction of the Smoke Signal Chieftain series office computers a lot of people's minds have been changed.

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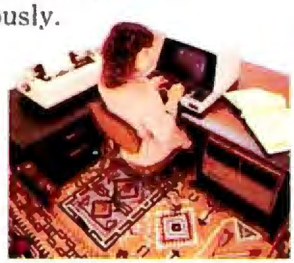

Chieftain systems starting at under $200.00 per month display performance on par with systems costing twice to three times as much.

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For dealers only, circle 24

All other inquiries, circle 7

SMOKE SIGNAL BROADCASTING

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Listing 2 continued:

```
WOULD YOU LIKE TO STUDY ANOTHER PAIR OF ELEMENTS?
ENTER A YES OR NO
? YES


          HYDROGEN   -  H
          LITHIUM    -  Li                FLOURINE    -  F
          SODIUM     -  Na                CHLORINE    -  Cl
          POTASSIUM  -  K                 BROMINE     -  Br
          RUBIDIUM   -  Rb                IODINE      -  I
          CESIUM     -  Cs


ENTER ELEMENT NUMBER ONE - H
ENTER ELEMENT NUMBER TWO - I



VO =  0.439
 N =  1.270



WHEN READY TO CONTINUE TYPE A CARRIAGE RETURN.

GRAPHICAL SOLUTION OF
TRANSCENDENTAL EQUATION

      -30                         0                           +30
      ------------------------------------------------------------
 -A1-                            !
 0.10-I                         * +
 0.20-I                         * +
 0.30-I                         * +
 0.40-I                         * +
 0.50-I                         * +
 0.60-I                         * +
 0.70-I                         * +
 0.80-I                         * +
 0.90-I                         * +
 1.00-I                         * +
 1.10-I                         * +
 1.20-I                         *+
 1.30-I                         *+
 1.40-I                         *   +
 1.50-I                        *         +
 1.60-I        +               *
 1.70-I                     +  *
 1.80-I                       X
 1.90-I                    *    +
 2.00-I                         +
 2.10-I                         +          *
 2.20-I                         +     *
 2.30-I                          +  *
 2.40-I                          + *
 2.50-I                          + *
 2.60-I                          + *
 2.70-I                          +*
 2.80-I                          +*
 2.90-I                          +*
 3.00-I                          +*
 3.10-I                          +*
 3.20-I                           X
      ------------------------------------------------------------
```

Listing 2 continued on page 56

26 MEGABYTES

$4995.

DRIVE A HARD BARGAIN!

Suddenly, S-100 microcomputer systems can easily handle 100 million bytes. Because Morrow Designs™ now offers the first 26 megabyte hard disk memory for S-100 systems—the DISCUS M26™ Hard Disk System.

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MORROW DESIGNS™

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Circle 25 on inquiry card.

Listing 2 continued:

```
AT WHAT VALUE OF A1 DO THE LINES SEEM TO INTERSECT?
A1 = ? 1.70

THE POINT OF INTERSECTION IS:
A1 =  1.791
B1 =  1.264

-CALCULATION OF PSI-

DO YOU WANT OUTPUT AS TABLE OF VALUES (1) OR IN GRAPHICAL FORM (2)?
ENTER A 1 OR 2
? 1
           TABLE OF VALUES
          -----------------

     A              PSI        (PSI)^2
 -1.000            0.000        0.000
 -0.938            0.112        0.012
 -0.875            0.222        0.049
 -0.813            0.330        0.109
 -0.750            0.433        0.188
 -0.688            0.531        0.282
 -0.625            0.622        0.387
 -0.563            0.706        0.498
 -0.500            0.781        0.610
 -0.438            0.846        0.715
 -0.375            0.900        0.810
 -0.313            0.943        0.889
 -0.250            0.974        0.949
 -0.188            0.993        0.987
 -0.125            1.000        1.000
 -0.063            0.994        0.988
  0.000            0.976        0.952
  0.063            0.948        0.899
  0.125            0.915        0.837
  0.188            0.876        0.767
  0.250            0.831        0.691
  0.313            0.782        0.611
  0.375            0.727        0.529
  0.438            0.668        0.446
  0.500            0.605        0.366
  0.563            0.538        0.289
  0.625            0.467        0.218
  0.688            0.394        0.155
  0.750            0.318        0.101
  0.813            0.240        0.058
  0.875            0.161        0.026
  0.938            0.081        0.007
  1.000            0.000        0.000

WOULD YOU LIKE TO SEE THE GRAPHICAL FORM?
ENTER A YES OR NO
? YES
```

Listing 2 continued on page 58

Text continued from page 48:

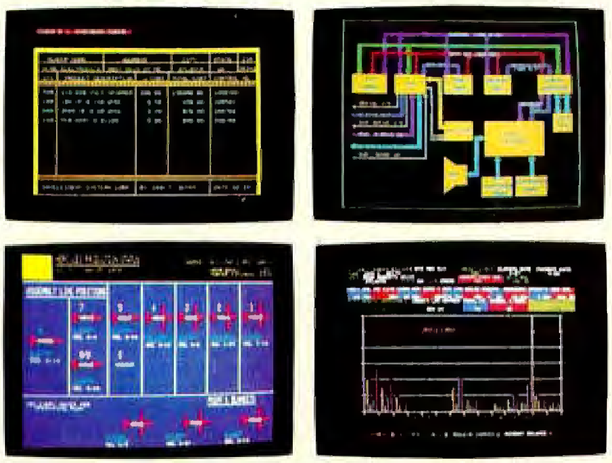
The format (PRINT USING) statements are somewhat rare and may have to be modified according to the particular version of BASIC with which you happen to be working. The program requires no special graphics systems. All graphic features are generated by using terminal keyboard symbols (such as the asterisk).

Uses of the Program

The program can be easily adapted for further study of chemical bonds in diatomic molecules. You can study the electron distribution for different bond lengths at a constant potential difference. Alternately, you could study the electron distribution for varying potential differences at a constant bond length.

It is also possible to estimate the ionic character of the bond. If the potential difference between two elements was infinitely large, the electron would be confined indefinitely to the lower side of the potential well. The most probable electron location in a symmetrical well would be at the center of the well, in this case at $x = -0.5a$. Since one nucleus would

Color communicates better. That's the *obvious* benefit of ISC's new CP/M®2 compatible desktop computer.



What isn't as obvious is the benefit of the CP/M2 operating system. CP/M2 allows Intecolor® 8963 users to choose from an abundance of software. The wide variety of business programs available in CP/M greatly reduces the need for specially-prepared software.

Simply load the CP/M2 operating system disk to run any CP/M program (without modification), whether it's in BASIC, COBOL, FORTRAN IV, or any other programming language. Add the superb readability and improved comprehension of color graphics and you've got unparalleled desktop performance.

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*U.S. domestic price

Unretouched photo of screen

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Circle 26 on Inquiry card.

Listing 2 continued:

```
               (PSI)^2

                    -------------------------------------------------------
            -1.0001
            -0.9381
            -0.8751  ==
            -0.8131  =====
            -0.7501  ==========
            -0.6881  ===============
            -0.6251  =====================
            -0.5631  ==========================
            -0.5001  =================================
            -0.4381  ======================================
            -0.3751  ============================================
            -0.3131  ================================================
            -0.2501  ====================================================
            -0.1881  ======================================================
            -0.1251  ======================================================
            -0.0631  ======================================================
             0.0001  ====================================================
             0.0631  ================================================
             0.1251  =============================================
             0.1881  ==========================================
             0.2501  =====================================
             0.3131  =================================
             0.3751  =============================
             0.4381  ========================
             0.5001  ====================
             0.5631  ===============
             0.6251  ===========
             0.6881  ========
             0.7501  =====
             0.8131  ==
             0.8751  =
             0.9381
             1.0001


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? NO
```

have exclusive possession of the electron, such a bond would be 100% ionic.

If there was *no* potential difference between the two elements, the most probable location in the symmetrical well would again be the center of the well, but this time at $x = 0$. The bond has 0% ionic character.

All real molecular bonds lie between these two extremes. To estimate the ionic character of a bond, search for the fractional value of the bond length at which the probability distribution curve has maximum amplitude. Multiply this number by two, make it positive, and convert it to a percentage form. The result is a model estimate of the ionic character of the bond.

This program represents a mere peek at the quantum mechanical world of atoms and molecules. Much has been discovered and much remains to be discovered. The computer facilitates investigation of this world. Moreover, the computer can be a spur to our imagination beckoning us to new vistas in the microscopic world and beyond. ■

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Hewlett-Packard's New Personal Computer

The HP-85

Christopher P Morgan
Editor-in-Chief

Photos by Ed Crabtree

A question often heard in personal computer circles is, "When is Hewlett-Packard going to bring out a personal computer?" The question has been answered, and the new HP-85 computer is quite a system.

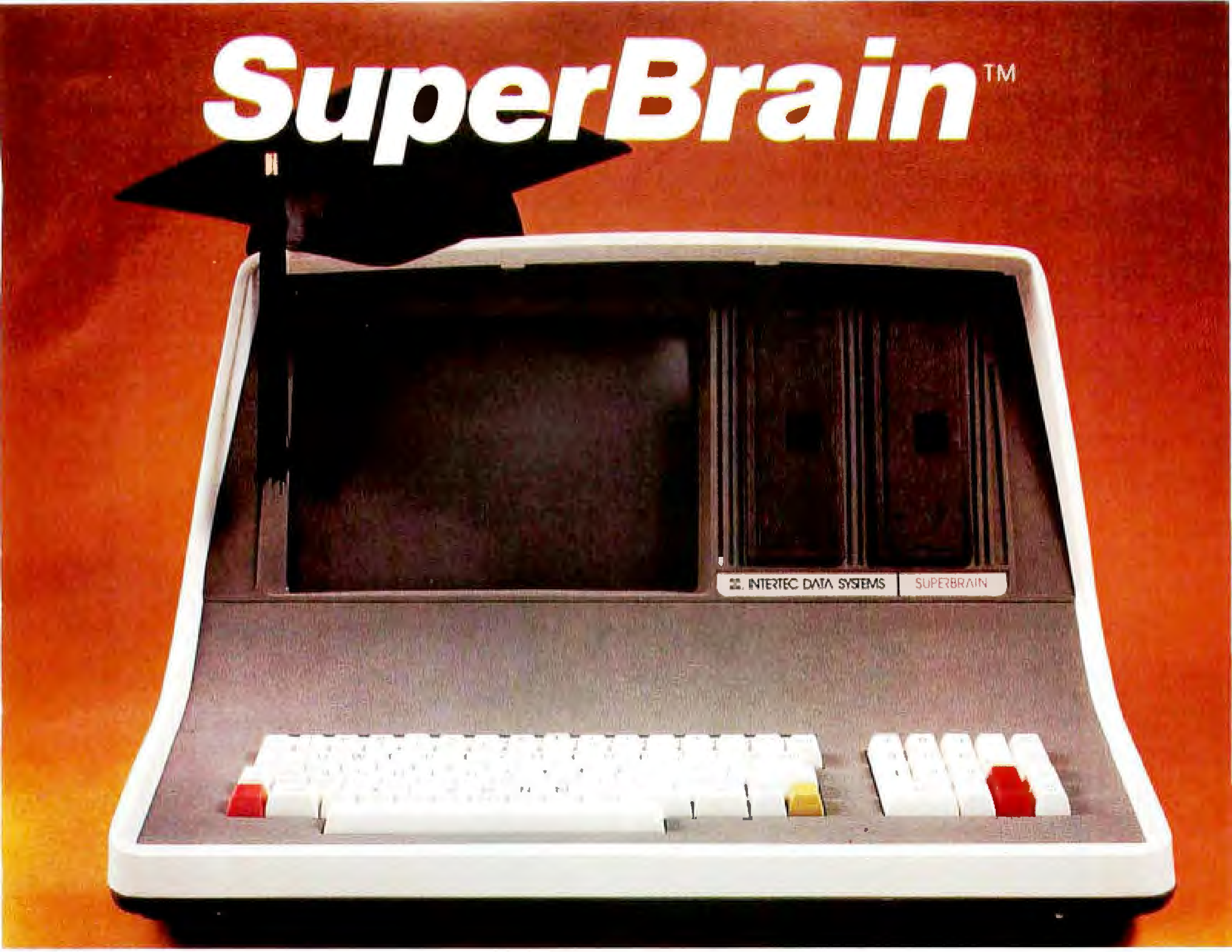
Hewlett-Packard (HP) has long been a respected manufacturer of minicomputers, desktop calculators, and handheld calculators; the high quality of their electronic test equipment is well known to the engineering community. Hewlett-Packard also has the reputation for being a careful, conservative company, and the HP-85 is, not surprisingly, a logical outgrowth of their desktop and handheld calculators.

We recently had the opportunity to audition the HP-85. Our preliminary findings are listed below.

System Features

The basic HP-85, shown in photo 1, costs $3250 and consists of a microcomputer with a custom 8-bit processor and several other custom integrated circuits, data cartridge drive for DC-100 tape cartridges, a high-resolution video display with a 5-inch screen (measured diagonally) with resolution of 256 by 192 dots (individually addressable) for graphics, 16 lines by 32 characters of text, keyboard, and thermal printer. The unit comes with 16 K bytes of program-

Photo 1: *Hewlett-Packard's new entry into the personal computer market: the HP-85. The $3250 unit features a 5-inch video display, data cartridge drive, keyboard with user-programmable keys, and thermal printer. The HP-85 also offers interesting graphics capabilities. Every point on the 256 by 192 dot array can be individually addressed by the programmer. The built-in thermal printer can make a copy of any graphic design on the screen or any alphanumeric data. Sophisticated features included in this unit are a hardware and software self-test key; four levels of security protection for files on data cartridges; plug-in memory expansion to the basic package of 16 K bytes of programmable memory and 32 K bytes of read-only memory; ANSI standard Enhanced BASIC with the ability to chain programs together; and line editing.*



The Honor Graduate

There's been a lot of talk lately about intelligent terminals with small systems capability. And, it's always the same. The systems which make the grade in performance usually flunk the test in price. At least that was the case until the SuperBrain graduated with the highest PPR (Price/Performance Ratio) in the history of the industry.

For less than $3,000*, SuperBrain users get exceptional performance for just a fraction of what they'd expect to pay. Standard features include: two dual-density mini-floppies with 320K bytes of disk storage, up to 64K of RAM to handle even the most sophisticated programs, a CP/M Disk Operating System with a high-powered text editor, assembler and debugger. And, with SuperBrain's S-100 bus adapter, you can even add a 10 megabyte disk!

More than an intelligent terminal, the SuperBrain outperforms many other systems costing three to five times as much. Endowed with a hefty amount of available software (BASIC, FORTRAN, COBOL), the SuperBrain is ready to take on your toughest assignment. You name it! General Ledger, Accounts Receivable, Payroll, Inventory or Word Processing . . . the SuperBrain handles all of them with ease.

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mable memory (14,500 of which are available to the user) expandable to 32 K bytes, and 32 K bytes of read-only memory. The latter contains the operating system and the Enhanced BASIC package.

Data Cartridges

One of the main differences between the HP-85 and most other small systems on the market is its use of data cartridges for reading and writing programs and data. This is not surprising, since the company expects to sell the unit in large quantities to professionals, and the data cartridge is one of the most reliable forms of mass storage available today. The cartridge-drive slot is located on the front of the machine (see photo 1).

Each cartridge can hold 780 program records consisting of 192 K bytes each, or 850 data records of 210 K bytes. There can be a maximum of forty-two named files per cartridge.

Cartridge rewind time is 29 seconds; search speed is 152 cm (60 inches) per second; data transfer speed is 25.4 cm (10 inches) per second; and tape length is 43 meters (141 feet). With the data cartridge system the user can create data files, input arrays into the computer with a single program statement, store an "autostart" program that is automatically loaded and executed at power-on, and secure programs from unauthorized access.

Keyboard

The keyboard is divided by function: the typewriter keyboard for entering alphanumeric data, the numeric pad for entering numeric information, and eight user-definable keys. (These keys are located directly under the video screen. Labels for the keys can be entered by the user and will appear at the bottom of the screen). Display, editing, and system-control keys permit the user to control the video display. The keyboard is hinged and can be easily swung out of the way after the cover is removed to service the processor board (see photo 3).

Video Display

One of the HP-85's strong points is its graphics and alphanumeric display capability. Sixteen lines of text can be displayed at a time on the screen, but a buffer holds up to sixty-four lines, so the user can back up and see a part of a listing that has scrolled off the screen— a decided convenience in writing or debugging programs. If you come to the end of the sixty-four-line section in the buffer, the display wraps around to the beginning again. Characters are formed in a 5 by 7 dot matrix.

In the graphics mode, the display consists of a 256 (wide) by 192 (high) dot field, giving a total of 49,152 individual dots available for high-resolution plotting. The HP-85 also stores the last alphanumeric display and the last graphics display in separate buffers so the user can switch more freely

Photo 2: *Inside the HP-85, showing the 5-inch video display cathode-ray tube, thermal printer, and data cartridge drive. The processor board is located under the keyboard (see photo 4). Note the set of user-definable keys at upper left of the keyboard. Labels for these keys are displayed at the bottom of the video screen.*

from one mode to the other without losing data.

Readers familiar with the company's desktop calculators will be immediately at home with the HP-85's graphics-handling routines. There are sixteen graphics commands for setting up graphs, locating the origin, and scaling and labeling the axes quickly.

Anything that appears on the screen can be printed on the thermal printer by simply pressing the GRAPH and COPY keys in that order. You may also enter commands from the keyboard while in graphics mode. Inverse video is also available, as well as a BPLOT routine for user-defined graphics.

The alphanumeric characters are on the small side compared to the average personal computer display because of the screen size. However, they are quite readable— not unlike the IBM 5100 display. Screen editing is convenient. There are five cursor-control keys, plus keys for clearing the screen, a line, or a single character. The ability to edit within a program line is a great time saver.

Security

The HP-85 offers unprecedented versatility when it comes to securing data and programs. The SECURE command is used to prevent specific program files from being listed, edited, or stored; to prevent any file's name from appearing in the directory listing; and to protect the user from writing over a file. The UNSECURE command removes security on secured programs or data files. The file name to be secured must already appear in the directory (ie: it must already exist on tape).

The file name may be any string of characters except the null string. The system takes the first two characters of the string and stores them as the security code. There are four levels of security.

At level 0, the program may not be listed or edited. Level 1 further prevents the program from being duplicated. At level 2, the program may also not be overwritten. Level 3 removes the name of the file from the catalog and replaces it with blank.

Printer

The thermal printer operates in both alphanumeric and graphics modes. In the alphanumeric mode, it can print the full 128-character ASCII character set, which includes uppercase and lowercase letters, numerals, and special symbols. The full character set can be underlined. Printer speed is 2 lines per second.

Enhanced BASIC

The HP-85's Enhanced BASIC interpreter meets and exceeds the most recent ANSI standard. Its features include: 12-digit accuracy and exponents up to ±499 for calculations; extremely versatile

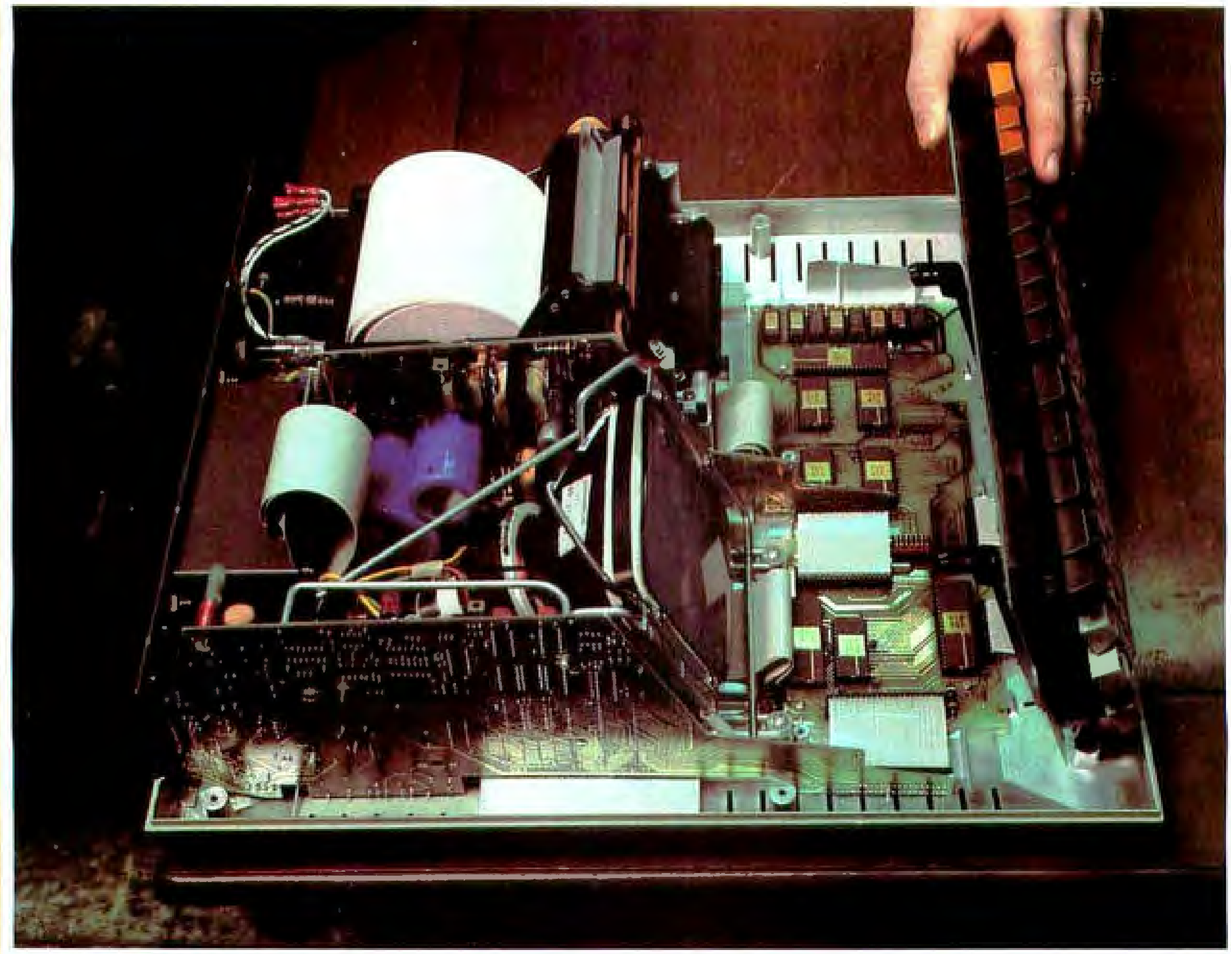


Photo 3: *Internal view of the HP-85, showing the processor board under the hinged keyboard. The 8-bit processor is a custom Hewlett-Packard design, as are most of the integrated circuits in the computer.*

string-handling capability (a string in HP-85 Enhanced BASIC can theoretically be up to 32 K bytes long) compatible with string handling on other HP computers; 42 predefined functions; formatted output; the ability to chain BASIC programs together; multistatement lines; a programmable sound generator that can play single-voice lines of melody through the built-in speaker or make audible beeps at predetermined times during the execution of a program; and calculator capability. For debugging, the user can single-step through BASIC programs, branch ON ERROR, or have the program provide a default value with DEFAULT ON to enable a program to continue executing. In particular, the formatted-output capability is useful for generating headings, columns, and spaces for program output.

Self-Test

A unique feature of the HP-85 is the built-in self-test routine. When the TEST key is pressed, the computer runs through an electronic check of all internal components— a feature common to many Hewlett-Packard electronic instruments. If everything checks out correctly, a particular set of characters is displayed on the screen. (The graphics display will be cleared, but programs and variables in memory will remain intact.) If the system is not operating correctly, the system displays "Error 23 SELF TEST."

Input/Output

Photo 4 shows the back of the HP-85 and the four input/output (I/O) ports. Additional memory can be added via the ports. The company will be introducing a variety of peripherals for the unit, including dual 5-inch floppy-disk drives, external printers, plotters, and so on. An extra 16 K bytes of memory costs $395.

Software

Software currently available on data cartridges for the HP-85 includes BASIC training, general statistics, mathematics, electrical engineering, finance, linear programming, and regression analysis. Each package costs $95. More packages are under development. BASIC program developed for Hewlett-Packard's desktop computers can be adapted for use on the HP-85, as can most programs written in ANSI BASIC. The unit also comes with a well-written, 350-page owner's manual and a standard application software package. Hewlett-Packard is quoting immediate delivery on the HP-85.

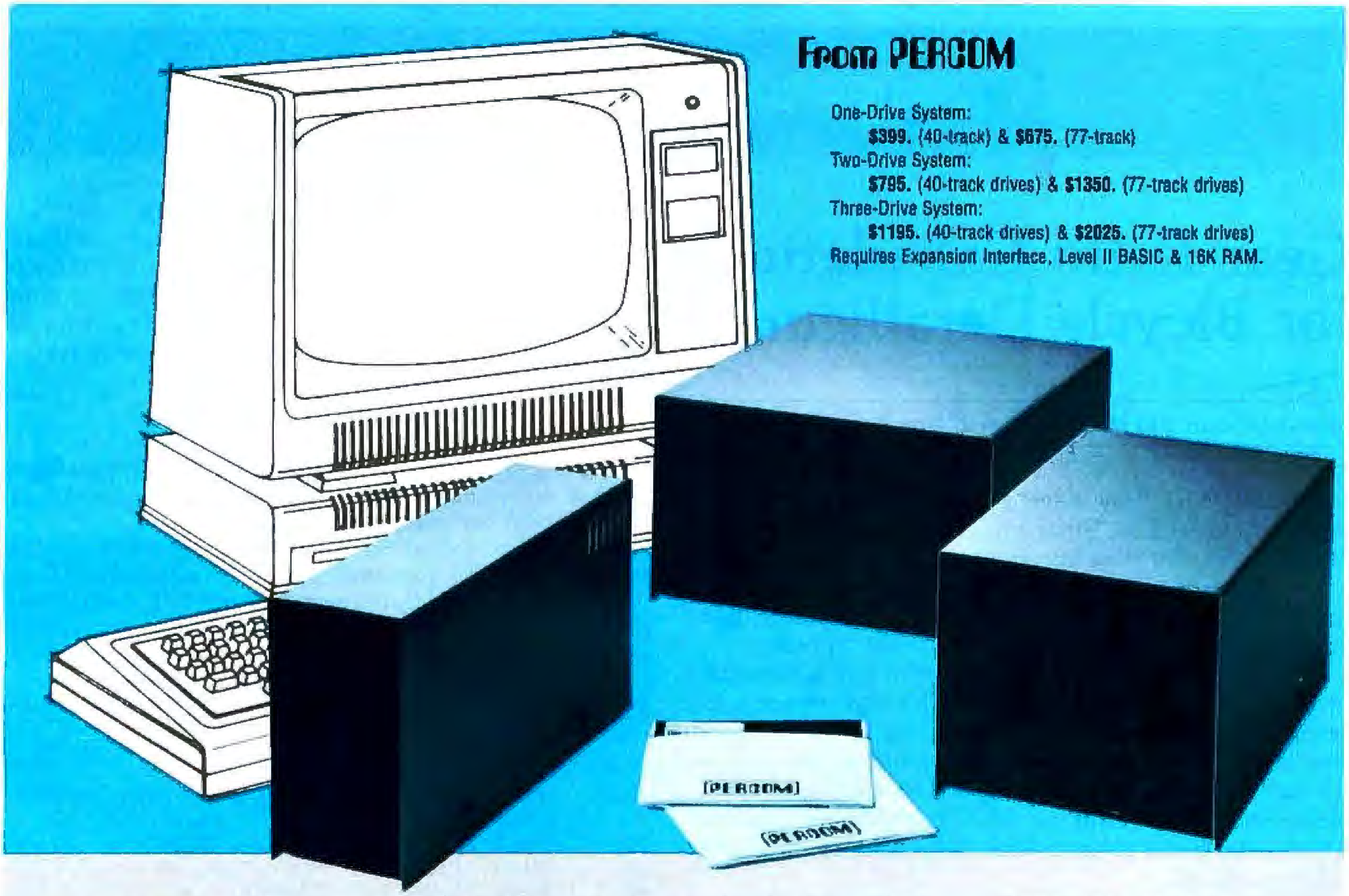
Evaluation

We were impressed with the performance of the HP-85 computer. The graphics alone make this an attractive, albeit not inexpensive, alternate to existing small systems on the market. And many of its features are unique. Although Hewlett-Packard is pinning its hopes on heavy sales to the professional marketplace, it is our guess that many personal computer experimenters and hackers will want this machine.

In future issues of BYTE we will evaluate the HP-85 in greater depth.

For further information about the HP-85, contact: Inquiries Manager, Hewlett-Packard Co, 1507 Page Mill Rd, Palo Alto CA 94303. ■

Photo 4: *Rear view, showing the four I/O ports and their removable covers.*



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Programming Quickies

Gear-Ratio Calculation for Bicycle Derailleurs

John A Lehman, 716 Hutchins, Apt 2, Ann Arbor MI 48103

KERCHUNK! "Hey, what gear is next on this thing?" asked my wife, Lisa. Since my old, reliable three-speed bicycle suffered a close encounter of the worst kind with a car impatient to turn right on a red light, we had both decided to buy used ten-speed bikes. Unfortunately, that meant having to worry about seven more "speeds."

"Why don't you use your computer to figure out what order to do things in?" she asked. This was a good suggestion, especially since one of our neighbors had been wanting me to figure out whether it would be worthwhile for him to change from a five-speed to a ten-speed shift mechanism. The result is this Programming Quickie which describes a program that helps answer these and other questions.

The most popular gear shift mechanism on bicycles these days is the *derailleur*. This mechanism uses one, two, or three front gear sprockets (ie: chain wheels) and either five or six rear gear sprockets. This means that one can have a five-, six-, ten-, twelve-, fifteen-, or eighteen-speed shift mechanism. The derailleur device moves the chain between the different gear sprockets, as shown in figure 1 on page 70. This means that, unlike two- and three-speed bikes, the shift mechanism cannot go directly from low to high gear. Rather, there are as many separate sequences of gear combinations as there are front chain wheels; the rider has to combine these different sequences into one overall shift pattern.

To make things more complicated, there are fairly wide variations in the number of gear teeth on the front and rear sprockets. Differently configured gear-tooth combinations are used for different riding conditions. For example, racers who ride mostly on level ground have a narrower gear-ratio range than bike tourists who have to manage both long, level stretches and steep hills. It would be nice to be able to tell what difference it would make riding up that long hill if you changed to a given front and rear sprocket combination.

The program given in listing 1 addresses both of these problems. It will analyze any combination of between five and eighteen speeds; it will produce a shift chart to indicate the order in which to use different combinations of front and rear gear sprockets and a chart of gear range so that comparisons can be made between different combinations of sprockets with variations in the number of gear teeth.

The unit of measure used here for gear range is the traditional one of wheel size. This is the size of the front wheel that would be necessary to produce the same drive ratio on one of the old high-wheel (ie: penny-farthing) bikes of the nineteenth century. The program is written in TDL 12 K BASIC, but should run unaltered on any computer that uses Microsoft or a similar BASIC system such as the TRS-80, PET, Apple II, or Ohio Scientific. Happy cycling, and wear a helmet!

Listing 1: *A program written in TDL 12 K BASIC that calculates the gear ratios available from combinations of front and rear gear sprockets with varying numbers of teeth.*

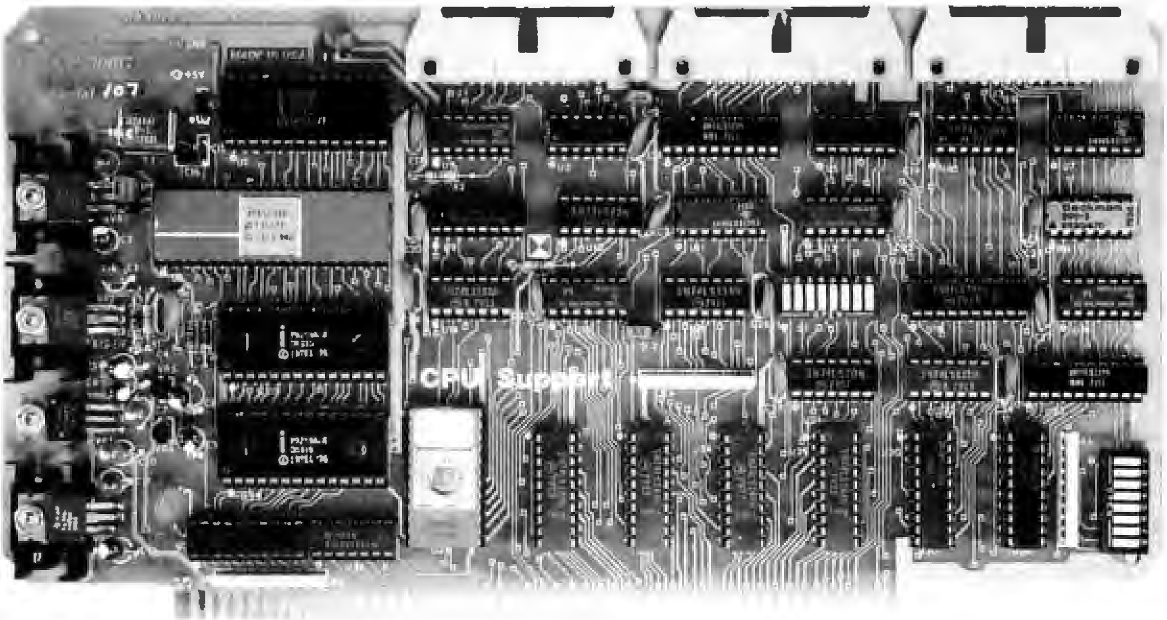
Special language features are as follows. A PRINT USING statement provides formatted output. A simple PRINT will work, but will be slightly less neat. If your BASIC does not have the EXCHANGE statement used in lines 310 thru 314, you can substitute a simple swap routine such as:

T1=P(J+1,1) : P(J+1,1)=P(J,1) : P(J,1)=T1

to perform the exchange. A question mark is an abbreviation for PRINT.

```
10   'PROGRAM TO CALCULATE 10 SPEED OR 15 SPEED
     GEAR RATIOS
20   DIM W(16),P(16,3)
30   INPUT "NUMBER OF FRONT GEARS";F1
40   INPUT "NUMBER OF GEARS ON REAR
     FREEWHEEL";R1
50   IF F1=0 THEN F1=2
60   IF R1=0 THEN R1=5
70   N=R1*F1
80   INPUT "REAR WHEEL DIAMETER";W1
90   IF F1=3 THEN 120
100  F$(1)="INNER ":F$(2)="OUTER "
110  GO TO 130
120  F$(1)="INNER ":F$(2)="MIDDLE ":F$(3)="OUTER "
130  FOR I=1 TO F1
140  PRINT "NUMBER OF TEETH ON ";F$(I); "GEAR";
150  INPUT T(I)
160  NEXT I
170  FOR I=1 TO R1
180  PRINT "NUMBER OF TEETH ON "; I;" REAR GEAR";
190  INPUT S(I)
200  NEXT I
210  FOR I=1 TO F1
220  FOR J=1 TO R1
225  X=(I-1)*R1+J
230  W(X)=T(I)/S(J)*W1
235  P(X,1)=X:P(X,2)=I:P(X,3)=J
240  NEXT J
250  NEXT I
260  FOR I=1 TO N:P(I,1)=I:NEXT I
270  'START SORT
280  FOR I=1 TO N
290  FOR J=1 TO N-1
300  IF W(P(J,1))<W(P(J+1,1)) THEN 320
310  EXCHANGE P(J,1),P(J+1,1)
312  EXCHANGE P(J,2),P(J+1,2)
314  EXCHANGE P(J,3),P(J+1,3)
320  NEXT J
330  NEXT I
340  ?:?:?
350  ?"WHEEL";TAB(10);"FRONT";TAB(20);"REAR"
360  FOR I=1 TO N
370  PRINT USING "###.##"; W(P(I,1));
375  PRINT TAB(10);F$(P(I,2));TAB(20);P(I,3)
380  NEXT
390  END
```

CPU Support Card



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Notes on Gear Ratios

Contrary to popular belief, on most ten-speed bicycles the first five gear ratios are not all produced using the small front sprocket, with the top five gear ratios correspondingly produced using the large front sprocket. The actual case is more complicated, as can be seen from listing 2.

On many bikes, the setup is as follows. The first and lowest gear ratio is produced using the small front sprocket and the largest rear sprocket. The second gear ratio is produced using the small front sprocket and the next-to-largest rear sprocket.

Now for the anomaly. The third gear ratio is produced using the large front sprocket and the largest rear sprocket. The fourth gear ratio is obtained using the small front sprocket and the third-largest rear sprocket. For the fifth gear ratio, we move the chain back onto the large front sprocket and onto the second-largest rear sprocket.

At this point, we may become perplexed. Is there not one pattern in the sprocket use that we can remember? Well, there is some regularity. Using the small front sprocket and all the rear sprockets in order from largest to smallest, we obtain gear numbers 1, 2, 4, 6, and 8. Using the large front sprocket and all the rear sprockets in order from largest to smallest, we obtain gear numbers 3, 5, 7, 9, and 10. So really, only the very top and bottom gears fall out of the easily remembered even/odd sequence.

Now you may object, "How am I supposed to follow such a complex shifting sequence while I am dodging traffic, pot holes, and vicious dogs?" Well, you don't have to follow the sequence strictly.

Most bike riders, in fact, rarely use gears three and eight. These are the extreme combinations of large front sprocket with largest rear sprocket, and of small front sprocket with smallest rear sprocket. Since the chain has to bend rather sharply when it is set up in these combinations, mechanical stress and wear are increased.

In my own riding around hilly Peterborough, New Hampshire, I typically leave the chain on the large front sprocket and shift up and down through the range made available by moving the chain to the various rear sprockets. I move the chain to the small front sprocket when I need the bottom two gears, such as when I ride up the steep hill that leads to my home. . . . **RSS ■**

Listing 2: *Sample execution of the program of listing 1. The gear ratios are measured in terms of the equivalent size of the front wheel of a high-wheel (ie: penny-farthing) bicycle needed to produce the same final drive ratio.*

```
RUN
NUMBER OF FRONT GEARS? 2
NUMBER OF GEARS ON REAR FREEWHEEL? 5
REAR WHEEL DIAMETER? 27
NUMBER OF TEETH ON INNER GEAR? 44
NUMBER OF TEETH ON OUTER GEAR? 52
NUMBER OF TEETH ON 1 REAR GEAR? 14
NUMBER OF TEETH ON 2 REAR GEAR? 16
NUMBER OF TEETH ON 3 REAR GEAR? 18
NUMBER OF TEETH ON 4 REAR GEAR? 20
NUMBER OF TEETH ON 5 REAR GEAR? 22


      WHEEL        FRONT     REAR
       54.00       INNER       5
       59.40       INNER       4
       63.82       OUTER       5
       66.00       INNER       3
       70.20       OUTER       4
       74.25       INNER       2
       78.00       OUTER       3
       84.86       INNER       1
       87.75       OUTER       2
      100.29       OUTER       1

READY:
```

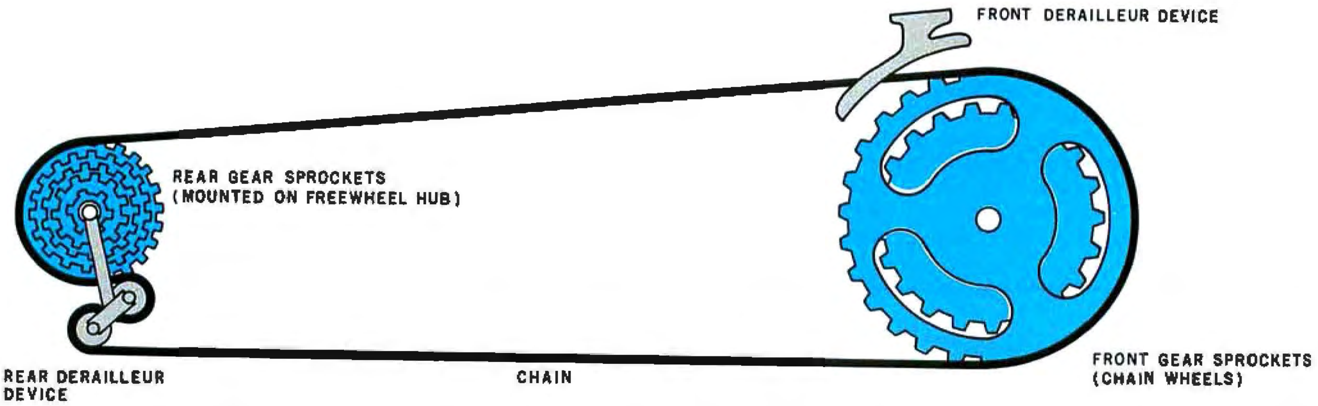

Figure 1: *Diagram of the drive mechanism of a ten-speed, derailleur-equipped bicycle. The pedal cranks (not shown) are attached to the front gear sprockets (ie: chain wheels) through the crank axle. The front derailleur device can shift the chain between the large front sprocket and the small front sprocket.*

The rear gear sprockets are attached to the rear axle by means of a freewheel hub that allows the rider to stop pedaling while the bicycle remains in motion. The rear derailleur device can shift the chain between any of the five rear gear sprockets. Different front and rear sprocket combinations produce the ten gear ratios.

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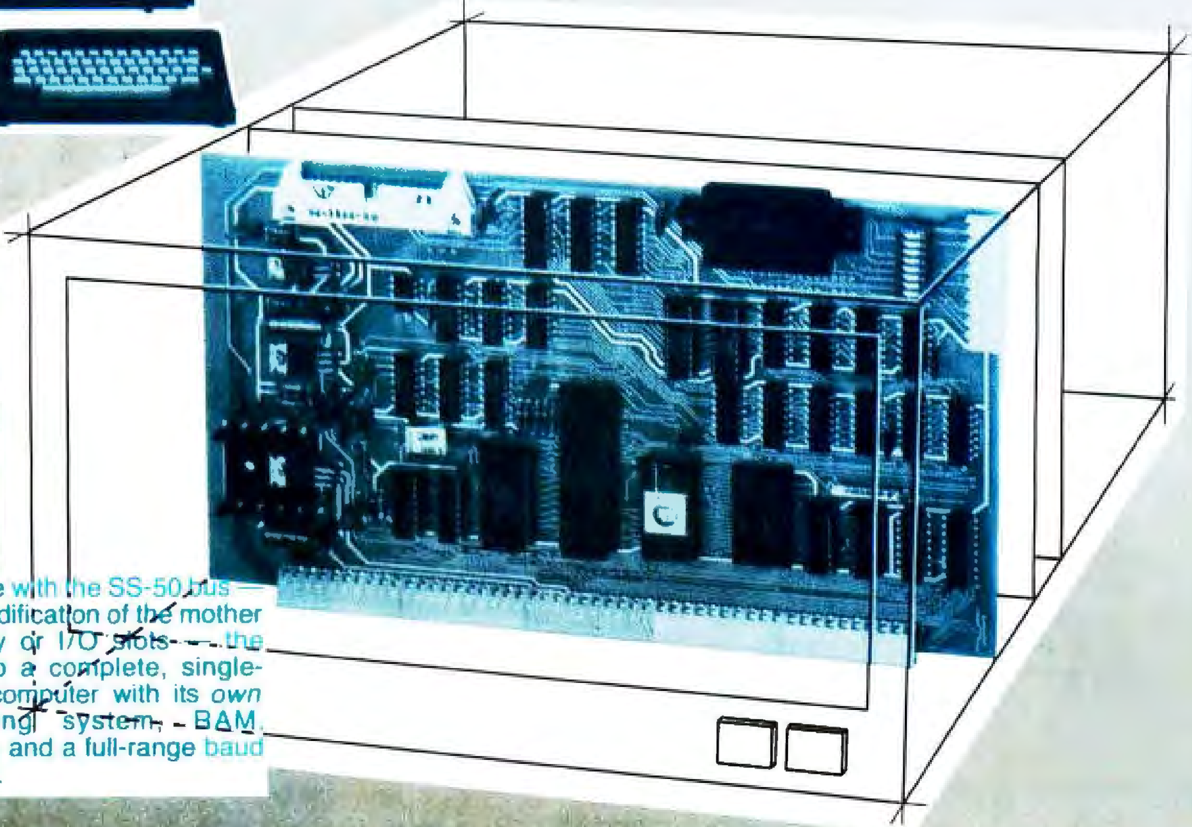

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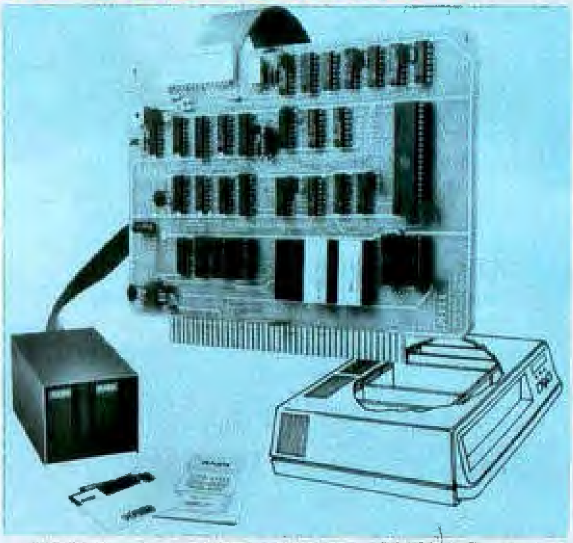

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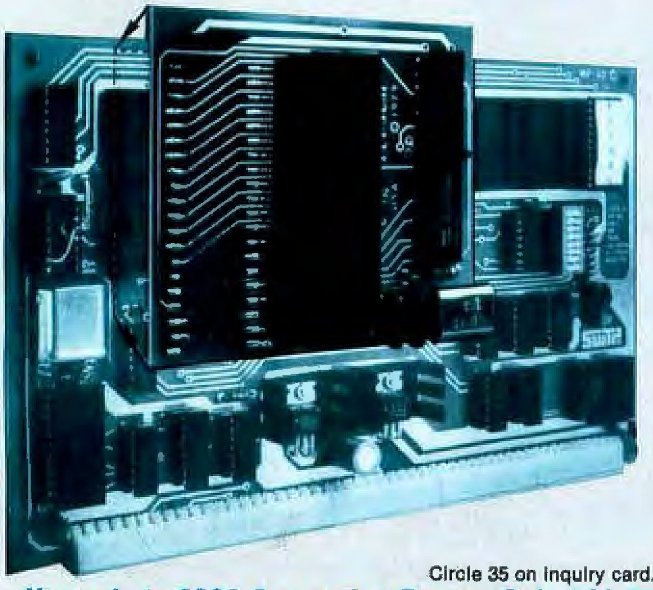

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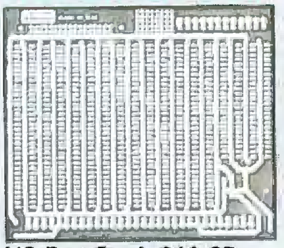

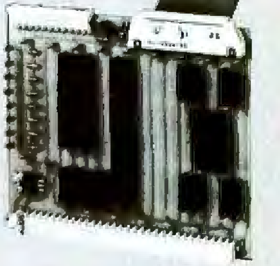

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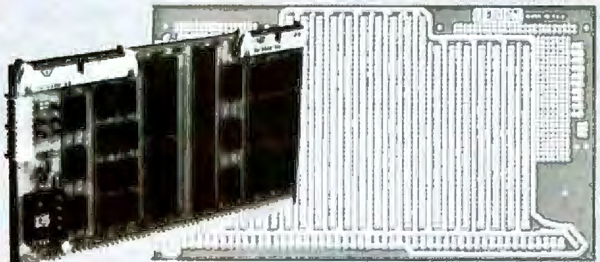

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Solving Problems Involving Variable Terrain

Part 2: Special Cases, Including Hexagonal Grids

Scott T Jones
271 NW 28th St
Boca Raton FL 33431

In part 1 some general terrain problems were defined. These were problems that could be expressed in terms of movement on a map, with terrain defined as any map feature affecting movement. By superimposing a rectangular grid and coordinate system on these maps, we were then able to represent the terrain with a set of boolean arrays or terrain masks. Movement, distance, and the concept of movement cost for different types of terrain were also defined. A scatter function was then defined to generate scatter maps representing all possible movement within the limits imposed by the terrain.

Finally, we demonstrated the use of these scatter maps to solve such problems as the feasibility of road construction within cost restraints and the determination of an optimal path between two points on a map, across variable terrain.

Part 2 is concerned with the application of these techniques to the problems encountered in conflict simulations.

Conflict Simulations and the Hexagonal Grid

The most common type of conflict simulation is the war game. In a war game, playing pieces that represent military units are moved on a terrain map to simulate a battle. The map has been overlaid with a grid; each unit has an inherent movement factor; and each type of terrain has a movement cost. The ideas presented in this article were developed when I was trying to solve the problems of writing programs to play conflict simulations.

The most common grid used today is the hexagonal grid. Instead of an array of squares, the map is divided into hexagons or "hexes" to form a honeycomb pattern. Each hexagon has six adjacent hexagons. We can easily define the distance between a hexagon and any adjacent hexagon to be equal to 1 without worrying about the ambiguous, diagonally adjacent squares that we encountered with rectangular grids. The problem is in defining a coordinate system and a distance function or *metric*.

Most games use an *offset* coordinate system. The hexagonal grid is treated as a rectangular grid in which every even-numbered column is offset by one-half the size of the squares. (See figure 9.) The trouble with this system is that there is no uniform relationship between these coordinates and a metric. Note the relationships of the coordinates of those hexagons adjacent to (2,2) as opposed to (3,2). Separate metrics must be used for the even and odd values of the first coordinate. Clearly, another system is required.

The solution is the *slant* coordinate system (X,Y) where the second coordinate is constant along a slanting, diagonal line from upper right to lower left, or vice-versa. (See figure 10.) The relationships of the coordinates are now consistent throughout the array.

By defining a third, dependent coordinate Z to be X−Y+C, where C is any integer constant, our slant metric (ie: distance function) is simply the maximum of the absolute values of the differences of the three coordinates. That is, for (a,b,c) and (d,e,f), the distance is defined as:

$$\max(|a-d|,|b-e|,|c-f|)$$

The Z coordinate is constant along the other slanting line from upper left to lower right. It will be left for the reader to prove both of these statements by working examples with figure 10.

Using these slant coordinates, we can now assign any hexagon to a square in a standard, rectangular scatter

```
+----+          +----+
|    |          |    |
+ 1,1 +----+ 3,1 +----+
|    |    |    |    |
+----+ 2,1 +----+ 4,1 +
|    |    |    |    |
+ 1,2 +----+ 3,2 +----+
|    |    |    |    |
+----+ 2,2 +----+ 4,2 +
|    |    |    |    |
+ 1,3 +----+ 3,3 +----+
|    |    |    |    |
+----+ 2,3 +----+ 4,3 +
     |    |    |    |
     +----+    +----+
```

Figure 9: *When working with a hexagonal grid, a set of coordinates different from those used for a square grid must be developed. One such coordinate system, shown here, is the offset coordinate system. This system produces difficulties when the distance between two coordinates must be determined. (Numbering of figures is continued from Part 1.)*

mapping. Each hexagon (X,Y) is assigned to the square or element in row X and column Y of the two-dimensional matrix. The hexagonal scatter function HSC will assign to each element in array B the value:

$$\begin{aligned} B(I,J) &= \\ HSC(A(I,J)) &= A(I,J) \text{ OR } A(I-1,J-1) \text{ OR } A(I-1,J) \\ &\quad \text{ OR } A(I,J-1) \text{ OR } A(I,J+1) \\ &\quad \text{ OR } A(I+1,J) \text{ OR } A(I+1,J+1) \end{aligned}$$

Figure 11 demonstrates the scatter mappings that are generated from the same initial position used with the square and city scatter functions in a previous example. (See part 1, figure 4.)

If we are working with a map that already has offset coordinates printed on it, in a case where we would prefer to use slant coordinates, the following relations allow an easy transformation from one system to the other:

$$X(\text{slant}) = X(\text{offset})$$

and

$$Y(\text{slant}) = Y(\text{offset}) + \text{INT}(X/2)$$

where INT is the greatest-integer function.

```
+-----+           +-----+
|     |           |     |
|     |           |     |
+ 1,1 +-----------+ 3,2 +-----------+
|     |           |     |           |
|     |           |     |           |
+-----+    2,2    +-----+    4,3    +
|     |           |     |           |
|     |           |     |           |
+ 1,2 +-----------+ 3,3 +-----------+
|     |           |     |           |
|     |           |     |           |
+-----+    2,3    +-----+    4,4    +
|     |           |     |           |
|     |           |     |           |
+ 1,3 +-----------+ 3,4 +-----------+
|     |           |     |           |
|     |           |     |           |
+-----+    2,4    +-----+    4,5    +
      |           |     |           |
      |           |     |           |
      +-----------+     +-----------+
```

Figure 10: *A coordinate system that solves the distance problems found in the offset coordinate system is the slant coordinate system. In this system, one of the coordinates is constant along a diagonal (ie: slanted) axis.*

Specific Game Applications

It should now be obvious how to determine movement in a game environment when fixed terrain is the only constraint. However, in many war games, the concept of a *zone of control* introduces a new type of terrain. The unit may enter this zone at the normal movement cost but may not leave until the opposing unit that *imposed* the zone of control is removed, usually by combat of some form.

A unit's zone of control is usually defined as all positions (ie: squares or hexagons) that are adjacent to the unit's own position. In other words, a unit's zone of control is simply the first scatter mapping of its position. Thus, when moving with the constraints of zones of control, a new terrain map Z must be defined where $Z(I,J)$ is 0 if (I,J) is 1 in the first scatter mapping of any opposing unit, and $Z(I,J) = 1$, otherwise.

This terrain map is then used to mask out starting positions that will be used on the next scatter. This gives us the relation:

$$\begin{aligned} Mn = Mn-1 \text{ OR } & (T1 \text{ AND XSC(Z AND } Mn-1)) \\ \text{OR } & (T2 \text{ AND XSC(Z AND } Mn-2)) \\ & \vdots \\ \text{OR } & (Tk \text{ AND XSC(Z AND } Mn-k)) \end{aligned}$$

```
0 0 0 0 0        0 0 0 0 0        1 1 1 0 0
0 0 0 0 0        0 1 1 0 0        1 1 1 1 0
0 0 1 0 0        0 1 1 1 0        1 1 1 1 1
0 0 0 0 0        0 0 1 1 0        0 1 1 1 1
0 0 0 0 0        0 0 0 0 0        0 0 1 1 1
   a. A           b. HSC(A)      c. HSC(HSC(A))
```

Figure 11: *An example of the hexagonal scatter-function mappings that develop from a central starting point, assuming that the movement cost of all terrain is equal.*

This relation now shows how we can "premask" our scatter mappings to include the effects of zones of control or other types of *no-exit* terrain found on our terrain map while we postmask to include the effects of movement costs.

This relation is the basis for our movement algorithm in most conflict simulations. With it, we can easily determine not only if a unit can reach a position, but also if the unit is inhibited by opposing units or if it is surrounded. By operating with sets of these scatter mappings, we can even coordinate the moves of a group of units. Scatter mappings can be weighted by the relative combat strengths of the corresponding units so that sums of these weighted mappings represent the total strength that can be applied to any position on the map.

The metrics (ie: distance functions) work well as range functions for game features that are unaffected by terrain, such as determining the range to a target in the simulation of naval battles. Line-of-sight rules that govern the use of projectile weapons in land-battle simulations pose new problems which we will not attempt to resolve at this time.

Directional Terrain Features

In a game environment, concessions are often made to the scale of the terrain map. This means that prohibited terrain, like rivers, or ideal terrain, such as roads, must be represented in a nonstandard way. In situations where you are not fixed by the terrain map provided with the game, you may either increase the scale so that terrain types can be easily isolated, or reduce the scale so that single locations contain many types of terrain, but the effects are dominated by only one type.

With a fixed scale, however, our algorithm must be modified. For example, when we have roads that lower the movement cost for units following the road, we must first adjust our cost scale so that this cheaper, road-movement cost is our *unit* cost.

Next we must define a set of directional terrain masks which function like the zone-of-control masks to premask invalid starting positions for the direction being considered. In the mask for a given direction, the locations contain values of 1 if movement is allowed from the current position in that given direction. Otherwise, the locations contain 0.

The number of directional terrain masks required equals the number of possible movement direction

multiplied by the number of different movement costs of directional terrain. For example, if trails reduce the movement cost to one-half, and roads reduce the movement cost to one-third, on a map using the city metric scatter function, eight directional terrain masks would be required and the unit movement cost would have to be reduced to one-sixth of its original value. This reduced value must be divisible by the least-common multiple of the reduction factors.

Prohibited terrain, such as a river that occupies only the edges of a position and can be crossed only via a bridge, poses yet another problem. A bridge is an example of directional terrain that does not affect the movement cost. To include the effects of bridges, you must define a set of directional terrain premasks to be used in conjunction with all other terrain masks. To represent the effects of directional terrain that adds a constant factor to the movement costs, yet another set of premasks must be defined.

The most effective way to use these directional terrain masks is by modification of the basic scatter function. Consider a game situation where we have clear terrain (one movement factor), rough terrain (two movement factors), roads (one-half movement factor in the direction that the road travels), and bridges over rivers (restricted movement that does not alter movement cost). Let us also use the city metric.

First, we must scale all of our movement costs to reflect the lower cost for the ideal terrain. Thus, we have roads (1), clear (2) and rough (4). Note that bridges are unaffected. Let T2 and T4 be the terrain masks for clear and rough terrain as described in part 1 of this article. Let I*d* be the terrain mask for the ideal terrain in the *d* direction and let P*d* be the terrain mask for the prohibitive terrain (eg: rivers without bridges) in the *d* direction, where $d=1, 2, 3, 4$. Both I*d* and P*d* will be 1 only if movement is allowed from that location in direction *d* for each position on the map. Note that $\mathrm{I}d(I,J)=\mathrm{I}d(I,J)$ AND $\mathrm{P}d(I,J)$ for all I and J.

Let us now define our modified scatter functions CSC′ and CSC″ as follows:

$$\begin{aligned}\mathrm{CSC}'(\mathrm{A}(I,J))=\mathrm{A}(I,J)\ &\mathrm{OR}\ (\mathrm{I1}(I,J+1)\ \mathrm{AND}\ \mathrm{A}(I,J+1))\\ &\mathrm{OR}\ (\mathrm{I2}(I,J-1)\ \mathrm{AND}\ \mathrm{A}(I,J-1))\\ &\mathrm{OR}\ (\mathrm{I3}(I+1,J)\ \mathrm{AND}\ \mathrm{A}(I+1,J))\\ &\mathrm{OR}\ (\mathrm{I4}(I-1,J)\ \mathrm{AND}\ \mathrm{A}(I-1,J))\end{aligned}$$

Similarly:

$$\begin{aligned}\mathrm{CSC}''(\mathrm{A}(I,J))=(I,J)\ &\mathrm{OR}\ (\mathrm{P1}(I,J+1)\ \mathrm{AND}\ \mathrm{A}(I,J+1))\\ &\mathrm{OR}\ (\mathrm{P2}(I,J-1)\ \mathrm{AND}\ \mathrm{A}(I,J-1))\\ &\mathrm{OR}\ (\mathrm{P3}(I+1,J)\ \mathrm{AND}\ \mathrm{A}(I+1,J))\\ &\mathrm{OR}\ (\mathrm{P4}(I-1,J)\ \mathrm{AND}\ \mathrm{A}(I-1,J))\end{aligned}$$

Finally, by replacing CSC in the mapping relation developed in part 1 with CSC′ and CSC″ we get:

$$\begin{aligned}\mathrm{M}n=\mathrm{M}n-1\ &\mathrm{OR}\ \mathrm{CSC}'(\mathrm{M}n-1)\\ &\mathrm{OR}\ (\mathrm{T2}\ \mathrm{AND}\ \mathrm{CSC}''(\mathrm{M}n-2))\\ &\mathrm{OR}\ (\mathrm{T4}\ \mathrm{AND}\ \mathrm{CSC}''(\mathrm{M}n-4))\end{aligned}$$

Summary

We have seen that many problems involving variable terrain may be solved through the use of scatter mappings, scatter sums, premasking, and postmasking. Fixed, prohibited, and ideal terrain, as well as no-exit conditions, have been discussed in reference to our general algorithm of successive scatter mappings. Three different scatter functions and distance-function metrics have been demonstrated for use with two different grids. Two different coordinate systems have also been presented for hexagonal-grid problems.

Since you will most likely want to code it in your favorite language, I have not tried to write this algorithm as a program. I will, however, make a few suggestions. Perform logical functions on groups of elements simultaneously. The rows and columns of the arrays used in the island problem lend themselves nicely to implementation as 8-bit bytes of data. By using a little judicious shifting of these bytes, entire arrays can be scattered with only a few operations.

Do not be afraid to waste a few bits of storage or perform a few unnecessary logical operations to gain a more general representation of your map. It is easier to employ a buffer of unused elements around your arrays than to check for array subscripts that are out of range. Notice how the water terrain provided just such a buffer in the island problem.

In conclusion, this graphical approach to terrain problems provides a viable solution for a wide range of applications, not the least of which is conflict simulation. ■

TRS-80 Performance
Evaluation by Program Timing

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I have been asked to evaluate the performance characteristics of numerous hardware and software computer products in my capacity as a systems programmer. In late 1978 I acquired a Radio Shack TRS-80 personal computer system with Level I BASIC and 4 K bytes of memory. I did not consider a performance evaluation; after all, this was my own toy. I did not have to respond to any requests for performance improvements or evaluations. Only my personal satisfaction was important.

As it turned out, I was satisfied, but my friends and colleagues were not. They were continually asking, "How fast does your toy run?" or "What new tricks have you taught it now?" It seemed that a comprehensive performance testing and evaluation plan was called for. I decided to compare my TRS-80 personal computer with one of the IBM computers (a System/370-148) at work. Since I was also in the process of converting from Level I to Level II BASIC and acquiring more hardware, I wanted to see if I could verify the performance improvements claimed by Radio Shack.

Listing 1: *Prime-number generator written in Level I BASIC for the TRS-80. No attempt was made here to optimize the speed of execution.*

```
30    PRINT " LIST OF PRIME NUMBERS"
40    PRINT
50    PRINT 1;2;3;
55    C=0
70    M = 3
80    M = M + 2
90    FOR K = 3 TO M/2 STEP K-1
100   IF INT(M/K)*K-M = 0 THEN 190
110   NEXT K
121   PRINT M;
122   C=C+1
190   IF M < 10000 THEN 80
195   PRINT "C= ";C
200   END
```

Listing 2: *Level I BASIC version of the prime-number generator in which abbreviations were used and explanatory material omitted to increase speed. Such practices are termed "optimization."*

```
80    F.M=5TO10000S.2
90    F.K=3TOM/2S.2
100   IFI.(M/K)*K=MT.N.M
110   N.K
120   P.M;
190   N.M
```

Test Problem

The test problem to be solved was one familiar to computer science students: calculation of prime-number integers from 5 to 10,000. This problem was chosen for several reasons. First, it is a problem that many computer programmers can relate to; second, it uses two program loops; and third, it requires calculations more complex than simple addition. The number of microseconds or nanoseconds required to perform a single function like addition does not adequately describe the performance characteristics of an individual computer, nor does comparison of timing determine the difference between two machines. What is needed is a comparison of a group of instructions or the use of a program representative of those which will be used extensively on that computer as the comparison base. The problem used here performs loops, does moderately complex arithmetic calculations, and performs some input/output (I/O) operations.

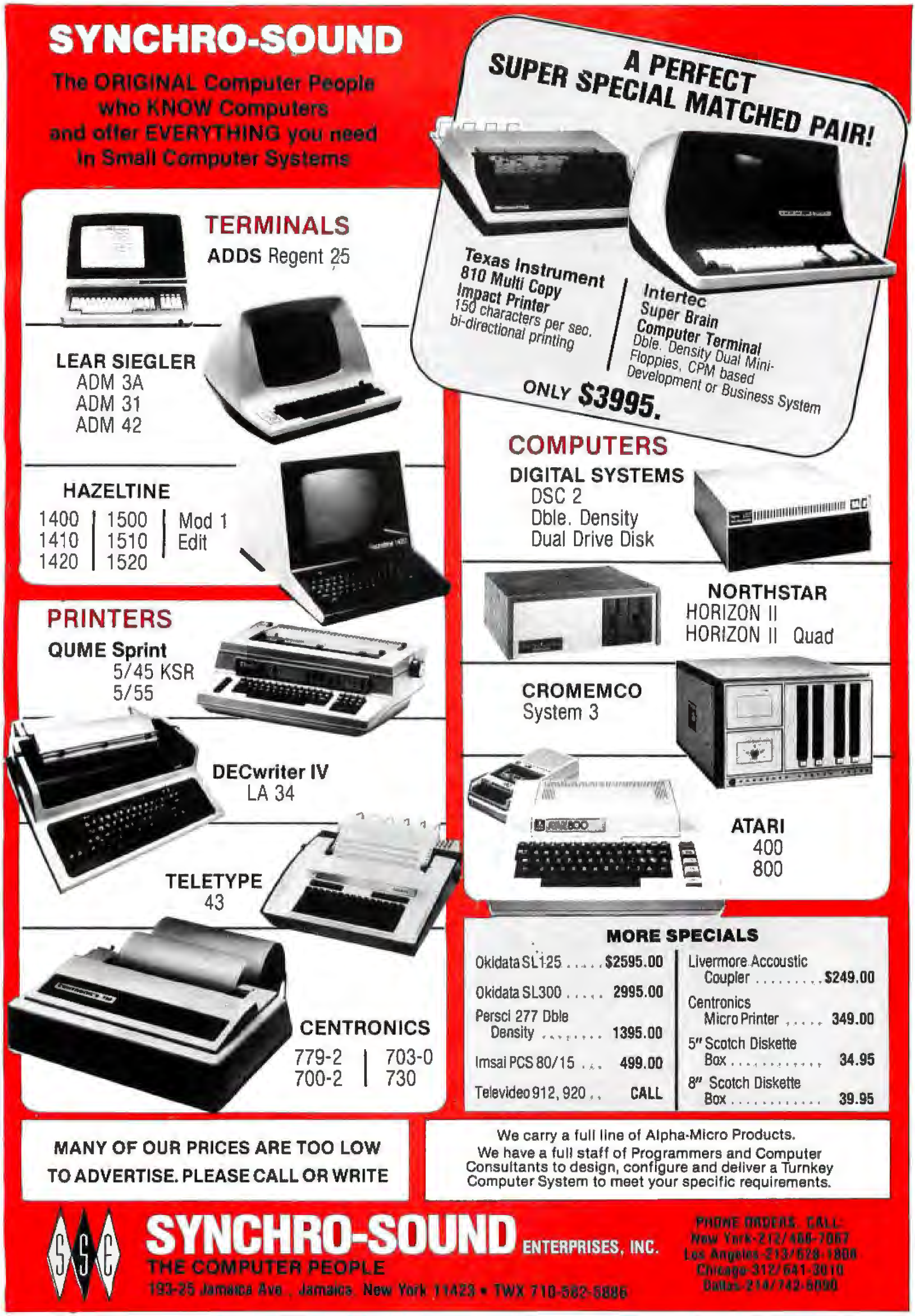
Test Problem and the TRS-80 Level I

Listing 1 gives the BASIC statements from my first coding of the test problem. Note that each keyword of the program was completely entered and spelled out in full, without regard to the abbreviations allowed in Level I. This code took 8 hours and 12 minutes to run to completion (see table 1 for a complete comparison of the results). By simply using the keyword abbreviations (ie: F. instead of FOR and N. instead of NEXT, shown in listing 2), the run time was cut to 7 hours and 12 minutes. The extra N.M (NEXT M) statement was used to speed up the loops, but at the completion of the problem run, a FOR-NEXT error results. This is okay because the problem has been completed.

Listing 3: *Level II BASIC version of test program. Keywords must be spelled out in Level II, but the use of integer variables makes it faster than the optimized Level I program. Level II BASIC is also an interpretive system.*

```
10    DEFINTM,K
80    FORM=5TO10000STEP2
90    FORK=3TOM/2STEP2
100   IFINT(M/K)*M=MTHENNEXTM
110   NEXTK
120   PRINTM;
190   NEXTM
```

The first performance conclusion has been reached; abbreviated syntax cut an 8-hour program by 1 hour. This gave me a 12% improvement in throughput, the magic measure of system performance. Now the problem solution can be accelerated with faster software. For $99 you can go back to fully spelled out keywords and still gain speed. *[Although Level II BASIC requires that keywords be entered in the fully spelled out form, and displays them in that way, the keywords are stored in memory in the*



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form of single-byte codes. A translation routine is used to spell out the meaning of these codes when the LIST command is given.... RSS]

Test Problem and Level II BASIC

I sent back my TRS-80 Level I 4 K computer. A short time later it came back with Level II BASIC and an expanded 16 K bytes user memory. The original test problem now ran in 6 hours and 31 minutes. This improvement was approximately 9%; there was an $11 investment for each percent of performance gained.

Test Problem and Z80 Assembly Language

Several years ago I became proficient in Datapoint 2200 assembly language, which is very similar to Z80 assembly language. I thought that several hours of coding and testing would be required to implement the test problem in Z80 assembly instructions. After several *days* of relearning the microinstruction format and developing the conversion and division subroutines, I finally ran my assembly test. To my surprise, it now ran in just under 22 minutes, an improvement of over 6 hours. Note that in the assembly-language program multiplication was not required, because all that is needed for prime number detection is division and determination of the remainder. The quotient proved useful in controlling the inner loop.

My next expansion of the system added a floppy-disk drive and more memory to a 32 K bytes total. There was an apparent five-second reduction in run time when the prime number output conversion was eliminated. However, I observed no noticeable performance change when the program ran in either the first 16 K bytes of memory or in the second 16 K bytes. Now that I had a disk and the TRSDOS disk operating system, I thought of the real-time CLOCK function now activated and wondered about its effect on performance.

Test	Listing	Run Time hours	minutes	seconds	Description
1	1	8	12	13	TRS-80 Level I Nonoptimized BASIC
2	2	7	12	27	TRS-80 Level I Optimized BASIC
3	3	6	31	10	TRS-80 Level II BASIC
4	4		21	55	Z80 Assembler Language
5	4		22	50	Z80 Assembler Language under TRSDOS Disk Operating System
6	5		1	19	PL/I for IBM 370-148 using Optimizing Compiler
7	6			56	370-148 Assembly Language IBM 370-148 Assembly Language

Table 1: *Summary of tests in our performance evaluation. In each case the program found integer prime numbers from 5 to 10,000.*

Test Problem and the TRSDOS Disk Operating System

I relocated my assembly-language program to hexadecimal location

Text continued on page 92

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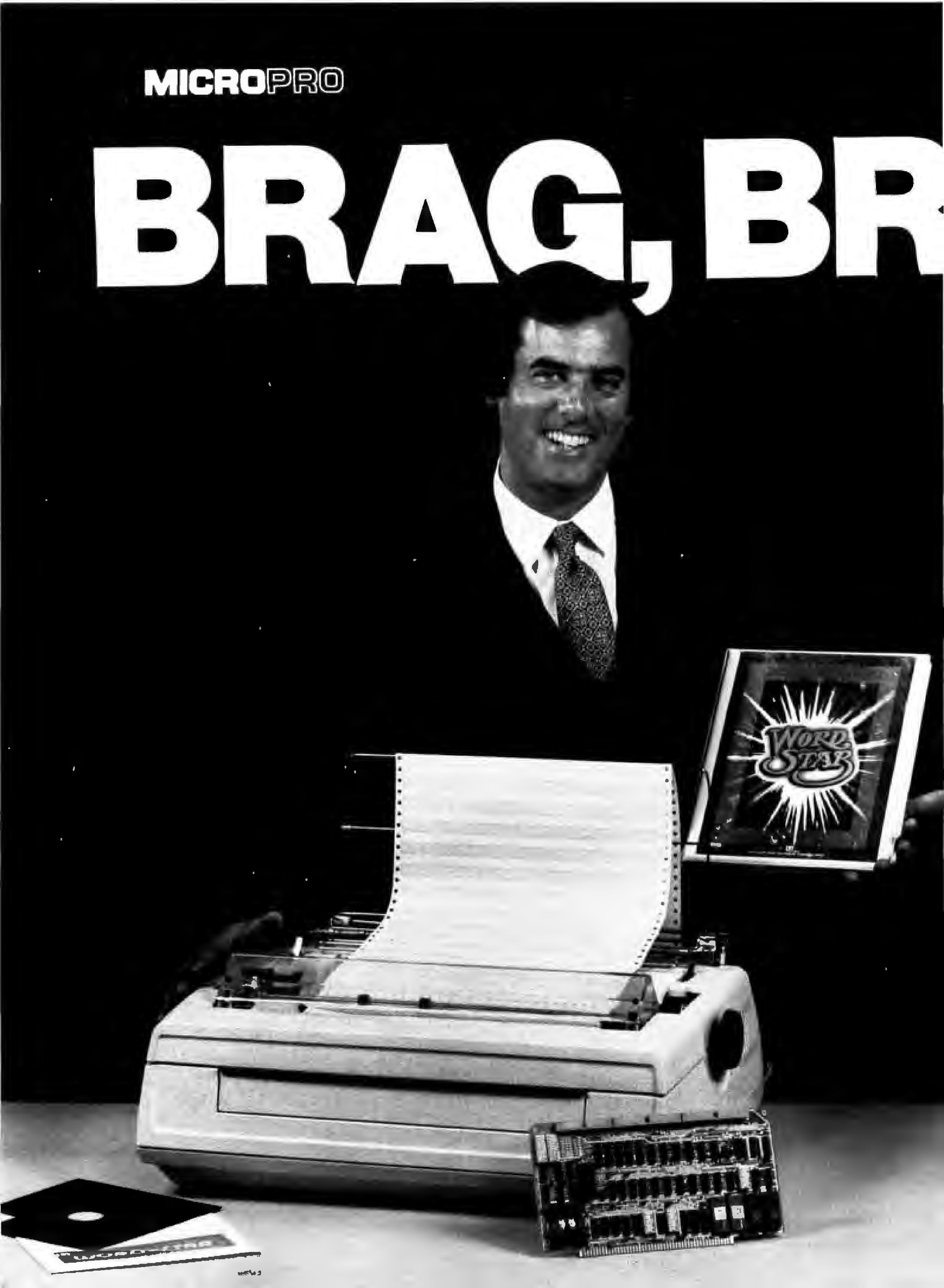
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Listing 4: *Prime-number generator coded in Z80 assembler for the TRS-80. The Radio Shack Editor and Assembler package was used. The efficiency of assembler coding is clearly shown in the greatly reduced execution time. No interpretation is required; we are speaking in the "native language" of the machine.*

```
        ORG     7000H
START   LD      HL,(NUM)          ;GET NUMBER
        INC     HL                ;BUMP NUMBER
        INC     HL                ;BY TWO TO INSURE ODD VALUE
        LD      (NUM),HL          ;SAVE FOR NEXT TIME
        LD      A,10000<8<-8      ;LSB OF 10000
        SUB     L                 ;DOUBLE PRECISION COMPARE
        LD      A,10000<-8        ;MSB OF 10000
        SBC     A,H               ;CHECK HIGH BYTE
        JR      C,DONE            ;END OF RUN
        LD      DE,1              ;START VALUE
        LD      (NUM2),DE         ;SAVE IT
;
DLOOP   LD      DE,(NUM2)         ;DIVISOR
        INC     DE                ;BUMP IT
        INC     DE                ;TWICE TO KEEP ODD
        LD      (NUM2),DE         ;SAVE FOR NEXT TIME
        LD      BC,(NUM)          ;TARGET
        LD      HL,0              ;CLEAR HIGH HALF OF DIVIDEND
        CALL    DIV16             ;PERFORM 16 BIT DIVIDE
        LD      A,H               ;CHECK REMAINDER
        OR      L                 ;IF ZERO WAS DIVISABLE
        JR      Z,START           ;AND NOT PRIME
        DEC     BC                ;CHECK FOR ONE
        LD      A,B               ;AS THIS MEANS WE
        OR      C                 ;HAVE GONE HALFWAY
        JR      NZ,DLOOP          ;NO, LOOP
        NUMBER IS PRIME
        LD      HL,(NUM)          ;DISPLAY THIS NUMBER
        LD      IX,WORK           ;WORK AREA
        CALL    DCONV             ;CONVERT TO ASCII
        LD      HL,WORK           ;AREA FOR DISPLAY
        CALL    DSPLY             ;TO SCREEN
        LD      HL,(COUNT)        ;COUNT PRIME NUMBERS
        INC     HL                ;BY ONE
        LD      (COUNT),HL
        JR      START
;
DONE    LD      HL,(COUNT)        ;DISPLAY TOTAL COUNT
        LD      IX,WORK
        CALL    DCONV             ;CONVERT TO ASCII
        LD      HL,TOTAL          ;DISPLAY STRING
        CALL    DSPLY
        JR      $                 ;LOOP
;
TOTAL   DEFM    'TOTAL='
WORK    DEFM    '12345  '
        DEFB    3
NUM     DEFW    1                 ;NUMBER TO BE TESTED
NUM2    DEFW    0                 ;TESTING NUMBER
COUNT   DEFW    0                 ;COUNT OF PRIME NUMBERS
;               DISPLAY STRING TO SCREEN
DCHAR   EQU     33H               ;LEVEL II CHAR DISPLAY
DSPLY   LD      A,(HL)            ;GET CHARACTER
        CP      3                 ;END OF STRING?
        RET     Z                 ;YES, DONE
        CALL    DCHAR             ;LET LEVEL II MANAGE SCREEN
        INC     HL                ;BUMP MEMORY POINTER
        JR      DSPLY
;               CONVERT HL TO 5 DIGIT AREA POINTED TO BY IX
DCONV   LD      C,' '             ;TRIGGER AND ASCII CHARACTER
        LD      B,5               ;COUNT OF CONVERSION
        LD      IY,CTBL           ;CONVERSION TABLE
DCONV1  LD      E,(IY)            ;LSB OF FACTOR
        INC     IY
        LD      D,(IY)            ;MSB OF FACTOR
        INC     IY
        SUB     A                 ;CLEAR C FLAG AND DIGIT COUNTER
DCONV2  SBC     HL,DE             ;16 BIT SUBTRACT
```

Listing 4 continued on page 92

Listing 4 continued:

```
              JR        C,DCONV3               ;UNDERFLOW
              INC       A                      ;BUMP DIGIT
              JR        DCONV2                 ;CONTINUE BUILDUP
DCONV3        ADD       HL,DE                  ;COMPENSATE FOR UNDERFLOW
              OR        A                      ;NON-ZERO DIGIT?
              JR        Z,DCONV4               ;NO, ZERO, DO NOT RESET TRIGGER
              LD        C,'0'                  ;ASCII TRIGGER
DCONV4        OR        C                      ;TURN INTO ASCII (OR BLANK)
              LD        (IX),A                 ;STORE DIGIT
              INC       IX
              DJNZ      DCONV1                 ;COUNT DOWN
              LD        A,(IX-1)               ;MUST SHOW A ZERO DIGIT
              OR        '0'                    ;IF ZERO
              LD        (IX-1),A
              RET
;                       CONVERSION TABLE
CTBL          DEFW      10000
              DEFW      1000
              DEFW      100
              DEFW      10
              DEFW      1
; 16 BIT DIVISION
;       DIVIDEND=HLBC
;         DIVISOR=DE
;      QUOTIENT=BC
;    REMAINDER=HL
DIV16    LD       A,16                 ;16 BIT DIVISION
DIV161   SLA      C                    ;MOVE C REG
         RL       B                    ;NOW B WITH CARRY
         ADC      HL,HL                ;BUMP REMAINDER
         SBC      HL,DE                ;16 BIT SUBTRACT WITH CARRY
         JR       NC,DIV162            ;UNDERFLOW
         ADD      HL,DE                ;ADJUST
         JR       DIV163               ;SKIP SETTING QUOTIENT BIT
DIV162   INC      C                    ;BUMP QUOTIENT
DIV163   DEC      A                    ;DECREMENT LOOP COUNTER
         JR       NZ,DIV161            ;LOOP TIL DONE
         RET
;
         END      START
```

Listing 5: *Test program coded in the PL/I language for the IBM System/370-148. An optimizing compiler was used to run this version. Compilation is more efficient than interpretation in reducing execution time. This program also finds prime numbers.*

```
PRIME: PROC OPTIONS(MAIN) REORDER;
       DECLARE (C, D, M) FIXED BINARY(31) INIT(0);
       DO M = 3 to 10000 BY 2;
              DO D = 3 TO M/2 BY 2;
                     IF MOD(M, D) = 0 THEN GOTO NOT_PRIME;
              END;
              C = C + 1;
              PUT LIST(M);
NOT_PRIME:
       END;
       PUT SKIP DATA(C);
END PRIME;
```

Text continued:

7000 and constructed a disk operating system command (CMD) file. When run under the disk operating system, the test problem execution time was extended by 55 seconds. I attributed this delay to the 25 ms interrupt from the expansion interface and the processing required to service the interrupt and update the clock. This amounted to about 4 to 5% overhead. Using the disk operating system BASIC, the T command to turn off the interrupt will speed up the execution of programs not requiring clock functions. Listing 4 represents the Z80 assembly-language version of the prime number finding program.

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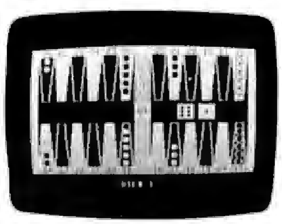

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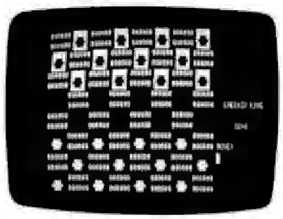

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Listing 6: *Test program coded in assembler language for the IBM 370. Writing in the native language of this very fast machine, we obtain the shortest time for finding prime numbers from 5 to 10,000.*

```
        LA      R2,5                 STARTING VALUE FOR TEST
        SR      R10,R10              COUNT OF PRIME NUMBERS
        LA      R6,2                 LOOP INCREMENT - INNER LOOP
        LR      R8,R6                LOOP INCREMENT - OUTER LOOP
        LH      R9,=H'10000'         UPPER LIMIT FOR OUTER LOOP
OLOOP   LA      R3,3                 STARTING VALUE FOR TESTING NUMBER
        LR      R7,R2                COMPUTE INNER LOOP LIMIT
        SRL     R7,1                 DIVIDE BY TWO
ILOOP   SR      R4,R4                ZERO EVEN DIVIDEND PAIR
        LR      R5,R2                LOAD ODD DIVIDEND VALUE
        DR      R4,R3                R3 IS DIVISOR
        LTR     R4,R4                CHECK REMAINDER
        BZ      NEXTO                ZERO IS NOT PRIME
        BXLE    R3,R6,ILOOP          INNER LOOP
        CVD     R2,WORK              CONVERT PRIME NUMBER TO DECIMAL
        UNPK    DATA(7),WORK+4(4)    MAKE EBCDIC
        OI      DATA+6,X'F0'         SET SIGN CORRECT
        PUT     SYSPRINT, DATA       OUTPUT PRIME NUMBER
        LA      R10,1(,R10)          INCREMENT PRIME NUMBER COUNT
NEXTO   BXLE    R2,R8,OLOOP          OUTER LOOP
        CVD     R10,WORK             CONVERT COUNT TO DECIMAL
        UNPK    DATA(7),WORK+4(4)    AND TO EBCDIC
        OI      DATA+6,X'F0'         SET SIGN CORRECT
        PUT     SYSPRINT, DATA       OUPUT COUNT
```


Test Problem and the Large System

At the completion of the TRS-80 testing phase, I coded two versions of the test problem to be run on the IBM 370-148. Listings 5 and 6 show PL/I language and 370 assembler language codings of the prime-number generator. The execution times showed little difference. The PL/I version (compiled, rather than interpreted) ran in 1 minute and 19 seconds of processor time. The test run in assembler language used 56 seconds of processor time.

The best comparison between the two machine's capabilities is arranged by counting the number of instructions needed to perform division; twelve for the TRS-80 (ten of which are looped sixteen times) and *one* for the 370. Performance difference is also indicated by the average execution time of 1108 μs for the Z80 division subroutine versus 30.7 μs for the DR (divide register into register) instruction of the 370-148. This is a time ratio of 36 to 1. If you compare a less complex function, such as 16-bit storage-to-register load, the TRS-80 performs closer to the 370 capability; the Z80 LD HL,(n) instruction takes 16 cycles or 9.008 μs, and the 370 load halfword takes 1.958 μs. The 16-bit load operation compares as a 4.6 performance ratio. Thus, it is shown that a single instruction comparison does not always represent the required work performance ratio.

Conclusions

The test program I chose can be run with the same results on both the TRS-80 and the IBM 370-148. There is a difference in system throughput and cost. An analysis of the TRS-80 performance indicates that the advertised improvements of Level I keyword abbreviations and Level II BASIC are present. The analysis of the TRS-80 BASIC versus Z80 assembler language shows a significant improvement in assembler language, if you care to code the program that way or if you need the speed. I now have an answer for my friends at work when they ask about the speed differences between my personal computer system and the impersonal IBM 370-148. ■

Editorial *Listing 1 continued from page 12:*

```
    x,n                  : INTEGER;
    sigma                : INTEGER;
    which_ring           : (second,third);

    a,b,c                 : absolute_time;
    ring_time             : absolute_time;
    second_contact_ring   : absolute_time;
    third_contact_ring    : absolute_time;
    tot_time              : absolute_time;
    time_totality         : absolute_time;
    margin_time           : absolute_time;
    current_time          : absolute_time;
    half_time             : absolute_time;
    quarter_time          : absolute_time;
    slack_in_totality     : absolute_time;
    dummy                 : absolute_time;
    total_duration        : absolute_time;

    maximum              : exposures;
    total_eclipse        : exposures;
    ring_frames          : exposures;
    current_shot         : exposures;

    ten_shot_grouping : PACKED ARRAY[0..9] OF an_exposure_detail;
    transient_shots   : PACKED ARRAY[0..1] OF an_exposure_detail;

PROCEDURE new_page;
   VAR
      stuff : STRING[24];
      clear_screen : CHAR;
   BEGIN
      stuff := '
      clear_screen := CHR(24);
      WRITELN(clear_screen,stuff);
      WRITELN(' ');
      WRITELN(' ');
      WRITELN(s)
   END (new_page);

PROCEDURE get_parameter(VAR time : absolute_time);
   VAR
      a_string : STRING[128];
      i : INTEGER;
      period : BOOLEAN;
      decimal_count : INTEGER;
      factor, result : INTEGER;

      PROCEDURE add_a_digit(position : INTEGER);
         VAR
            digit : INTEGER;
         BEGIN
            digit := (ORD(a_string[position])-ORD('0'));
            IF period THEN
               BEGIN
                  decimal_count := decimal_count + 1;
                  IF decimal_count < 4 THEN
                     BEGIN
                        time.thousandths := time.thousandths
                              + ((1000 * digit) DIV factor);
                        factor := 10 * factor
                     END
               END
            ELSE (before period)
               time.units := (time.units * factor) + digit
         END;

BEGIN (get_parameter)
   PAGE(OUTPUT);
   time.units := 0;
   time.thousandths := 0;
   WHILE ((time.units=0) AND (time.thousandths=0)) DO
      BEGIN
         factor := 10;
         decimal_count := 0;
         period := FALSE;
         WRITELN(s);
         READLN(a_string);
         FOR i := 1 TO LENGTH(a_string) DO
            BEGIN
               CASE a_string[i] OF
                  '0','1','2','3','4','5','6','7','8','9':
                     add_a_digit(i);
                  '.':
                     period := TRUE
               END


               END
         END (WHILE)
   END (get_parameter);

PROCEDURE initialize;
   VAR
      i : INTEGER;
   BEGIN (initialize)
      s := '';
      current_time.units        := 0;
      current_time.thousandths := 0;
      current_shot := 0;
      ten_shot_grouping[0].duration     := 1;
      ten_shot_grouping[1].duration     := 4;
      ten_shot_grouping[2].duration     := 16;
      ten_shot_grouping[3].duration     := 64;
      ten_shot_grouping[4].duration     := 128;
      ten_shot_grouping[5].duration     := 256;
      ten_shot_grouping[6].duration     := 512;
      ten_shot_grouping[7].duration     := 1024;
      ten_shot_grouping[8].duration     := 2048;
      ten_shot_grouping[9].duration     := 4096;
      FOR i := 0 TO 9 DO
         ten_shot_grouping[i].wait_after   := overhead_duration;

      transient_shots[0].duration     := 4;
      transient_shots[1].duration     := 32;
      FOR i := 0 TO 1 DO
```

Listing 1 continued on page 98

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Circle 61 on inquiry card.

Listing 1 continued:

```
            transient_shots[i].wait_after   := overhead_duration;

        s := 'Preliminary data initialization';
        new_page;
        WRITELN(
            '"totality" is defined as time from second to third contacts' );
        s := '    Enter number of exposures';
        get_parameter(dummy);
        maximum := dummy.units;
        s := 'Enter number of exposures during totality';
        REPEAT
            BEGIN
                get_parameter(dummy);
                total_eclipse := dummy.units
            END
        UNTIL
            (total_eclipse > 0)
                                AND
            (total_eclipse < maximum);
        s := '    Enter time of totality in "seconds.thousandths"';
        get_parameter(time_totality);
        s := '    Enter slack time margin (in seconds)';
        get_parameter(slack_in_totality);
        crash_ahead := TRUE
    END (initialize);

PROCEDURE error_abort;
    BEGIN
        maximum := 250;
        total_eclipse := 200;
        ring_frames := 25;
        WRITELN('Unrecoverable error in data' );
        crash_ahead := FALSE
    END;

PROCEDURE subtract_time(a,b : absolute_time; VAR c : absolute_time );
    BEGIN
        c.thousandths := a.thousandths - b.thousandths;
        sigma := 0;
        IF c.thousandths < 0 THEN
            BEGIN
                c.thousandths := c.thousandths + 1000;
                sigma := -1
            END;
        c.units    := a.units  - b.units    + sigma
    END;

PROCEDURE divide_time(
                        VAR a : absolute_time;
                        b : absolute_time;
                        n : INTEGER
                       );
    { a <-- b DIV n }
    VAR
        p,q : INTEGER[16];
    BEGIN
        a.thousandths := 0;
        a.units := 0;
        q := b.units;
        q := q * 1000;
        q := q + b.thousandths;
        q := q DIV n;
        p := q DIV 1000;
        IF p < 32768 THEN
            a.units := TRUNC(p);
        p := q - (1000 * p);
        IF p < 32768 THEN
            a.thousandths := TRUNC(p)
    END;

PROCEDURE add_time(a,b : absolute_time; VAR c : absolute_time );
    BEGIN
        sigma := a.thousandths + b.thousandths;
        c.thousandths := sigma MOD 1000;
        c.units    := a.units    + b.units    + (sigma DIV 1000)
    END;

PROCEDURE print_time(a : absolute_time );
    VAR
        z1000,z100 : STRING[1];
    BEGIN
        IF a.thousandths < 100 THEN z1000 := '0' ELSE z1000 := '';
        IF a.thousandths < 10 THEN z100 := '0' ELSE z100 := '';
        WRITELN(s,a.units,'.',z1000,z100,a.thousandths )
    END;

PROCEDURE normalize_timing;
    VAR
        i                   : INTEGER;

    PROCEDURE sum_up_ring(ring: INTEGER; VAR ring_total : absolute_time );
        VAR
            index,i : INTEGER;
            this_ring : absolute_time;

        BEGIN
            ring_total.units        := 0;
            ring_total.thousandths := 0;
            FOR i := 1 TO ring_frames  DO
                BEGIN
                    this_ring.units := 0;
                    this_ring.thousandths := transient_shots[ring].wait_after;
                    add_time(this_ring,ring_total,ring_total );
                    this_ring.thousandths := transient_shots[ring].duration;
                    add_time(this_ring,ring_total,ring_total )
                END
        END;

    PROCEDURE sum_up_eclipse(VAR eclipse_total : absolute_time );
        VAR
            this_shot : absolute_time;
            index,i,j : INTEGER;
        BEGIN
            eclipse_total.units := 0;
            eclipse_total.thousandths := 0;
            FOR i := 1 TO total_eclipse DO
                BEGIN
```

Listing 1 continued on page 100

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Circle 63 on inquiry card.

Listing 1 continued:

```
            this_shot.units := 0;
            index := (i-1) MOD 10;
            this_shot.thousandths := ten_shot_grouping[index].wait_after;
            add_time( this_shot,eclipse_total,eclipse_total );
            this_shot.thousandths := ten_shot_grouping[index].duration;
            add_time( this_shot,eclipse_total,eclipse_total )
         END
    END;

PROCEDURE preliminary_allocation;
    BEGIN
      s := 'Allocation of Eclipse Times...';
      new_page;
      s := '                     Total time for eclipse = ';
      print_time( time_totality );

      WRITELN( '----------------------------------------------------------' );
      which_ring := second;
      sum_up_ring( ORD( which_ring ),second_contact_ring );

      s := 'Time required for second contact transient  =   ';
      print_time( second_contact_ring );

      which_ring := third;
      sum_up_ring( ORD( which_ring ),third_contact_ring );

      s := 'Time required for third contact transient   =   ';
      print_time( third_contact_ring );

      add_time( second_contact_ring,third_contact_ring,ring_time );
      s := 'Total time devoted to diamond ring sequences=  ';
      print_time( ring_time );
      divide_time( quarter_time,second_contact_ring,2 );
      s := '  Anticipation time for first diamond ring  =   ';
      print_time( quarter_time );


      WRITELN( '----------------------------------------------------------' );
      sum_up_eclipse( tot_time );
      s := '                     Time devoted to totality = ';
      print_time( tot_time );
      s := '       Slack time margin at end of totality  =  ';
      print_time( slack_in_totality );

      divide_time( half_time,ring_time,2 );
      s := 'Extra slack due to diamond ring overlaps     =   ';
      print_time( half_time );

      add_time( tot_time,slack_in_totality,total_duration );
      add_time( total_duration,half_time,total_duration );
      s := 'Total time committed before margin alloc.   = ';
      print_time( total_duration );

      WRITELN( '----------------------------------------------------------' );
      subtract_time( time_totality,total_duration,margin_time );
      s := '   Difference is time margin for allocation =  ';
      print_time( margin_time )
    END {preliminary_allocation};

PROCEDURE margin_dispersal;
    VAR
      margin_per_frame : absolute_time;
      i : INTEGER;
    BEGIN
      divide_time( margin_per_frame,margin_time,total_eclipse );
      FOR i := 0 TO 9 DO
         ten_shot_grouping[i].wait_after :=
            ten_shot_grouping[i].wait_after +
            (1000 * margin_per_frame.units) +
            margin_per_frame.thousandths;
      s := '      Margin per totality frame = ';
      print_time( margin_per_frame )
    END {margin_dispersal};

PROCEDURE final_allocation;
    BEGIN
      sum_up_eclipse( tot_time );
      s := '   Adjusted time devoted to total phase      = ';
      print_time( tot_time );

      add_time( tot_time,slack_in_totality,total_duration );
      add_time( total_duration,half_time,total_duration );
      s := '   Adjusted total time committed             = ';
      print_time( total_duration );

      WRITELN( '----------------------------------------------------------' );
      subtract_time( time_totality,total_duration,margin_time );
      s := '   Margin time after allocation to totality =   ';
      print_time( margin_time )
    END {final_allocation};

PROCEDURE alloc_exposures;
    BEGIN
      ring_frames :=
         (maximum - total_eclipse) DIV 2;
      IF ring_frames < 2 THEN error_abort;
      sigma := maximum - (total_eclipse + (2 * ring_frames));
      total_eclipse := total_eclipse + sigma;
      WRITELN( '' );
      WRITELN( 'Exposures map:' );
      WRITELN( '   First diamond ring  = ',ring_frames );
      WRITELN( '   Totality            = ',total_eclipse );
      WRITELN( '   Second diamond ring = ',ring_frames );
      WRITELN( '                         ---------' );
      WRITELN( '         TOTAL         = ',maximum );
      WRITELN( '' );
      WRITELN( '' );
      WRITELN( 'Press return to continue' );
      READLN( s )
    END {alloc_exposures};


BEGIN {normalize_timing}

    alloc_exposures;

    preliminary_allocation;
```

Listing 1 continued on page 102

Listing 1 continued:

```
      margin_dispersal;

      final_allocation

   END (normalize_timing);

PROCEDURE await_cue;
   BEGIN (await_start)
  END (await_start);

PROCEDURE diamond_ring_burst;
   BEGIN (diamond_ring_burst)
   END (diamond_ring_burst);

PROCEDURE totality;
   BEGIN (totality)
   END (totality);

PROCEDURE summarize;
   BEGIN (summarize)
      WRITELN('Press return to end program');
      READLN(s)
   END (summarize);

BEGIN (eclipse_monitor_simulation)
   initialize;
   normalize_timing;
   await_cue;
   diamond_ring_burst;
   totality;
   await_cue;
   diamond_ring_burst;
   summarize
END. (eclipse_monitor_simulation)
```

Listing 2: *Preliminary allocation steps. The first stage of the execution of the program is this listing of an interactive sequence to determine the independent variables of the simulation.*

```
Preliminary data initialization
"totality" is defined as time from second to third contacts
   Enter number of exposures
250
 Enter number of exposures during totality
200
   Enter time of totality in "seconds.thousandths"
240
   Enter slack time margin (in seconds)
6

Exposures map:
  First diamond ring  = 25
  Totality            = 200
  Second diamond ring = 25
                       --------
        TOTAL         = 250

Press return to continue
```

Listing 3: *Final computation. Using a brute force technique of adding up various time intervals, the program arrives at this calculated model of the parameters. It first sums up the required time budget for all the events that must happen. The difference between this value and the time of totality is a margin value. This value is then evenly allocated to the timing of exposures during the main part of the eclipse. In the example, I have assumed 250 exposures total, 200 of which occur in the main portion of a 240.0 second eclipse event with a 6.0 second margin for manual timing at the end of the main sequence of totality.*

```
Allocation of Eclipse Times...
               Total time for eclipse = 240.000
-------------------------------------------------------
Time required for second contact transient  =   5.100
Time required for third contact transient   =   5.800
Total time devoted to diamond ring sequences=  10.900
  Anticipation time for first diamond ring  =   2.550
-------------------------------------------------------
                  Time devoted to totality  = 202.980
         Slack time margin at end of totality  =   6.000
Extra slack due to diamond ring overlaps    =   5.450
Total time commited before margin alloc.    = 214.430
-------------------------------------------------------
    Difference is time margin for allocation =  25.570
     Margin per totality frame = 0.127
    Adjusted time devoted to total phase      = 228.380
    Adjusted total time committed             = 239.830
-------------------------------------------------------
    Margin time after allocation to totality =   0.170
Press return to end program
```

Editorial *text continued from page 12:*

time is calculated as the difference between all the time commitments and the total time available during totality. (Half the time required for the diamond ring effects is assumed to take place during actual totality, so that the transient effects will be bracketed in time.) The margin time must be equally divided among the individual shots during totality. The procedure "margin-dispersal" is used to divide the margin by the number of totality exposures, then add this amount to the "wait-after" field of each of the ten unique totality exposure specifications in the array "ten-shot-grouping."

Finally, the procedure "final-allocation" reports on the actual allocation achieved by recalculating the margin time. This second margin time calculation reflects the allocation's effect. In photo 3, the value of 0.17 seconds is well within the limits of human hand/eye coordination by yours truly. (Hand/eye coordination will be used to observe the digital wristwatch set to Universal Coordinated Time and pick the precise time to start the real-time sequence of the program by hitting any key on the Apple keyboard. Later in the eclipse, the second diamond ring event (third contact) will be initiated by a similar procedure while watching the eclipsed sun.)

As it stands in listing 1, the program still must be filled out with the actual details of procedures "await-cue," "diamond-ring-burst," "totality," and "summarize." These are all relatively straightforward procedures, which will execute the real-time process of the eclipse observation. Other details to be verified include the actual model of the bulb-release exposure event (ie: what fixed overhead time is associated with the mirror flip/shutter opening action of the mechanism), calibration of a Pascal "do nothing" timing loop running with the Apple II's crystal clock so that the entire program executes all exposures within the time set by the model, and so forth. I will have more details on this in a forthcoming editorial, as I complete the model and finish verifying the system concept.

The most important concept here is the very real machine-independent viability of a high-level language, such as Pascal, in designing and then communicating the idea of a program. The functional simulation stage of my eclipse control program is now complete in concept and awaits some final details to be added over the next week or so. When it is done, going from the functional simulation to the actual eclipse control program I bring with me to Africa will be achieved by the simple act of reconfiguring the textual displays for a more limited 40-column output display and making multiple, redundant copies of the software on floppy disks for my travels.

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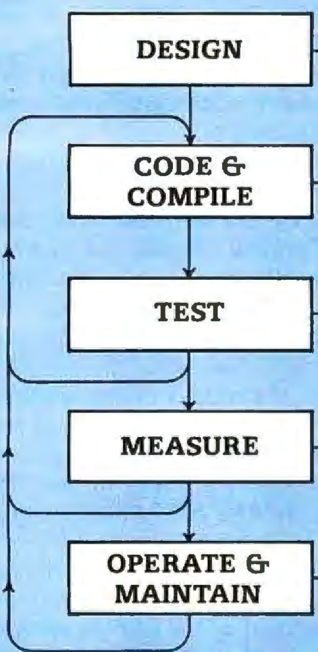

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Circle 66 on inquiry card.

Listing 4: *A camera interface test program. This Pascal test program exercises the camera shutter control interface of figure 1 by alternating the state of Apple II Game I/O annunciator output AN0.*

```
PROGRAM test_interface;
   (This program, written December 25, 1979 is designed to test out
      the interface to the Nikon MD-2 motor drive by alternately
      setting the state of output transistor Q2 in response to carriage
      return characters.  A delay count set by a null FOR statement
      is used to allow repeated actuation with a minimum time between
      output state changes.  A variant record technique is used in the
      Pascal software of the procedure "ref_memory" in order to set and
      reset the output bit at absolute addresses C058 and C059 hexadecimal.
   )

   CONST
      open_shutter_address  = -16295 (sets AN0 output to "1");
      close_shutter_address = -16296 (resets AN0 output to "0");

   VAR
      reiterations : INTEGER;
      j,k,i : INTEGER;
      s : CHAR;

   PROCEDURE ref_memory(address : INTEGER);
      ( This procedure uses the variant record technique to
         reference an address passed to it as a 16 bit signed
         INTEGER.  The Apple-II hardware will set or reset the
         annunciator outputs of the Game I/O connector if the
         appropriate addresses are simply referenced by a program.
      )

      TYPE
         ptr = ↑CHAR;

         memory_access = (pointer,number)
         (this is a dummy statement required by the syntax of
            Pascal variant records such as "memory" below. The
            variant record "trick" is not the most elegant way
            to reference an absolute hardware address, since it
            requires an implementation-dependent assumption about
            variant records, ie: that a 16 bit signed two's complement
            INTEGER type maps bit for bit into the 16 bit positive
            integer value of an address stored in a Pascal pointer
            data type.
         );

         memory =
            RECORD
               CASE memory_access OF
                  pointer : (a_pointer : ptr);
                   number  : (a_number : INTEGER)
            END;

      VAR
         anybyte : memory;
         anychar : CHAR;

      BEGIN
         anybyte.a_number := address;
         anychar := anybyte.a_pointer↑
      END (ref_memory);

    PROCEDURE end_exposure;
       BEGIN
          WRITELN('Motor drive now fires... and shutter cocks');
          ref_memory(close_shutter_address)
       END (end_exposure);

    PROCEDURE start_exposure;
       BEGIN
          WRITELN('Shutter opens with a "click"');
          ref_memory(open_shutter_address)
        END (start_exposure);

    PROCEDURE change_reiterations;
       BEGIN
          WRITELN('Enter integer time delay count');
          WRITELN('    (old count was = ',reiterations,')');
          READLN(reiterations);
          IF reiterations < 1 THEN reiterations := 1;
          IF reiterations > 2500 THEN reiterations := 2500
        END (change_reiterations);

   BEGIN
      reiterations := 1000;
      FOR i := 1 TO 1000 DO
         BEGIN
            FOR j := 1 TO reiterations DO;
            WRITELN('*** Shutter is now closed ***');
            READLN(s);
            IF s = ' ' THEN
               ELSE IF s = 'N' THEN change_reiterations
                  ELSE IF s = 'E' THEN i := 1000;
            start_exposure;
            FOR j := 1 TO reiterations DO;
            WRITELN('****** Shutter is now open ******');
            READLN(s);
            IF s = ' ' THEN
               ELSE IF s = 'N' THEN change_reiterations
                  ELSE IF s = 'E' THEN i := 1000;
            end_exposure
         END
   END.
```

Bar Codes and Home Brewing . . . Progress Reports

As of early December 1979, we received some exciting word about the state of manufacturing of bar-code-reader wands. This word comes from John Sien of Hewlett-Packard's Optoelectronics Division in Palo Alto, California. Hewlett-Packard has just completed the formal announcement of a truly inexpensive optical bar-code reader, which will be available from stocking distributors of their component lines, possibly by the time you are reading this issue of BYTE.

The bar-code reader interfaces to transistor-transistor logic (TTL) or complementary metal-oxide semiconductor (CMOS) logic with three wires: signal, ground and power. It enables an individual with a personal computer to read Universal Product Codes (as on grocery items) or PAPERBYTES bar codes, or a host of other possible machine-readable printed formats. This reader costs a mere $99.50 in single quantities from a distributor and much lower in manufacturing quantities.

John reports that there is a great deal of interest from one or more microwave-oven manufacturers in using bar codes and this reader to transfer individual cooking programs from food-packets or recipe books into the oven's control circuitry.

This product is the same bar-code reader used with the Hewlett-Packard HP-41C calculator for the distribution of miscellaneous user-submitted programs. In short, now that the single enabling piece of hardware is widely available in an inexpensive form, bar codes have arrived.

Returning to the subject of my homebrew 6809 project, I have put off further work until return from the eclipse trip early this month. In a personal analogy to concepts held dear by many of our readers, I have pushed the homebrew 6809 down on my internal procedure stack, in order to execute a higher priority procedure that has a definite, celestial time deadline. The stack will be popped up upon return from my trip, so the next installment of the 6809 homebrew project can occur no sooner than the issues of BYTE published early next summer. ■

ALTOS BREAKS THE MICRO BARRIER.

Yesterday, microcomputer meant micro performance. Once you outgrew it, you had to step up to a mini. Which meant a big step up in price.

Today, there's the new Altos ACS8000-6 single-board microcomputer system.

It's the first system for the OEM, small businessman and personal user, that offers minicomputer performance and minicomputer storage capacities—at a microcomputer price.

MULTI-USER, WINCHESTER STORAGE, FLOPPY BACK UP: $14,260.

The new Altos ACS8000-6 is a highly advanced Z80* based microcomputer system with high-speed RAM, floppy disk and Winchester hard-disk controllers, DMA, six serial and two parallel I/O ports and the AMD 9511 floating point processor all on a single board. A typical four-user system configuration with two megabytes of Shugart floppy and 29.0 megabytes of Shugart Winchester storage, including CPU and 208K bytes of RAM, costs only $14,260—compared to $30,000 or more for a similar minicomputer system. And that adds up to mini performance at less than half the cost!

MULTI-USER EXECUTIVE SUPPORTS FOUR INDEPENDENT USERS RUNNING CP/M COMPATIBLE PROGRAMS.**

This revolutionary new microcomputer system features an Altos-developed Multi-User Executive (AMEX) software program that's unique in two ways. It includes a multi-user CP/M capability and the ability to handle Winchester-type hard disks. This advanced Z80 operating program supports four independent CP/M compatible programs in any of six popular languages: BASIC, FORTRAN, COBOL, PASCAL, APL, C, and a large assortment of additional business application packages. AMEX is compatible with both the 1.4 and 2.0 versions of Digital Research's CP/M, which means programs based on either version can run under AMEX without modification.

With AMEX at the helm, your Altos ACS8000-6 system can support up to four simultaneous users with 48K bytes of RAM each plus 58 megabytes of Winchester storage and 4 megabytes of floppy back up. And that adds up to the first microcomputer to give you the power and performance of a minicomputer.

SINGLE-USER, HARD-DISK SYSTEMS START AT $9450.

The Altos ACS8000-6 series. It's a barrier breaker in every sense. Our entry-level, single-user, hard-disc system with floppy back up is priced under $10,000 and even our 4-user CP/M model is available for under $12,000. And all configurations are easily upgraded. For specific details about pricing or performance, call or write: Altos Computer Systems, 2360 Bering Drive, San Jose, CA (408) 946-6700. TELEX 171562 ALTOS SNA.

ALTOS
COMPUTER SYSTEMS

Circle 68 on inquiry card.

BYTE News . . . .

FRANCE TO INTRODUCE HOME TERMINALS: The French Postal and Telecommunications agency is undertaking a project to put a computer terminal in every home. According to a report that appeared in *Business Week* magazine, the government agency intends to give all telephone customers a free two-way video display terminal, in lieu of printed directories. A similar machine that can send and receive a full page of text in two minutes will also be offered for under $500. Over 1000 terminals will be installed early next year. Each terminal is expected to cost the agency less than $100.

IBM MOVES TO ASCII: Until now you either did it the ASCII way or the IBM way. In other words, all IBM communication was done in Extended Binary-Coded-Decimal Interchange Code (EBCDIC), while all other computer manufacturers used the American Standard Code for Information Interchange (ASCII). Anyone who has tried to interface an IBM terminal to a non-IBM system has encountered the problem.

Now IBM has introduced their first product that uses ASCII, the model 3101 video terminal. Depending on options, prices range from $1300 to $1520. These units can be ordered over the telephone, and IBM installation is not required, as is the case with all other IBM products. The unit, largely made in Japan, qualifies for discounts up to 20%—a new departure for IBM.

IBM has apparently been forced to compete with other computer component makers on their level. This may be the forerunner of a new IBM marketing philosophy for small-computer systems.

Rumor has it that IBM will become more aggressive in the small-computer market with enhancements to its 5110 tabletop computers. Look for IBM to increase the number of "retail stores" for small-business computer systems to 200 by the end of 1980. Most of these stores will be in branch offices of the General Systems Division.

TANDY, APPLE AND ATARI ASK FCC FOR DELAY: Atari asked the Federal Communications Commission (FCC) to delay the effective date of the waiver of rules for Texas Instruments (as previously reported in the January 1980 BYTE News) until a rulemaking proceeding on television-interface devices is completed. Atari cited allegedly illegal action by the FCC in granting the waiver and noted the potential increased radio and television interference. After two weeks consideration, the FCC rejected Atari's request.

Tandy Corporation and Apple Computer Company asked the FCC to delay the deadline for compliance with the FCC's new radio frequency interference (RFI) standard, which is due to go into effect on July 1, 1980. Both firms have claimed that this is too short a time to change manufacturing processes and order the necessary components.

LATEST RUMORS: Designers of Radio Shack's successor to the TRS-80 Model I have changed their minds and will employ Microsoft for writing the BASIC interpreter and operating system. Motorola also made a bid to do this software development; however, Microsoft ended up with the contract. Radio Shack had been planning to call the unit the "TRS-90," but the firm is now leaning toward "TRS-80/COLOR." . . . It is rumored that Sony and Texas Instruments have reached an agreement whereby Sony will sell Texas Instruments' personal-computer systems in the United States under the Sony name, with a Sony Trinitron color video monitor, instead of the Zenith monitor Texas Instruments is currently using. . . .Microtype Corporation will soon introduce a $250 electronic typewriter with RS-232 input/output (I/O). It will use a daisy-wheel-like printing method, and it will print 15 characters per second. Look for it by the end of 1980. . . .

RANDOM NEWS BITS: Burroughs has introduced a 6 megabyte floppy-disk drive. It holds two disks on a common spindle and uses four data-transfer heads on a common assembly. Cost is only $1950 in original equipment manufacturers quantities. . . .GR Electronics Ltd of Santa Monica, California, has introduced a pocket ASCII terminal in a case the size of a standard pocket calculator. It has forty keys and transmits the 128 ASCII character codes. It has an light-emitting diode display and stores thirty received characters. It has an RS-232C interface (110 or 300 bits per second), requires 5 V at 400 mA for power, and sells for $395....Hewlett-Packard (HP) has introduced its personal-computer system. The system costs $3250 and is being manufactured at HP's Corvallis, Oregon, calculator division. See page 60 in this issue for a report....Godbout Electronics, Oakland Airport, California, plans to introduce an S-100 processor circuit card that contains both 8088 and 8085 microprocessors on the same card. The 8088 is a 16-bit processor with 8-bit I/O (it executes 8086 ob-

MICROSOFT. NOBODY DOES IT BETTER.

In 1975, Microsoft wrote the first BASIC interpreter for the 8080. Today, hundreds of thousands of microcomputers run with Microsoft software. And tomorrow—a full line of system software for the 8086 and Z8000. With microcomputer software, nobody does it better.

BASIC Compiler Microsoft's BASIC compiler is the ideal software tool for the development of BASIC applications programs for resale. Compiled object code for any application may be distributed to your customers on diskette or ROM, thus safeguarding the source program. And execution speeds with our compiled BASIC code are faster than with any other BASIC. Highly optimized, compact object code means maximum efficiency in any application. The BASIC Compiler supports all the language features of our BASIC-80 Interpreter. Comes with macro assembler and loader. Runs with CP/M, ISIS-II, TRSDOS. $395.

BASIC Interpreters for 8080, Z80, 8086, 6800, 6809 Language features above and beyond any other BASIC have made Microsoft's BASIC the world's most popular interpreter. And now three new versions are available for the 8086, 6800, and 6809. The latest releases of BASIC-80 and BASIC-86 support the new WHILE conditional, plus CHAINing of programs with COMMON variables, dynamic string space allocation and variable length records in random files. All versions have double precision arithmetic, full PRINT USING, tracing, renumbering, edit mode, and many other features. BASIC-80 for CP/M, ISIS-II, TEKDOS: $350. BASIC-86 standalone on SBC 86/12: $600. BASIC-68 for FLEX: $200. BASIC-69 for FLEX: $250.

COBOL-80 Compiler The best implementation of the world's most widely used programming language is COBOL-80 from Microsoft. As small business applications become not-so-small, COBOL-80 is ready with powerful use of disk files, data manipulation facilities, CHAIN, segmentation and interactive ACCEPT/DISPLAY. Plus three-dimensional arrays, full COPY facility, indexed and relative files and an optional packed decimal format that saves on mass storage by as much as 40%. Comes with macro assembler and loader. Runs on CP/M, ISIS-II, and TRSDOS. $750.

NEW muSIMP/muMATH-79 At last, a sophisticated math package for microcomputers. muMATH performs mathematical operations efficiently and accurately. Use it to solve equations and simplify formulas; or perform exact arithmetic, symbolic integration and differentiation, infinite precision integer arithmetic and symbolic matrix inversion. muMATH is an invaluable tool for engineering and scientific applications involving lengthy, analytical computations. It is also an ingenious teaching method for all levels of math from arithmetic to calculus. muMATH is implemented in muSIMP, a highly structured language for complex symbolic manipulations. muSIMP/muMATH Package, CP/M versions: $250.

NEW muLISP-79 LISP—the lingua franca of the artificial intelligence world—is now available in this efficient, low-cost version for microcomputers. Features include dynamic allocation of storage resources; program control structures such as an extended COND and a multiple exit LOOP; user functions defined as CALL by Value or CALL by Name; and 83 LISP functions. muLISP-79, CP/M version: $200.

NEW XMACRO-86 For the development of 8086 programs, our new XMACRO-86 cross assembler has just been released. It supports the same features as our MACRO-80 assembler. Develop 8086 programs now on your current CP/M, ISIS-II, or TEKDOS system. $300.

NEW Micro-SEED DBMS If you are developing applications software in-house or bundling hardware and software for resale, a database manager could be the software tool you've been looking for. Micro-SEED is the first CODASYL compatible database management system to run with CP/M; and Microsoft's FORTRAN-80 has been implemented as the host language. When an application becomes limited by traditional floppy disk file handling, but remains overpowered by the cost and maintenance of a minicomputer, the solution is Micro-SEED. $900.

FORTRAN-80 Compiler Microsoft FORTRAN-80 is the most complete microcomputer FORTRAN available. It has all of ANSI-66 FORTRAN (except COMPLEX data), plus unique enhancements for use in the microcomputer environment. An extensive library of single and double precision scientific functions, too. Comes with macro assembler and loader. Versions for CP/M, ISIS-II, TEKDOS. $500.

MACRO-80 Assembler The most powerful microcomputer assembler on the market today is Microsoft's MACRO-80. It is fast, and it supports Intel-standard macros, relocation pseudo-ops, conditionals and listing controls. MACRO-80 comes with a relocatable linking loader and runs with CP/M, ISIS-II, and TEKDOS. $200.

EDIT-80 Text Editor Random access to floppy disk files makes EDIT-80 the fastest microcomputer text editor. It's the essential tool for creating and maintaining all files. EDIT-80 includes FILCOM, a file compare utility. EDIT-80, CP/M version: $120.

Prices quoted are USA domestic only. OEMs should contact Microsoft for prices.

MICROSOFT ▼ / OS ➤	CP/M	ISIS-II	TRSDOS	TRSDOS Md II	TEKDOS
BASIC-80 INTERPRETER	●	●			●
BASIC COMPILER	●	●		●	
FORTRAN-80 COMPILER	●	●			●
COBOL-80 COMPILER	●	●		●	
muMATH/muSIMP muLISP	●		●		
MICROSEED DBMS	●				
EDIT-80 TEXT EDITOR	●				
MACRO-80 ASSEMBLER	●	●			●

MICROSOFT

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We set the standard.

ject code). A user can run the standard CP/M operating system on the 8085 to handle all I/O devices, and use the 8088 to run software such as a multi-user BASIC system. The processor card will drive 24 address lines (16 megabytes of memory space), and has a direct-memory-access (DMA) peripheral controller. . . .Heath Company has decided to resume production of the H8 8080-based microcomputer system. Surprisingly, the sales of the H8 have increased, despite the introduction of the Heath/Zenith H89 integrated Z80-based system. Apparently, with its plug-in bus construction, the H8 is more to the liking of hobbyists who prefer to configure their own systems. Also, Zenith is now producing the assembled Heath H19 video terminals on one of its television set production lines. . . .Mattel Electronics and General Instrument are about to start testing a television attachment that can receive a variety of video games sent over cable television. . . .McGraw-Hill, *The New York Times*, *Times-Mirror*, and *Time Magazine* are considering setting up systems which would allow personal-computer users to access their data bases.

HIGH-DENSITY 5-INCH DISK DRIVES: Micropolis Corporation and several other floppy-disk drive makers have announced 5-inch floppy-disk drives with a density of 96 tracks per inch (tpi). Forty-eight tracks per inch has been standard, while some firms have sold 77 tpi drives.

The Micropolis disk system will read older 48 tpi disks by skipping every other track under software control. The new drives will range in capacity from 436 K to 1064 K unformatted bytes and will cost between $450 to $570 each.

PERSONAL COMPUTER SYSTEM DELIVERIES DELAYED: Texas Instruments (TI), Mattel Electronics, and Atari have all experienced delayed deliveries of their personal computer systems in the past few months. Delays were due to a shortage of parts, which restricted production of these new systems. Atari did not start shipping units until October 1979, and TI did not start until November. Quantities were severely limited during the Christmas season. Mattel did not even start shipping until after Christmas. In all cases, the companies claimed that "silicon shortages" caused the delays. TI and Atari had promised to start deliveries in August. This problem is common throughout the computer industry, due to an unexpectedly high demand for integrated circuits.

DATA-STORAGE ADVANCES PREDICTED: A San Jose, California, market research firm has released an interesting report on the future of microcomputer storage systems. Creative Strategies International predicts that during the next two years we will see the introduction of new, low-cost 5-inch and 8-inch Winchester-technology disks, new sizes (4-inch and 6-inch) of Winchester drives, "back-end" processors (disk controller and data base manager), and on-line archives in both video-disk and cartridge-tape form.

Low-cost, 5-inch floppy-disk drives and digital cassettes are expected from Japan. They will be mass-produced for intelligent-typewriter and home-computer applications. Prices of floppy-disk and Winchester disk drives are expected to drop to less than one-third of current prices.

The new small Winchester disk drives, or micro-Winchesters, will have storage capacities starting at 1 megabytes and removable disk modules about the size of an 8-track audio tape cartridge. The back-end processors will be available by the mid-1980s. They will combine Winchester-disk-controller and data-base-management functions in large-scale integrated circuits, with fast parallel architecture, content-addressed memory, charge-coupled memory systems or bubble memory. On the other hand, 8-inch floppy disks should reach the 5 megabyte capacity by the mid-1980s.

BUBBLE MEMORY STATUS REPORT: Bubble memory has developed considerably during the past year. Device size has jumped from 64 K bit, serial shift-register architectures to 1 megabit major/minor-loop, block-replicate architecture. Four megabit devices, organized as 4- and 8-bit words, are expected next year. Access times have dropped from hundreds of milliseconds; under 10 milliseconds is expected by the end of 1980. Five companies, Fujitsu, Intel, Plessey, Rockwell and Texas Instruments, are now competing for a share of the developing bubble memory business. Three more companies, Hitachi, Motorola, and Siemens, are expected to enter the market this year.

SPEECH-SYNTHESIS TECHNOLOGY IMPROVING: A year and a half ago when Texas Instruments introduced its Speak & Spell toy with voice output, the experts were amazed at is voice quality and low cost. Now single-board synthesizers, which can be easily interfaced to computers, are available from Texas Instruments, the Votrax Division of Federal Screw Works in Troy, Michigan, and Telesensory Systems Inc (TSI) of Palo Alto, California (TSI specializes in products for aiding the blind). Even IBM has added voice output to a typewriter. Further, Texas Instruments has now made available a low-cost voice synthesizer chip set for use by game and appliance manufacturers.

The Texas Instrument synthesizer stores words in its memory and thus is limited to 180 standard words, plus up to 180 words stored in external read-only memory. On the other hand, the Votrax unit is programmed with 62 phonemes (sound units) and can form an unlimited number of words.

Circle 70 on inquiry card.

The voice quality of present units is acceptable but still leaves much to be desired. Most listeners agree that the Texas Instruments' unit produces better quality voices. There is no doubt that next year we will see a larger number of devices and appliances with voice output on the market, some possibly with voice input.

ANALOG MEMORY DEVELOPED: Sanyo Electric Company of Tokyo, Japan, recently reported at a Institute of Electrical and Electronics Engineers conference that it has developed a nonvolatile analog memory. The memory permits the direct storage of analog signals, eliminating the current technique of digitizing the analog signal and storing it in binary form. Analog memory could greatly simplify the circuitry used in voice and music synthesizer equipment, as well as in such applications as television tuning.

TANDY TO ENTER DISK DRIVE BUSINESS: Tandy Corporation has agreed to form a joint floppy-disk manufacturing venture with Datapoint Corporation. Final approval is still pending from the boards of directors of both companies. Tandy currently buys floppy-disk drives for its Radio Shack computers from Shugart Associates, Control Data, and Tandon Magnetics. Datapoint makes their own units under a license from Shugart. Last year, Tandy attempted to purchase Perkins Elmer's Orbis floppy-disk operation for $2.2 million, but was outbid ($2.5 million) by Siemens.

DUAL-SIDED FLOPPY-DISK AVAILABILITY IMPROVES: In 1977, floppy-disk manufacturers started showing prototypes of their dual-sided floppy-disk drives. Shipments started in early 1979, but the firms soon ran into production problems. The double-sided drives caused excessive wear on disks and had other reliability problems. Manufacturers now have apparently learned how to manufacture these drives reliably and are finally getting into quantity production.

Last year a total of nearly 250,000 8-inch drives and 500,000 5-inch drives were made. It is expected that well over 1 million 5-inch drives will be made this year, and that nearly 30% will be double-sided.

RADIO SHACK TAKES ACTION TO PROTECT TRS-80 TRADEMARK: At the opening of a recent microcomputer show in Boston, federal court injunctions were served to three exhibitors, ordering them to immediately stop selling or distributing anything with the characters "TRS-80" written on it, and to hand over all such items and literatuie to Tandy-Radio Shack for disposal. Further, Radio Shack demanded $10,000 for damage done to Radio Shack by each of the three companies.

Radio Shack claimed the companies were using the TRS-80 trademark illegally and in such a manner that people would think they were buying Radio Shack products. Further, Radio Shack claimed that business was being stolen from them, and that should the products prove defective, Radio Shack's reputation would be damaged.

The exhibitors had no prior warning of the injunction. Two of the exhibitors immediately appealed the injunction, pointing out that Radio Shack was clearly credited as the trademark owner in all advertising; the injunction was rescinded. The third exhibitor, who failed to take immediate legal action, was prevented from selling his regular merchandise at the show; instead he substituted a line of goods contained in packages not bearing the legend "TRS-80."

16-BIT MICROPROCESSOR STATUS REPORT: Intel has been producing its 8086 16-bit processor in volume since the spring of 1979. The 8086 has been successful but it is generally considered to be a less powerful device than either the Zilog Z8000 or Motorola 68000. While Zilog has been providing samples of the Z8000 for over six months, the firm is only now begining volume production. Reportedly the samples did not execute all instructions correctly. Motorola has been sampling the 68000 for several months, and production quantities are expected soon. Recipients of sample devices from Motorola have reported that some instructions do not execute correctly and that the device will not operate at maximum rated speed. The companies are aware of these problems, and actual production units are expected to operate properly.

Other problems slowing the adoption of the Zilog and Motorola processors are lack of availability of peripheral devices (such as the Zilog memory-management integrated circuit), lack of software, and the fact that second-source suppliers are still far from production.

MAIL NOTE: I receive a lot of mail each month, as a result of this column. If you write to me and wish a response, enclose a self-addressed, stamped envelope.

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Electronic Planimetry

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A planimeter is an instrument (formerly mechanical) for measuring the area of a two-dimensional figure by tracing its perimeter. Area measurements obtained from planimeters are useful for a variety of applications, such as cartography, geology, metallurgy and biology. Our biomedical application requires area and length measurements of irregularly shaped two-dimensional figures. To this end an *electronic planimeter* has been designed consisting of a Summagraphcs Bit Pad and a Terak microcomputer programmed in UCSD Pascal (Version I.5).

In practice, a user specifies a scale factor and then traces the boundary line of a figure using either a stylus or a single-button cursor. To improve the accuracy of the area measurement, the program detects closure (ie: when the end of the tracing meets the beginning) and displays the calculations. You can trace additional figures with the same scale by using only the stylus or cursor switch. Using this electronic planimeter, area and perimeter length measurements are more accurate and can be obtained faster than with a mechanical planimeter.

The Terak Microcomputer

The Terak 8510 (see photo 1) is a completely self-contained, 16-bit microcomputer using a Digital Equipment Corporaiton (DEC) LSI-11 with the hardware floating-point option. The Terak contains 56 K bytes of memory, a single 8-inch floppy disk drive, 128-character ASCII keyboard, 12-inch video monitor with a 320-by-240 graphics dot matrix, a 24-line-by-80-character display, and an RS-232C and 20 mA serial interface. The cabinet also houses an additional serial or 16-bit parallel interface card. The Terak is supported by the DEC RT-11 operating system and UCSD Pascal.

The Terak is well suited for UCSD Pascal, which can be purchased for a reasonable price. The Terak is a conservative, but well-designed system which performs with a high degree of reliability. It serves as a general-purpose laboratory computer and in this application as a host computer for the Summagraphics Bit Pad digitizer.

The Summagraphics Bit Pad

The Bit Pad includes a digitizing surface or data tablet, control unit, power supply, and writing stylus or a single-button cursor. The control unit consists of an 8-bit microcomputer (Intel 8035), a control program in erasable, programmable read-only memory, and binary counters. The control unit generates X and Y coordinate points of the location of the stylus or cursor as it travels across the tablet surface. These coordinate points are generated as serial or parallel data and can be used by a host computer for a variety of applications.

Theory of Operation

The Bit Pad operates on a magnetic principle. Current is pulsed along a *send* wire that lies perpendicular to a mesh of magnetostrictive wires lying beneath the writing surface of the tablet. The current pulse changes the dimensions of the magnetrostrictive material and a strain wave simultaneously propagates down all the wires in one direction. This propagated strain wave is sensed by a *receive* coil in the stylus or cursor. The control unit times the delay

Terak is a registered trademark of Terak Corporation.

RT-11 and LSI-11 are registered trademarks of Digital Equipment Corporation.

Bit Pad is a registered trademark of Summagraphics Corporation.

*Superbrain is a registered trademark of Intertec Data Systems.

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SuperBrain users get exceptional performance for just a fraction of what they'd expect to pay. Standard system features include: two double density mini-floppies with 285 K bytes of disk storage, 64K of RAM memory to handle even the most sophisticated programs, a CP/M Disk Operating System with a high powered text editor, assembler, debugger and a disk formator. And, with SuperBrain's S-100 bus adaptor, you can add all the programming power you will ever need . . . even a 10 megabyte disk!

SuperBrain's CP/M operating system boasts an overwhelming amount of available software in BASIC, FORTRAN, COBOL, and APL. Whatever your application . . . General Ledger, Accounts Receivable, Payroll, Inventory or Word Processing . . . SuperBrain is tops in its class. But best of all, SuperBrain tackles your toughest jobs for less than one-third the cost of other similar systems.

You'll appreciate the careful attention given to every engineering detail. Standard SuperBrain features include: a full ASCII keyboard with numeric pad and user-programmable function keys. A non-glare, dynamically focused, 12-inch CRT for sharp images everywhere on the screen. Twin Z80 microprocessors to insure efficient data transfer to auxiliary peripheral devices. A universal RS-232 communications port for serial data transmission. And, a single board design to make servicing a snap!

Performance and packaging have never been better matched. Your operators will appreciate SuperBrain's good looks. You'll appreciate SuperBrain's outstanding value. Twin Z80A processors, dual double density disk drives, and a high resolution CRT terminal. All in a single, smart looking, self-contained desktop unit. And, all for a price that's substantially less than the competition!

Make no mistake about it. The freshman students in the small systems business can't begin to compete with this year's honor graduate. The SuperBrain. The only system at the top of its class in price and performance

System Specifications

CPU	
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
Floppy Disk	
Storage Capacity	285K 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 ¼ inch mini-disk
Disk Rotation	300 RPM
Internal Memory	
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
CRT	
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)
Communications	
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
System Utilities	
Disk Operating System	CP/M
DOS Software	An 8080 disk assembler, debugger, text editor and file handling utilities
Optional Software	
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
Keyboard	
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
Internal Construction	
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
Environment	
Weight	Approximately 45 pounds
Physical Dimensions	14 [illegible]" (H) x 21 [illegible] (W) x 23 [illegible] (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 model available)

*Specifications subject to change without notice

DEALER/OEM QUANTITIES AND SPECIAL PRICING AVAILABLE VIA MICROAMERICA DISTRIBUTING

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Photo 1: *The Terak microcomputer with dual floppy-disk drive, video display, and keyboard. The Summagraphics Bit Pad consists of the digitizing tablet and the microcomputer control unit.*

required for the strain wave to reach the receive coil, and this delay is used to calculate X and Y coordinate data.

Digitizing Tablet

The data tablet is a low-profile, plastic pad that has an active surface area of approximately 784 square centimeters. The X,Y origin is located in the lower left corner of the tablet and is not relocatable. The active surface area can be visualized as a square matrix of 2795 by 2795 points with a resolution of 0.1 mm. The Bit Pad can also be configured for English unit measurements.

Microcomputer Control Unit

The control unit contains six front-panel, push-button switches (see photo 1). One is a reset switch, three switches control the digitizing rate, and two switches control the operating mode. These switches may be overridden by software from the host processor, thus allowing complete host control.

The three rate switches select 64, 32, 16, 8, 4, 2, or 1 coordinate pairs to be generated per second. The two mode switches select point, switch-stream, or stream operating mode.

A coordinate pair is generated for each depression of the Z-axis switch in the stylus or cursor in the *point* mode. In the *switch-stream* mode, coordinate pairs are generated continuously as long as the Z-axis switch remains depressed. Coordinate points are generated continuously in the *stream* mode. It should be noted that no points are generated unless the stylus or cursor is within 4 mm of the active surface area of the tablet.

The control unit also contains an 8-bit input and output (I/O) port, an interrupt line, a single-bit reset line, and optionally a TTL or RS-232C serial line. The input port (also referred to as the command byte, figure 1) allows for control of both the operating mode and transmission rate of the Bit Pad by a host processor. Three bits are allocated for the transmission rate, two bits for the operating mode and three bits serve as hand-shaking signals between the host processor and the Bit Pad.

The three handshaking bits are: *status valid,* which is used by the host computer to signal a change in mode or rate; *byte received,* which indicates that a byte of data has been read by the host; and *next byte,* which is used by the host to request the next byte of data from the Bit Pad. An additional single-bit line (*in strobe*) enables the host to reset the Bit Pad's control unit.

A host processor can receive data from the Bit Pad by polling or handshaking, or the Bit Pad interface can be driven by interrupts. The output port of the Bit Pad provides coordinate points to the host processor in a sequence of five data bytes (see figure 2). A 1 in the most significant bit of the first byte signals the host

MOST SIGNIFICANT BIT			INPUT				LEAST SIGNIFICANT BIT	
NEXT BYTE	BYTE RECEIVED	MODE 2	MODE 1	RATE 4	RATE 2	RATE 1	STATUS VALID	CLEAR OR RESET

Figure 1: *The bit format of the input or command byte for the Bit Pad. In addition, a single line is used by the host computer to reset or clear the Bit Pad's electronic circuitry.*

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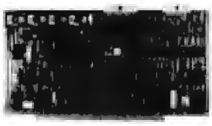

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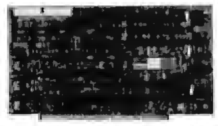

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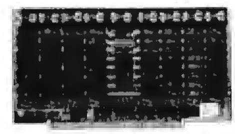

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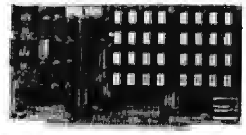

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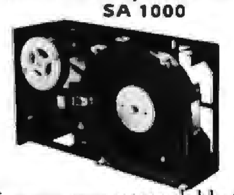

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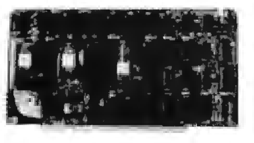

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	MOST SIGNIFICANT BIT			OUTPUT				LEAST SIGNIFICANT BIT
BYTE 1	FIRST BYTE	BYTE AVAILABLE	F3	F2	F1	F0	0	0
BYTE 2	FIRST BYTE	BYTE AVAILABLE	X5	X4	X3	X2	X1	X0
BYTE 3	FIRST BYTE	BYTE AVAILABLE	X11	X10	X9	X8	X7	X6
BYTE 4	FIRST BYTE	BYTE AVAILABLE	Y5	Y4	Y3	Y2	Y1	Y0
BYTE 5	FIRST BYTE	BYTE AVAILABLE	Y11	Y10	Y9	Y8	Y7	Y6

Figure 2: *Five bytes of data are transmitted from the Bit Pad's output port for each coordinate pair of points generated. The first byte contains information concerning depression of the Z-axis switch. The next four bytes contain a 12-bit representation of the X and Y coordinates. Each byte also contains two control bits,which are used for handshaking purposes.*

that the current byte is the first of the five-byte sequence. The next bit (*byte available*) when set to 1 indicates that a byte of data is available, and the bit labeled F0 corresponds to the status of the Z-axis switch.

An optional four-button cursor may also be used. The four buttons correspond to bits F0 thru F3 in byte 1. The next four bytes in the sequence contain a 12-bit representation of the X and Y coordinates. This data can also be transmitted in serial format with parity and stop bits, at data transmission rates from 37.5 bps to 28,000 bps.

The control unit does not contain a pilot light; however, it does contain two diagnostic routines that can be used to check its circuits and interface connections to the host processor. The control unit requires power supplies of +5 V and +12 V, and −12 V or, with optional regulators, +8 V, +16 V, and −16 V.

Pascal Program: PLANIMETER

This program, which appears in listing 1, receives coordinates points five bytes at a time from the Bit Pad. The line length and area of a closed two-dimensional figure are calculated by integrating the figure with trapezoids. By using Pascal and the Terak, it is possible to receive and process approximately thirty coordinate points per second.

User-defined data types are used to interface the Bit Pad to the Terak minicomputer. LOWBYTE is the image of the output from the Bit Pad. It contains three fields: the data (D), READY (*byte available*) and the FIRST-byte bits. DEVICE is a datatype that represents the I/O buffers on the Terak's port which are connected to the Bit Pad.

At the beginning of the main program, the pointer BITPAD is set to the integer value −160 (which is the address of the port) using a variant record type. The pointer BITPAD.P points to the port, and BITPAD.P↑ contains the Terak I/O buffers for the parallel port.

Each input byte is read as LOOKB := BITPAD.P↑.INBUF in the procedure NEXTBYTE using handshaking. The sequence begins by waiting for the next byte to be ready (LOOKB.READY is true). The Terak signals the Bit Pad that it has read the data by sending the command byte OUTRECEIVED. The program increments the counter (BYT), waits for the Bit Pad to clear and then signals

Circle 74 on inquiry card.

```
PROGRAM PLANIMETER;
(*  Written by:     John Fryhofer

     and modified by Greg Hansen.

     This program reads parallel data from a digitizing tablet and calculates
      the area and perimeter of a closed figure traced on it    *)

CONST
   PORTADDR = -160;
   OUTRECEIVED = 95 (* 01011111 *);
   OUTNEXT      = 159(* 10011111 *);
   MINPTS    = 13;

TYPE
    (* Output from BIT PAD *)
   LOWBYTE = PACKED RECORD
              D : 0..63 ;
              READY : BOOLEAN;
              FIRST : BOOLEAN
           END;
  (* this is what the device looks like *)
   DEVICE = PACKED RECORD
                 CSR        : PACKED ARRAY [0..15] OF BOOLEAN;
                 OUTBUF     : INTEGER;
                 INBUF      : LOWBYTE;
             END;

VAR
   BITPAD : RECORD (*  Loads the device address as an integer and
                          points to it *)
              CASE BOOLEAN OF
                  FALSE : (P : ↑DEVICE );
                  TRUE  : (I : INTEGER )
           END;

   CALCDELTA, CLOSEDELTA, BYT, P : INTEGER;
   LOOKB: LOWBYTE;
   RESPONS: CHAR;
   START,         (* Start new figure *)
   DIDPRINT:      (* Already printed for button up *)
      BOOLEAN;
   FIRSTX, FIRSTY, LASTX, LASTY, X, Y,
                       AREA, LEN, CUMAREA, CUMLEN, MAGR: REAL;
   K: PACKED ARRAY [0..1] OF CHAR;  (* Dummy array; K[0] holds command *)
   PTR  : INTERACTIVE;

PROCEDURE NEXTBYTE;
VAR W: LOWBYTE;
BEGIN             (* Reads next byte from BIT PAD *)
   REPEAT
      IF NOT UNITBUSY(2) THEN UNITREAD (2,K[0],1,,1); (* Look for command *)
      LOOKB := BITPAD.P↑.INBUF
   UNTIL LOOKB.READY OR (K[0] = 'Q'); (* Good data *)
   BITPAD.P↑.OUTBUF := OUTRECEIVED;

   IF LOOKB.FIRST THEN BYT := 0;
   BYT := BYT + 1;

   REPEAT
      W := BITPAD.P↑.INBUF
   UNTIL NOT W.READY;  (* BIT PAD reset *)
   BITPAD.P↑.OUTBUF := OUTNEXT;  (* BIT PAD sends next byte *)
END (* NEXTBYTE *);

PROCEDURE DEBUGO;
                  (* used for debugging only *)
BEGIN
   WRITE(LOOKB.D);
   IF LOOKB.READY THEN WRITE('  READY');
   IF LOOKB.FIRST THEN WRITE('  FIRST');
   WRITELN;
END;

PROCEDURE PRINT;
BEGIN                  (* Print results *)
   WRITELN ('# Points :', P:5, '    / Area :', SQR(MAGR)*ABS(CUMAREA):9:6,
          ' sq mm    / Length :', MAGR*CUMLEN:9:6, ' mm');
   IF (K[0] = 'P') AND (P <> 0) THEN
     WRITE (PTR, '# Points :', P:5,'   / Area :', SQR(MAGR)*ABS(CUMAREA):9:6,
                ' sq mm    / Length :', MAGR*CUMLEN:9:6, ' mm', CHR(10));
END;  (* PRINT *)

PROCEDURE NEWFIGURE;
BEGIN             (* initialize *)
   START := FALSE;
   FIRSTX:= X;
   FIRSTY:= Y;
   LASTX := X;
   LASTY := Y;
   P      := 0;
   CUMAREA := 0;
   CUMLEN  := 0;
   WRITE ('*DOWN', CHR(7));
```

Listing 1 continued on page 122

Listing 1: *Pascal program that uses input from the Summagraphics Bit Pad and determines the area perimeter of a traced figure.*

the Bit Pad with OUTNEXT that the next byte is ready to be received.

The first loop in the main program waits for the depression of the cursor Z-axis switch ("button down" in the listing). The loop also synchronizes the program with the five data bytes from the Bit Pad. Only the first byte of the five-byte sequence contains a 1 in bit 7 (FIRST is TRUE), and a 1 in bit 2 (D = 4) when the switch is depressed. Bit 6 is set to 1 (READY is TRUE) by the Bit Pad when the byte is available. When the switch is released the results are displayed using the procedure PRINT.

The second loop is executed for each point when the switch is depressed and coordinates are being received. Bits 0 thru 5 (D) of input bytes 2 and 3 contain the 12-bit X coordinate and D in bytes 4 and 5 contain the Y coordinate. After each byte is fetched, the CASE-statement code transfers the data into the integers X and Y by adding up the values. When the final byte is taken, it may then start a new figure if the switch was just pushed, calculate the next point, and/or detect closure and print the results.

The procedure CALC is called after each X,Y coordinate input that is located at a distance at least CALCDELTA away from the last point. X and Y are the integer coordinates in units of the Bit Pad's increments, which are 0.1 mm from the tablet's origin (lower left corner). The maximum value possible for X and Y is 2795. The length is calculated with the formula for the distance (*d*) between two points:

$$(d) = \sqrt{(X1-X0)^2 + (Y1-Y0)^2}$$

where X1 and Y1 are the current coordinates and X0 and Y0 are the last coordinates. Since many points are processed, the length of an irregular line is calculated from a number of short straight lines that yield a good approximation of the true line length.

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Listing 1 continued:

```
END;  (*NEWFIGURE*)

PROCEDURE CALC;
BEGIN            (* Caculate incremental area and length *)
   P:= P + 1;
   AREA:= (X - LASTX) * (Y + LASTY) / 2 / 100;
   LEN:= SQRT(SQR(LASTX-X) + SQR(LASTY-Y)) / 10;
   CUMAREA:= CUMAREA + AREA;
   CUMLEN:= CUMLEN + LEN;
   IF K[0] = 'A' THEN (* Print each point *)
        PRINT;
   LASTX:= X;  (* Save this point *)
   LASTY:= Y
END; (* CALC *)

PROCEDURE CLOSURE;
BEGIN           (*  back at first point: finish *)
   CUMAREA:= CUMAREA + (FIRSTX - LASTX)*(FIRSTY + LASTY) / 2 / 100;
   CUMLEN:= CUMLEN + SQRT(SQR(LASTX-FIRSTX) + SQR(LASTY-FIRSTY)) / 10;
   WRITELN ('*CLOSURE', CHR(7) );
   PRINT;
   DIDPRINT:= TRUE;
   START := TRUE;
END;

BEGIN   (* MAIN *)
 REWRITE(PTR,'REMOTE:');
 BITPAD.I := PORTADDR;
 BITPAD.P↑.OUTBUF := OUTNEXT;
 WRITELN('  LENGTH AND AREA MEASUREMENTS');
 WRITELN;
 WRITELN('Please leave all the switches out.  The program sets the BIT PAD to');
 WRITELN(' stream mode and full speed.');
 WRITELN;
 WRITELN('Type a ''Q'' at any time to change magnification or quit,');
 WRITELN(
       '''A'' to see all the points displayed ( with speed degradation ),');
 WRITELN('       ''P'' to turn on the printer,');
 WRITELN('  and press a space to turn off the modes.');
 REPEAT
   K[0] := ' ';
   WRITELN;
   WRITE('CALCDELTA: ');
   READLN(CALCDELTA);
   WRITE('CLOSEDELTA: ');
   READLN(CLOSEDELTA);
   WRITE ('MAGNIFICATION FACTOR? ');
   READLN (MAGR);
   WRITELN ('READY. FACTOR = ', MAGR :9:7);
   START := TRUE;
   DIDPRINT := TRUE;

   WHILE K[0] <> 'Q' DO
      BEGIN              (* Loop for each point *)

        REPEAT             (* Wait for button down *)
          NEXTBYTE;
          IF (BYT = 1) AND (LOOKB.D <> 4) AND NOT DIDPRINT THEN
             BEGIN                    (* If first point and button up *)
               WRITELN('*UP', CHR(7));
               PRINT;
               DIDPRINT:= TRUE;
               START := TRUE
             END                     (* If first point and button up *)
        UNTIL (BYT = 1) AND (LOOKB.D = 4) OR (K[0] = 'Q');
              (* Button is down *)
        WHILE (BYT < 5) AND (K[0] <> 'Q') DO
           BEGIN   (* Get whole point *)
             NEXTBYTE;
             DIDPRINT:= FALSE;
             CASE BYT OF
                2: X := LOOKB.D;
                3: X := X + 64*LOOKB.D;
                4: Y := LOOKB.D;
                5: BEGIN
                     Y := Y + 64*LOOKB.D;
                     IF START THEN
                       NEWFIGURE
                     ELSE IF (ABS(X - LASTX) > CALCDELTA) OR
                             (ABS(Y - LASTY) > CALCDELTA) THEN
                          CALC; (* Only take points far enough away *)
                     IF (ABS(X-FIRSTX) < CLOSEDELTA) AND
                        (ABS(Y-FIRSTY) < CLOSEDELTA) AND (P > MINPTS) THEN
                        CLOSURE; (* Back at first point +/- DELTA *)
                   END(* 5: *)
             END; (* CASE *)
           END;   (* Get whole point *)

      END;          (* Next point *)
   WRITE ('ANOTHER MEASUREMENT? ');
   READ(RESPONS);
 UNTIL RESPONS = 'N';
 END.
```

Area Calculation

Area is calculated by integration, by dividing the figure being traced into trapezoids. The trapezoids are calculated with the X axis as the base and up to the present and last points as the top. This formula is calculated for each new point:

$$\text{Area} = [(X1 - X0)\times(Y1 + Y0)]/2.$$

When the current point is within a distance equal to CLOSEDELTA of the *first* point, closure is detected. This is done in order to achieve the lowest possible error by ending the figure where it started (ie: within 0.3 mm of the beginning of the trace). When closure is detected, final calculations are made to close the figure. The results are printed, and START is set so it will clear the variables the next time around for a new figure.

CALCDELTA is used to correct for oscillation of the coordinates due to the analog-to-digital (A/D) conversion, which results in inaccurately measured line lengths. If CALCDELTA is too small, then oscillation between points causes many coordinates to be inappropriately summed resulting in an overestimation of the true length of the traced figure. If CALCDELTA is too large, not enough points will be fitted, resulting in a less accurate approximation. Good results have been obtained with CALCDELTA = 3 (that is, 0.3 mm).

Conclusion

This electronic planimeter has been used for thousands of measurements in a laboratory environment. It is faster to use and more accurate than a mechanical planimeter. The relative error between twenty repeated area-tracings of several different figures was consistently less than 0.5%. This electronic planimeter is less expensive and more flexible than commercially available dedicated-microprocessor systems that are specifically designed for planimetry, such as the Leitz Image Analysis System and the Zeiss MOP-3. A microcomputer or minicomputer user whose application involves length and area calculations of irregularly shaped figures will find this system useful and relatively inexpensive to construct.■

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A Power-Line Protection Circuit

Neil A Schneider
Bror E Erickson
9434 Ironwood
Des Plaines IL 60016

Several years ago while he was working with color organ circuits, a friend of mine connected a color organ to an All American Five radio receiver. For those of you who are too young to remember, the All American Five was a popular five-tube radio design containing no power transformer. To my friend's surprise, and fortunately not to his harm, the connection of his color organ to this radio resulted in foot-high flames as the audio output transformer burned.

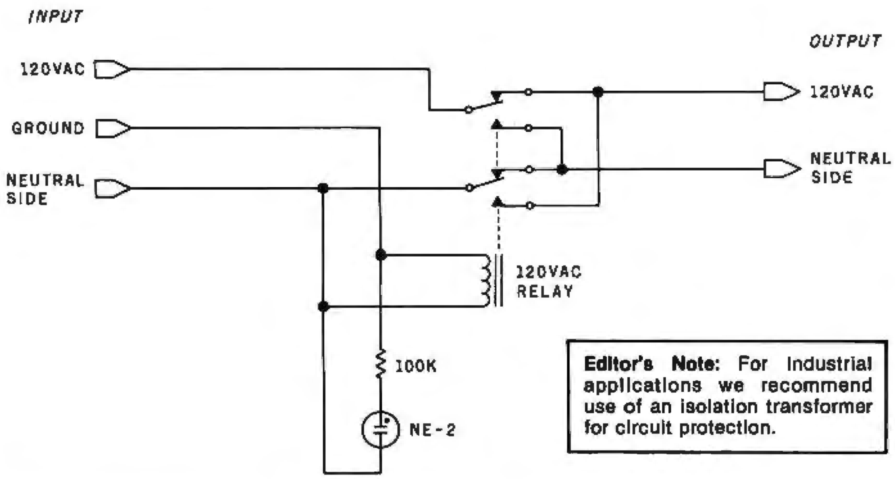
The radio receiver had a "hot" internal chassis which was isolated from the outside world by its plastic case. The power cord was not polarized to connect the chassis to the low side of the AC power line. As my friend made his connection, he placed the 117 VAC power line current across the 8 ohm impedance audio-output secondary winding of the transformer, and across the speaker. This resulted in flames and a destroyed radio receiver.

Home computer enthusiasts of today face the same problem. While my friend's error only resulted in the loss of a radio (about $15), the connection of computer circuits to transformerless hot-chassis television sets can result in the loss of hundreds of dollars in digital circuits.

The obvious solution is to use three-wire power cords on all equipment to insure that the television chassis is at *earth ground*. This solution works fine as long as no wiring errors have been made in the AC power socket. If you transport your computer to a friend's house, you are again betting the hundreds of dollars, and maybe your life, on the accuracy of *his* electrical system.

The circuit shown in figure 1 is a better solution. This circuit is less expensive than an isolation transformer, and it can even incorporate a power-line fault indicator. The circuit simply detects ground-fault conditions. The 117 VAC relay connects between the cold-side power and earth-ground lines.

If a wiring error has been made, and the cold terminal is hot with respect to earth ground, the relay closes to *reverse* the power connection to the television. A neon lamp wired across the relay will provide a line-fault indication. CAUTION! *No protection is provided with this circuit if the earth-ground line is defeated.*



Editor's Note: For industrial applications we recommend use of an isolation transformer for circuit protection.

Figure 1: *A simple circuit that offers some protection by using a relay to reverse connections to the power line. However, no protection is provided if the earth-ground line is defeated.*

All that is required to provide full power-line protection is the addition of a double-pole, double-throw on/off switch as shown in figure 2. This switch is used to present reversible power to the relay. When the AC line is switched to the proper connection, the relay activates, and applies power to the load. If any attempt is made to defeat the earth ground, the circuit will not function, and the load will not receive power.

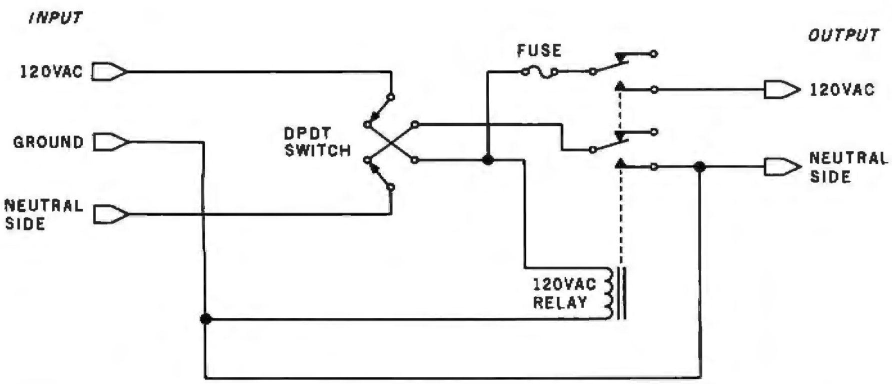


Figure 2: *A better circuit that uses a double-pole, double-throw switch to present reversible power to the relay. If an attempt is made to defeat the earth ground, the power is cut off.*

The result is a circuit that is, for most applications, less expensive and physically smaller than an isolation transformer. This relay circuit should fit inside almost any television set that you wish to modify for your video terminal. It may protect you and your equipment from a fatal mistake.■

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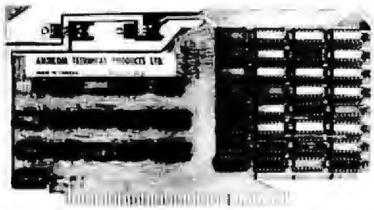

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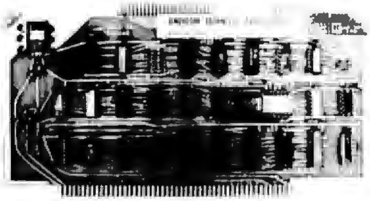

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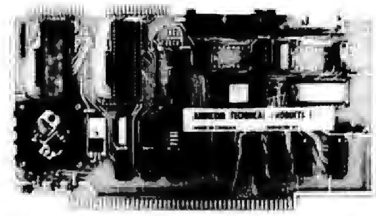

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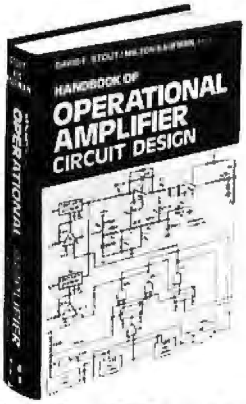

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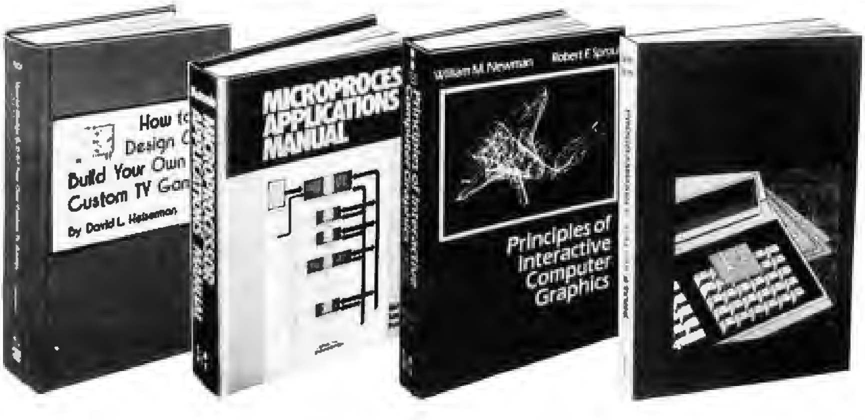

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Landing Module Simulation with Random Surface

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Spokane WA 99218

This article describes a program that simulates the landing of a jet-propelled craft on a random surface. The surface is generated by a random-number generator. As seen in photo 1, the craft can be steered vertically or horizontally by the firing of the main jet, the side jets, or both of them. During the dynamic simulation, the craft will move vertically along the central vertical line of the oscilloscope. The horizontal movement of the random surface causes the craft to appear to move in the opposite direction.

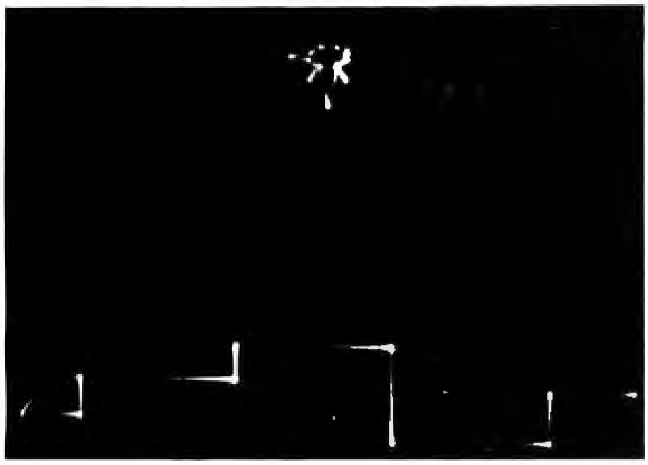


Photo 1: *Landing module hovering over the five-segment random surface as it cautiously approaches its landing site.*

The sequence of the simulation is as follows:

- The dynamic equations of the craft are solved by Euler's method. The solutions are velocity and displacement.
- The craft is displayed according to the vertical displacement, and the jets are made visible when they are fired.
- The random surface is displayed relative to the horizontal displacement of the craft. There are 256 segments of random surface which form a continuous terrain. Only five surface segments are shown on the oscilloscope at one time.
- When the craft has touched down on the surface, the vertical and horizontal velocity are compared with the crash velocity. If the craft exceeds the crash velocity, it will disappear from the screen. If it lands safely, it will remain on the surface waiting for lift-off.

The needed hardware is: a Motorola MEK6800 D2 Kit, two 8-bit digital-to-analog (D/A) converters, and an oscilloscope with DC inputs, as shown in figure 1. The capacitors at the output of the digital-to-analog converter are used to obtain a straight line display between two points. The keyboard will be used to enter the following commands:

G — Go to start the simulation
M — Main jet firing
R — Right jet firing
P — Left jet firing

After the program has been entered, the microprocessor will be directed to execute the program beginning at hexadecimal address 00F1 (listing 1). The oscilloscope will display a stationary craft and a random surface. Closure of the G key will start the dynamic simulation. Now you may control the firing of jet engines by pressing the M, R, or P keys. The objective of the control is to land safely. If the craft crashes, it will disappear from the screen. By pressing the G key, a new craft for you to command will appear on the screen. A star will be

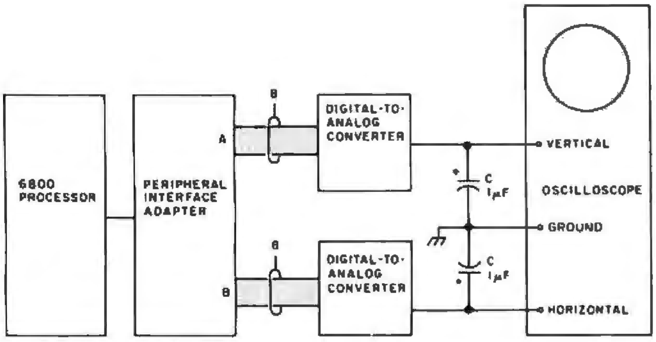


Figure 1: *A block diagram illustrating the interface connections used to monitor the landing simulation on an oscilloscope.*

seen above the craft whenever you make a safe landing. The craft will stay on the surface until you lift it from the surface by pressing the G and M keys simultaneously. The degree of control skill required depends on the speed of the simulation. You may change the speed by increasing or decreasing the time delay at hexadecimal address 01BB.

The graphic resolution is 256 by 256 points on the screen for an 8-bit microprocessor. The contour of the craft and jets is defined by coordinate points, and lines between points. Each point needs 2 bytes of storage. The first byte defines the horizontal coordinate, and the second byte defines the vertical coordinate. If the value of the first byte is 0, this will signal the end of display. The coordinate points for the top section of the craft begin at hexadecimal address 01F1. This is followed by the left jet, left side, main jet, right side, right jet, and a 5-point star.

The movement of the craft on the screen is obtained by the translation of points. This is accomplished by adding to or subtracting from the first byte with the amount of horizontal displacement, and the second byte with the amount of vertical displacement. The motion is such that the shape, size, and orientation are not changed. The display program DSPLY begins at hexadecimal address 01A3. You can see here that only the second byte is translated to simulate the vertical motion of the craft. The random surface is displayed by the subroutine SURF (hexadecimal address 01C0), that simulates the horizontal motion for the craft.

The subroutine RAND (hexadecimal address 0056) can generate a string of 256 random numbers before repeating the numbers. A number is picked as the seed for producing a string of random numbers. Beginning with the seed, the random-surface generator SRFGEN (hexadecimal address 0062) always produces the same string of numbers. The length of the string is determined by the total horizontal displacement of the craft. Only the last five numbers are used to represent the height of five surface segments. The third surface segment is located directly below the craft.

The length of the horizontal display is hexadecimal FF, and each surface segment has a width of hexadecimal 40. The subroutine BXING (hexadecimal address 0085) will add or subtract a random number from the string whenever the horizontal displacement of the craft is increased or decreased by an amount of hexadecimal 40. This will create a continuous horizontal movement for the craft which appears to be flying over an unknown terrain. The last random number of the string is saved as the seed for the next simulation. Therefore, none of the landing simulations will be the same.

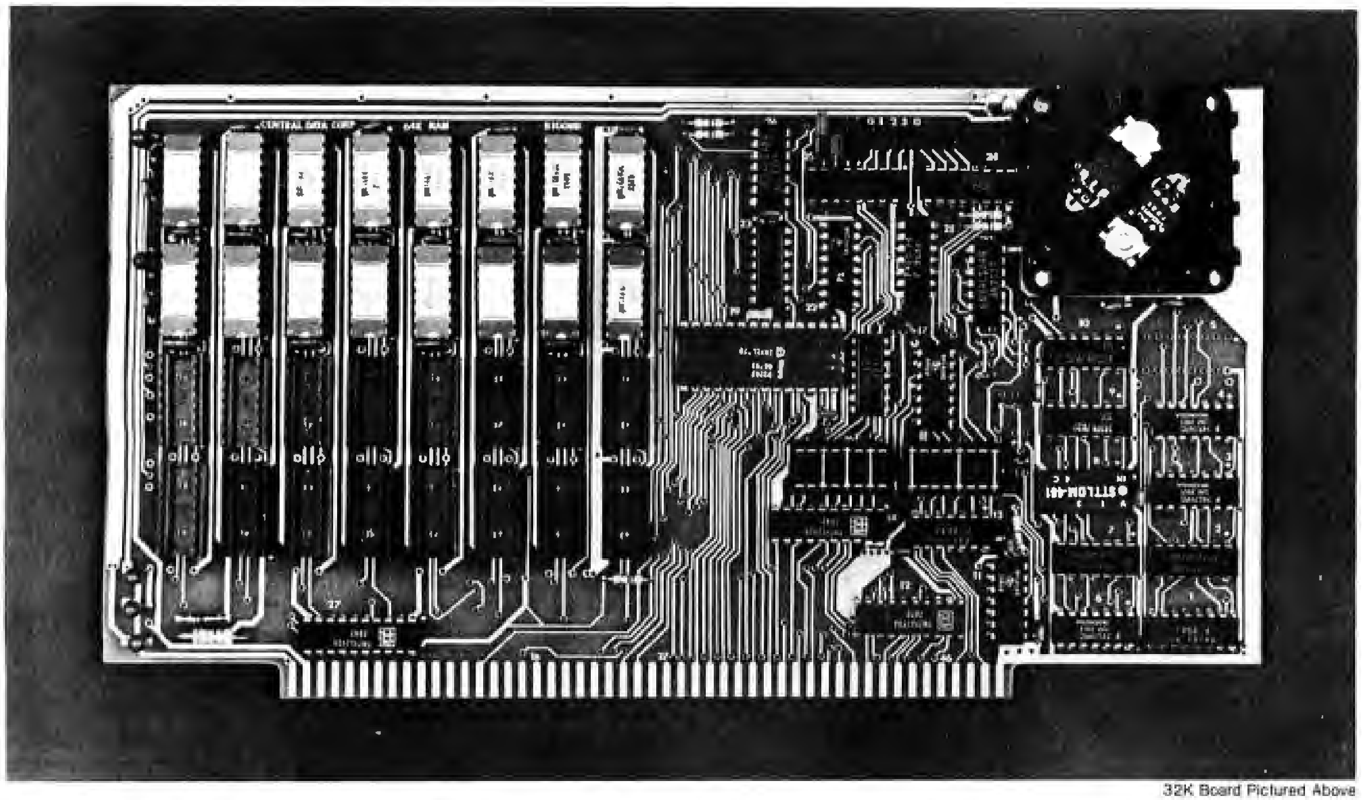
An 8-bit microprocessor represents a numerical range of decimal 0 to 255, or hexadecimal 0 to FF. It seems that

Text continued on page 139

Listing 1: *M6800 assembler listing of the program that controls all movement of the landing module. The speed adjustment can be made by modifying the contents of hexadecimal location 01BB. The subroutine SURF, starting at hexadecimal location 01C0, displays the random surface which simulates the horizontal motion of the craft. The coordinate points for the top section of the craft are stored at hexadecimal location 01F1.*

```
                          NAM    LM       SIMULATTON
           8004    PIA    EQU    $8004    2.
           8006    PIB    EQU    $8006    3.
           8005    CRA    EQU    $8005    4.
           8007    CRB    EQU    $8007    5.
           8022    SCNREG EQU    $8022    6.
           8020    DISREG EQU    $8020    7.
      0000                ORG    0        8.
      0000 80      X1     FCB    $80      9.
      0001 00      X2     FCB    0        10.
      0002 00      Y1     FCB    0        11.
      0003 00      Y2     FCB    0        12.
      0004 00      RND    FCB    0        13.
      0005 00      RNDO   FCB    0        14.
      0006 F6      G0     FCB    $F6      15.
      0007 0A      G1     FCB    $A       16.
      0008 05      JL     FCB    $5       17.
      0009 FB      JR     FCB    $FB      18.
      000A 00      FLAG1  FCB    0        19.
      000B 00      FLAG2  FCB    0        20.
      000C 00      FLAG3  FCB    0        21.
      000D 00      TEMP   FCB    0        22.
      000E 00      ODOM   FCB    0        23.
      000F 00      FLAG4  FCB    $00      24.
      0010 0000    GETSRF FDB    $0       25.
      0012 00      SUR    FCB    0        26.
      0013 0000           FDB    0        27.
      0015 00      BS     FCB    0        28.
      0016 96 02   SYS    LDA A  Y1       29.
      0018 D6 03          LDA B  Y2       30.
      001A 8D 31          BSR    EULER    31.
      001C 97 02          STA A  Y1       32.
      001E 96 03          LDA A  Y2       33.
      0020 D6 0A          LDA B  FLAG1    34.
      0022 27 06          BEQ    NEXT     35.
      0024 D6 07          LDA B  G1       36.
      0026 8D 25          BSR    EULER    37.
      0028 20 04          BRA    STORE    38.
      002A D6 06   NEXT   LDA B  G0       39.
      002C 8D 1F          BSR    EULER    40.
      002E 97 03   STORE  STA A  Y2       41.
      0030 96 00          LDA A  X1       42.
      0032 D6 01          LDA B  X2       43.
      0034 8D 17          BSR    EULER    44.
      0036 97 00          STA A  X1       45.
      0038 96 01          LDA A  X2       46.
      003A D6 0B          LDA B  FLAG2    47.
      003C 26 01          BNE    FIRE     48.
      003E 39             RTS             49.
      003F D6 08   FIRE   LDA B  JL       50.
      0041 7D 000B        TST    FLAG2    51.
```

Listing 1 continued on page 134



32K Board Pictured Above

Listing 1 continued:

```
0044 2E 02              BGT     LFIRE
0046 D6 09              LDA B   JR
0048 8D 03      LFIRE   BSR     EULER
004A 97 01              STA A   X2
004C 39                 RTS
004D CE 0002    EULER   LDX     #$2
0050 57         EO      ASR B
0051 09                 DEX
0052 26 FC              BNE     EO
0054 1B                 ABA
0055 39                 RTS
0056 D6 04      RAND    LDA B   RND
0058 17                 TBA
0059 58                 ASL B
005A 58                 ASL B
005B 1B                 ABA
005C 58                 ASL B
005D 1B                 ABA
005E 4C                 INC A
005F 97 04              STA A   RND
0061 39                 RTS
0062 D6 0E      SRFGEN  LDA B   ODOM
0064 D7 0D              STA B   TEMP
0066 D6 05              LDA B   RNDO
0068 D7 04              STA B   RND
006A 8D EA      NXT     BSR     RAND
006C 7A 000D            DEC     TEMP
006F 26 F9              BNE     NXT
0071 CE 0010            LDX     #GETSRF
0074 C6 05              LDA B   #$5
0076 D7 0D              STA B   TEMP
0078 8D DC      NXTS    BSR     RAND
007A 44                 LSR A
007B 44                 LSR A
007C A7 00              STA A   0,X
007E 08                 INX
007F 7A 000D            DEC     TEMP
0082 26 F4              BNE     NXTS
0084 39                 RTS
0085 7F 000F    BXING   CLR     FLAG4
0088 96 00              LDA A   X1
008A 84 3F              AND A   #$3F
008C 81 30              CMP A   #$30
008E 2A 09              BPL     XING
0090 81 10              CMP A   #$10
0092 2B 05              BMI     XING
0094 84 20              AND A   #$20
0096 97 15              STA A   B5
0098 39                 RTS
0099 84 20      XING    AND A   #$20
009B 16                 TAB
009C 90 15              SUB A   B5
009E 27 0F              BEQ     OUT
00A0 2B 05              BMI     PLUS
00A2 7A 000E            DEC     ODOM
00A5 20 03              BRA     SAVE
00A7 7C 000E    PLUS    INC     ODOM
00AA 7C 000F    SAVE    INC     FLAG4
00AD D7 15              STA B   B5
00AF 39         OUT     RTS
00B0 8D D3      TERR    BSR     BXING
00B2 D6 0F              LDA B   FLAG4
00B4 27 02              BEQ     SDSPLY
00B6 8D AA              BSR     SRFGEN
00B8 BD 01C0    SDSPLY  JSR     SURF
00BB 39                 RTS
00BC 4F         KEY     CLR A
00BD 97 0A              STA A   FLAG1
00BF 97 0B              STA A   FLAG2
00C1 86 20              LDA A   #$20
00C3 8D 25              BSR     TKEY
00C5 2B 03              BMI     L
00C7 7C 000A            INC     FLAG1
00CA 86 10      L       LDA A   #$10
00CC 8D 1C              BSR     TKEY
00CE 2B 03              BMI     R
00D0 7C 000B            INC     FLAG2
00D3 86 A0      R       LDA A   #$A0
00D5 8D 13              BSR     TKEY
00D7 2B 03              BMI     EXT
00D9 7A 000B            DEC     FLAG2
```

Listing 1 continued on page 136

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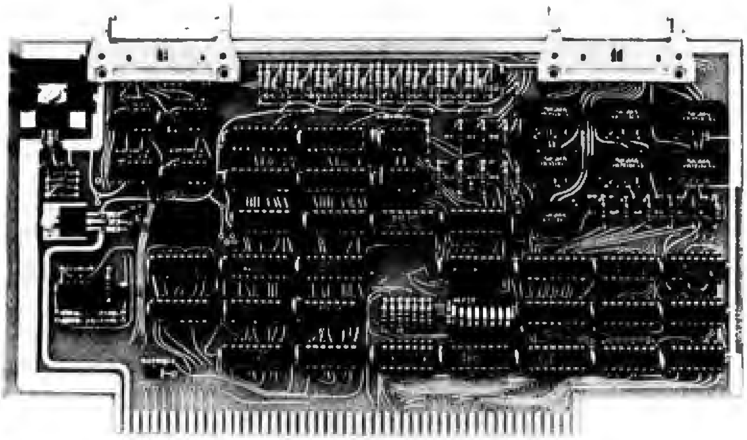

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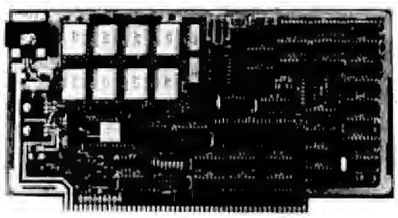

88-MODEM S-100 ORIGINATE/ANSWER MODEM WITH AUTO-DIALER. Software selectable baudrate provides any baudrate from 66-600 baud. Provides 1.5 stop bits when operated in 5-bit code mode. Auto-answer programs available for CROMEMCO CDOS, CP/M, North Star Horizon and MDS, and Alpha Micro.

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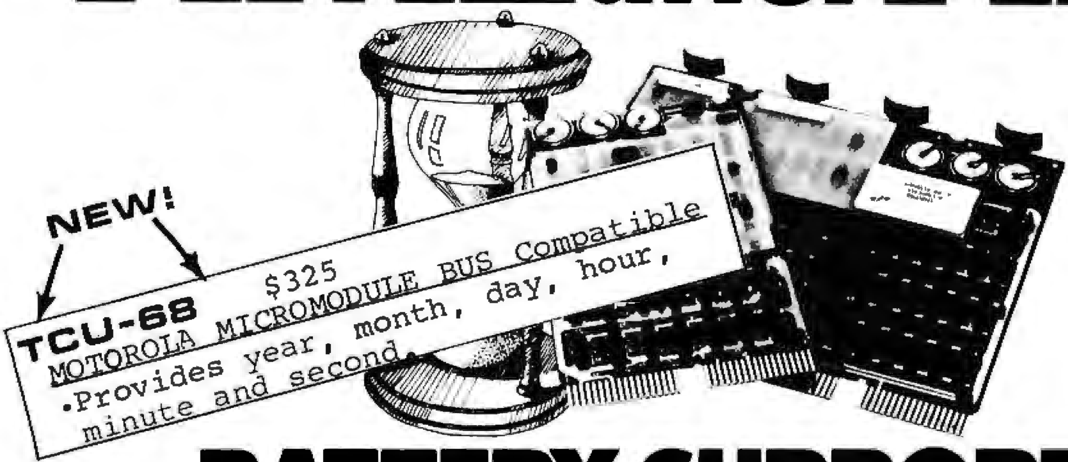
Listing 1 continued:

```
0ODC 39        EXT    RTS
00DD 7F 000C GO       CLR      FLAG3
00E0 86 E0            LDA A    #$E0
00E2 8D 06            BSR      TKEY
00E4 2B 03            BMI      O
00E6 7C 000C          INC      FLAG3
00E9 39        O      RTS
00EA B7 8022 TKEY     STA A    SCNREG
00ED 7D 8020          TST      DISREG
00F0 39               RTS
00F1 7F 8005 BEGIN    CLR      CRA
00F4 7F 8007          CLR      CRB
00F7 86 FF            LDA A    #$FF
00F9 B7 8004          STA A    PIA
00FC B7 8006          STA A    PIB
00FF 86 25            LDA A    #$25
0101 B7 8005          STA A    CRA
0104 B7 8007          STA A    CRB
0107 4F        INIT   CLR A
0108 97 03            STA A    Y2
010A 86 0A            LDA A    #$A
010C 97 01            STA A    X2
010E 86 60            LDA A    #$60
0110 97 02            STA A    Y1
0112 86 20            LDA A    #$20
0114 97 0E            STA A    ODOM
0116 96 04            LDA A    RND
0118 97 05            STA A    RNDO
011A 8D 5C     START  BSR      LANDER
011C BD 00B0          JSR      TERR
011F 8D BC            BSR      GO
0121 D6 0C            LDA B    FLAG3
0123 27 F5            BEQ      START
0125 8D 95     MOTION BSR      KEY
0127 BD 0016          JSR      SYS
012A 8D 4C            BSR      LANDER
012C 8D 4A            BSR      LANDER
012E 8D 48            BSR      LANDER
0130 BD 00B0          JSR      TERR
0133 96 02            LDA A    Y1
0135 8B 80            ADD A    #$80
0137 90 12            SUB A    SUR
0139 22 EA            BHI      MOTION
013B 81 FB            CMP A    #$FB
013D 2B 10            BMI      CRASH
013F 96 01     LAND   LDA A    X2
0141 81 08            CMP A    #$8
0143 2A 0A            BPL      CRASH
0145 81 F8            CMP A    #$F8
0147 2B 06            BMI      CRASH
0149 96 03            LDA A    Y2
014B 81 F0            CMP A    #$F0
014D 2A 0B            BPL      SAFE
014F BD 00B0 CRASH    JSR      TERR
0152 8D 89            BSR      GO
0154 D6 0C            LDA B    FLAG3
0156 2E AF            BGT      INIT
0158 20 F5            BRA      CRASH
015A C6 04     SAFE   LDA B    #$4
015C D7 03            STA B    Y2
015E 5F               CLR B
015F D7 01            STA B    X2
0161 D7 0A            STA B    FLAG1
0163 D7 0B            STA B    FLAG2
0165 CE A04D SF       LDX      #S
0168 8D 39            BSR      DSPLY
016A 8D 0C            BSR      LANDER
016C BD 00B0          JSR      TERR
016F BD 00DD          JSR      GO
0172 D6 0C            LDA B    FLAG3
0174 2E AF            BGT      MOTION
0176 20 ED            BRA      SF
0178 CE 01F1 LANDER   LDX      #TOP
017B 8D 26            BSR      DSPLY
017D D6 0B            LDA B    FLAG2
017F 2F 05            BLE      RJET
0181 CE 01FA          LDX      #LJ
0184 8D 1D            BSR      DSPLY
0186 CE A031 RJET     LDX      #LS
0189 8D 18            BSR      DSPLY
018B D6 0A            LDA B    FLAG1
```

Listing 1 continued on page 138

TIME after TIME



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- Interval interrupts between 1/1024 seconds and 64 seconds.

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DIGITAL PATHWAYS

Circle 85 on inquiry card.

Circle 86 on inquiry card.

Listing 1 continued:

```
018D 27 05            BEQ    NOJET      214.
018F CE A03A          LDX    #MJ        215.
0192 8D 0F            BSR    DSPLY      216.
0194 CE A03D  NOJET   LDX    #RS        217.
0197 8D 0A            BSR    DSPLY      218.
0199 D6 0B            LDA B  FLAG2      219.
019B 2C 05            BGE    NORJ       220.
019D CE A048          LDX    #RJ        221.
01A0 8D 01            BSR    DSPLY      222.
01A2 39       NORJ    RTS               223.
01A3 A6 00    DSPLY   LDA A  0,X        224.
01A5 27 12            BEQ    END        225.
01A7 B7 8004          STA A  PIA        226.
01AA A6 01            LDA A  1,X        227.
01AC 9B 02            ADD A  Y1         228.
01AE 8B 70            ADD A  #$70       229.
01B0 B7 8006          STA A  PIB        230.
01B3 08               INX               231.
01B4 08               INX               232.
01B5 8D 03            BSR    TDELAY     233.
01B7 20 EA            BRA    DSPLY      234.
01B9 39       END     RTS               235.
01BA C6 80    TDELAY  LDA B  #$80       236.
01BC 5A       DELAY   DEC B             237.
01BD 26 FD            BNE    DELAY      238.
01BF 39               RTS               239.
01C0 CE 0010  SURF    LDX    #GETSRF     240.
01C3 4F               CLR A             241.
01C4 E6 00            LDA B  0,X        242.
01C6 B7 8004          STA A  PIA        243.
01C9 F7 8006          STA B  PIB        244.
01CC 8D EC            BSR    TDELAY     245.
01CE 96 00            LDA A  X1         246.
01D0 43               COM A             247.
01D1 84 3F            AND A  #$3F       248.
01D3 B7 8004  NEXTS   STA A  PIA        249.
01D6 8D E2            BSR    TDELAY     250.
01D8 08               INX               251.
01D9 E6 00            LDA B  0,X        252.
01DB F7 8006          STA B  PIB        253.
01DE 8D DA            BSR    TDELAY     254.
01E0 8C 0014          CPX    #GETSRF+4    255.
01E3 27 04            BEQ    LAST       256.
01E5 8B 40            ADD A  #$40       257.
01E7 20 EA            BRA    NEXTS      258.
01E9 86 FF    LAST    LDA A  #$FF       259.
01EB B7 8004          STA A  PIA        260.
01EE 8D CA            BSR    TDELAY     261.
01F0 39               RTS               262.
01F1 8820     FOP     FDB    $8820,$8424,$7C24,$7820    263.
01F3 8424
01F5 7C24
01F7 7820
01F9 00               FCB    $00        264.
01FA 701E     LJ      FDB    $701E      265.
01FC 00               FCB    $00        266.
A031                  ORG    $A031      267.
A031 781C     LS      FDB    $781C,$7C18,$7810,$7C18    268.
A033 7C18
A035 7810
A037 7C18
A039 00               FCB    $00        269.
A03A 8000     MJ      FDB    $8000      270.
A03C 00               FCB    $00        271.
A03D 8418     RS      FDB    $8418,$8810,$8418,$881C,$8820    272.
A03F 8810
A041 8418
A043 881C
A045 8820
A047 00               FCB    $00        273.
A048 901E     RJ      FDB    $901E,$881C    274.
A04A 881C
A04C 00               FCB    $00        275.
A04D 8540     S       FDB    $8540,$8050,$7B40,$884A    276.
A04F 8050
A051 7B40
A053 884A
A055 784A             FDB    $784A,$8540    277.
A057 8540
A059 00               FCB    0          278.
                      END               279.
```

Text continued from page 132:
we do not have much room to move around, but the landing simulation is very realistic. In numerical calculation the 2's complement arithmetic is used. The 2's complement number has a range of decimal −128 to +127, or hexadecimal 80 to 7F. Since the number can be positive or negative, the summation will only be sufficient to perform addition and subtraction. The shift instructions ASL and ASR can be used to perform multiplication or division by 2 respectively. By repeating the use of shift operation, it is possible to multiply or divide a number by 2, 4, 8, and so on.

The dynamic equations for the landing craft are given by the following four first-order ordinary differential equations:

$$\frac{dX_1}{dt} = X_2$$

$$\frac{dX_2}{dt} = \pm SJET$$

$$\frac{dY_1}{dt} = Y_2$$

$$\frac{dY_2}{dt} = -g + JET$$

where:

X_1 = horizontal displacement
X_2 = horizontal velocity
SJET = side jet thrust; negative for the right-hand side jet, positive for the left-hand side jet, and 0 when neither are firing
Y_1 = vertical displacement
Y_2 = vertical velocity
g = gravity
JET = main jet thrust; 0 when it is not firing
t = time

According to the Euler's method (see reference on "Applied Numerical Methods"), an equation of the form:

$$\frac{dZ}{dt} = f(t,Z)$$

can be replaced by the following equivalent numerical routine:

$$Z_{n+1} = Z_n + hf(t_n, Z_n)$$
$$t_{n+1} = t_n + h$$
$$n = 0,1,2,....$$

where the quantity Z_{n+1}, at the time t_{n+1}, can be calculated by adding the previously calculated value Z_n, and the product of the time increment h and the function $f(t_n, Z_n)$. Starting from the given initial value Z_0 at t_0, the solution for Z_n at t_n can be obtained by repeating the calculation from the Euler's routine. This concept has been carried out in the program SYS (address 0016). An assumption is made that the time increment h is equal to 1/4 second.

A total of 553 bytes of memory is needed for the program. If you have more memory space available, you may want to add more constraints to your simulation. The limited fuel capacity can be added to the program. The fuel gauge, velocity, altitude, displacement, and elapsed time can also be displayed on the screen. The trace between craft and surface can be blanked by the beam-intensity modulation. The control line on the peripheral interface adapter (PIA), such as CA2 or CB2, can be used for the blanking control.

The microprocessor can be a useful tool in the classroom for the dynamic simulation. An automobile traveling on a random surface can be an interesting subject for studying the suspension system. Even a simple mass, spring, and dashpot system would prove to be an interesting simulation to observe on the osccillosope. ■

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1. Carnahan, B, H A Luther, and J O Wilkes, *Applied Numerical Methods*, John Wiley and Sons Inc, New York, 1969, chapter 6.
2. Grieser, D,"Pseudorandom Number Generator," BYTE, November 1977, page 218.
3. *M6800 Microprocessor Programming Manual*, Motorola Inc, chapter 4.

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The Dirt-Cheap Bootstrap

More Notes on Bringing Up a Microcomputer

Albert S Woodhull
RFD 2, Enfield Rd
Amherst MA 01002

How do you take the very first steps into learning about microprocessors? An article by Sol Libes ("Notes on Bringing up a Microcomputer," January 1978 BYTE, page 162) described a procedure for the initial testing of a homebrew microcomputer which uses simple procedures to determine whether or not address and control signals are functioning properly. The procedures described are effective, but in order to use them you need a way to load some programs into memory.

If you are building a kit or following a complete microcomputer design, then the details of input and output interfacing will be provided for — a bootstrap program will either be available in read-only memory or can be easily entered from a front panel. But suppose you are just feeling your way along, as I did. I had obtained an 8080A chip set through Intel's University Program, but I had no intention of building a real computer. I had full access to an Altair and an IMSAI at the college where I teach; I wanted only to learn a little about how the hardware worked. I certainly did not want to spend either the money or the time to imitate the Altair's front panel. The following is a description of how I solved this problem in an economical way.

To set the stage: I had the 8080A microprocessor interfaced with the 8224 clock generator/driver device and 1 K bytes of programmable memory. I had thirty-two light-emitting diodes (LEDs), driven by simple emitter-follower transistor buffers, which indicated the state of the bidirectional data bus, the address bus, and the decoded status signals. Three problems seemed important:

- I needed to be able to single-step the processor so that the light-emitting diodes would show more than a meaningless blur.
- I needed a way to transfer data from the outside world to memory.
- I needed some kind of keyboard or switch panel for entering data.

Single-Stepping

The 8080A is a dynamic device. This means that you can't slow it down to human speed by slowing its clock signal. The 8080A can, however, be made to enter a *wait* state in which it essentially does nothing at high speed. While in the wait state, the processor uses the clock signal to keep its internal registers refreshed, but does not change its state.

To single-step through a program to make the computer perform each operation only at my command, I needed to be able to hold the processor in a wait state. The processor would stay in this wait state until I asked it to take a step; it would then immediately return to the wait state. As shown in the schematic diagram of figure 1, it was very easy to do this with only a single flip-flop.

The output of the flip-flop (half of a 7474 dual D edge-triggered type) was connected to the RDYIN line on the 8224 clock generator and driver. This line initiates a wait state when it is pulled low. Three inputs of the 7474 were used. The D (data) line was connected to ground. The clock input on the 7474 was driven by the SYNC output of the 8080A. Finally, a simple pulse generator drove the SET input to the flip-flop.

The operation of this circuit resembles that of a person whose reflexive response to the sound of an

Number	Type	+5 V	GND
IC1	7474	14	7
IC2	555	8	1
IC3	7404	14	7

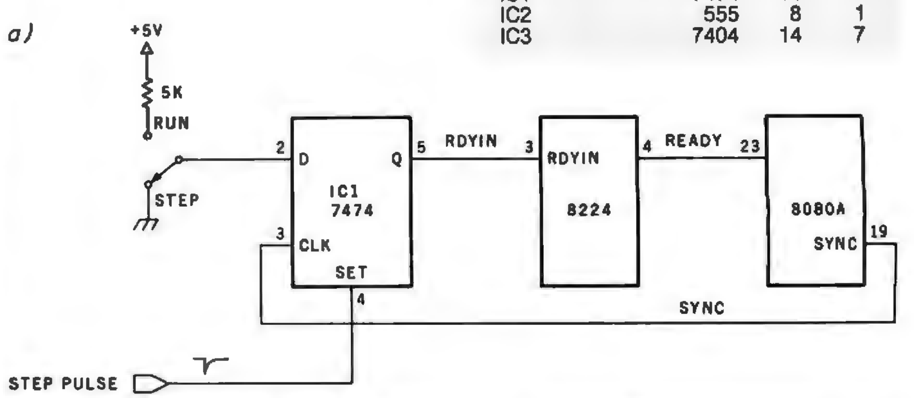

Figure 1a: *A single-step mode can be implemented on an 8080A processor by using a flip-flop and the 8080A SYNC signal to clock a low-logic level through to the READY line. This puts the 8080A into a wait state. A very brief pulse to the SET input of the flip-flop ends the wait state until the next SYNC signal.*

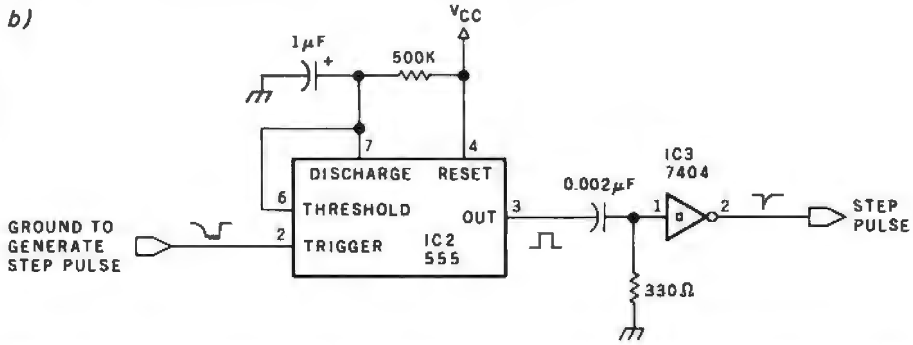

Figure 1b: *The very narrow STEP pulse can be generated by a half-monostable circuit, a resistor-capacitor network at the input to a 7400 inverter. The manual switch contact must be debounced by a monostable circuit with a 0.1 to 1 second pulse width, for which a 555 timer is well-suited.*

alarm clock is to roll over and turn it off. Normally the processor is in the wait state. A pulse to the SET input of the flip-flop ends the WAIT state, allowing the computer to complete execution of the process that is in suspension. At the very beginning of the processor's next cycle, it will send out a SYNC signal which will again clock the flip-flop output low, and reinitiate the processor wait state.

Getting the Data In

There are two ways an 8080A can access the outside world. IN or OUT instructions generate status signals which can be decoded, along with an 8-bit address, to activate input buffers or output latches. Alternatively, a memory address that is not actually used by memory devices can be decoded, along with read-from-memory or write-to-memory status signals. This can be used to activate a *memory-mapped* buffer or latch. If a limited amount of memory and a small number of I/O (input/output) ports are to be addressed, the decoding can be ambiguous—some of the address lines may be ignored.

For bootstrapping purposes I took this to the limit: I arranged a switch to allow *all* memory-read signals to activate an input buffer, regardless of the state of the address lines. The principle is illustrated in the schematic diagram of figure 2. In the LOAD position of the switch, the real memory is never read, but memory-write signals are still capable of performing their normal function. When the processor begins an instruction cycle, it reads a byte from "memory" which is interpreted as an instruction. It makes no difference to the processor if the byte actually originates on the *front panel*.

This arrangement makes it possible

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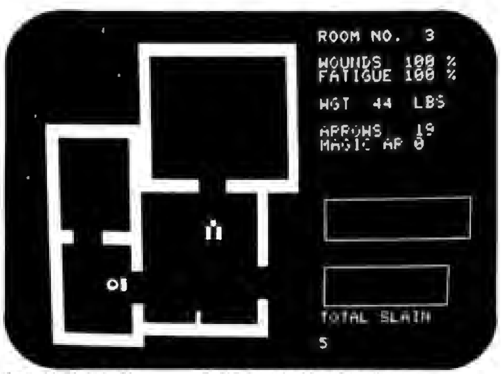

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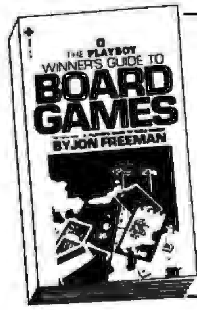

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IC2	7404	14	7

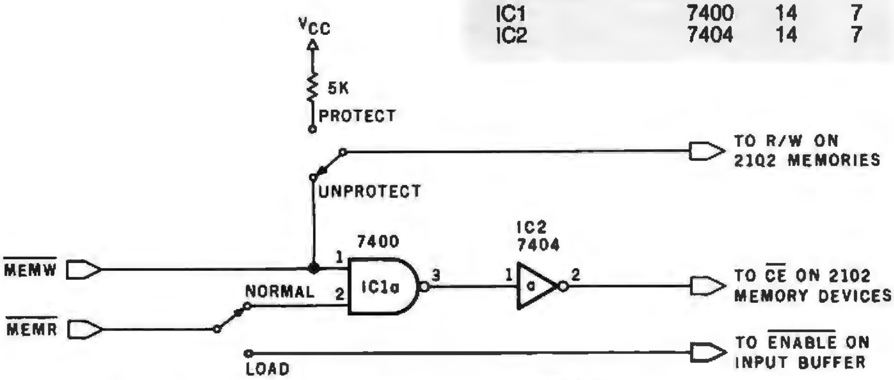


Figure 2: *The LOAD/NORMAL switch routes the $\overline{\text{MEMR}}$ signal to an input buffer instead of to the memory, thus enabling the operator to control the processor by entering instruction codes from the outside. Also shown is another switch which can protect memory from inadvertent writing during debugging.*

to move a byte of data from the front panel to the real memory by first setting up the code for a *move immediate data to memory* instruction (MVI M) on the panel, allowing the processor to execute a single step, and then setting up the value to be loaded on the panel. A second single step will read the data from the panel input, and a third step will then write that data into a memory location.

The particular memory location must be specified somehow, so several additional bytes of instructions must have been *previously* entered. A few simple additions to the hardware already described make it necessary to do this only once, even if many bytes are to be loaded into memory. A look at the computer to human interface should come first, however.

Cheap Keyboard Substitute

Figure 3 illustrates the ultimate in low-budget input devices. I took a scrap of copper-clad circuit board, scored it with a hacksaw into two rows of ten copper-bearing squares each, and soldered a length of wire to each square. Eight pairs of wires went to the inputs of simple latch circuits made by cross-connecting 7400 NAND gates; the other four pads on the circuit board were available for other controls. Light-emitting diodes (LEDs) indicated the state of each of the eight bits. A probe made from a defunct ball-point pen could be used to momentarily ground any of the pads.

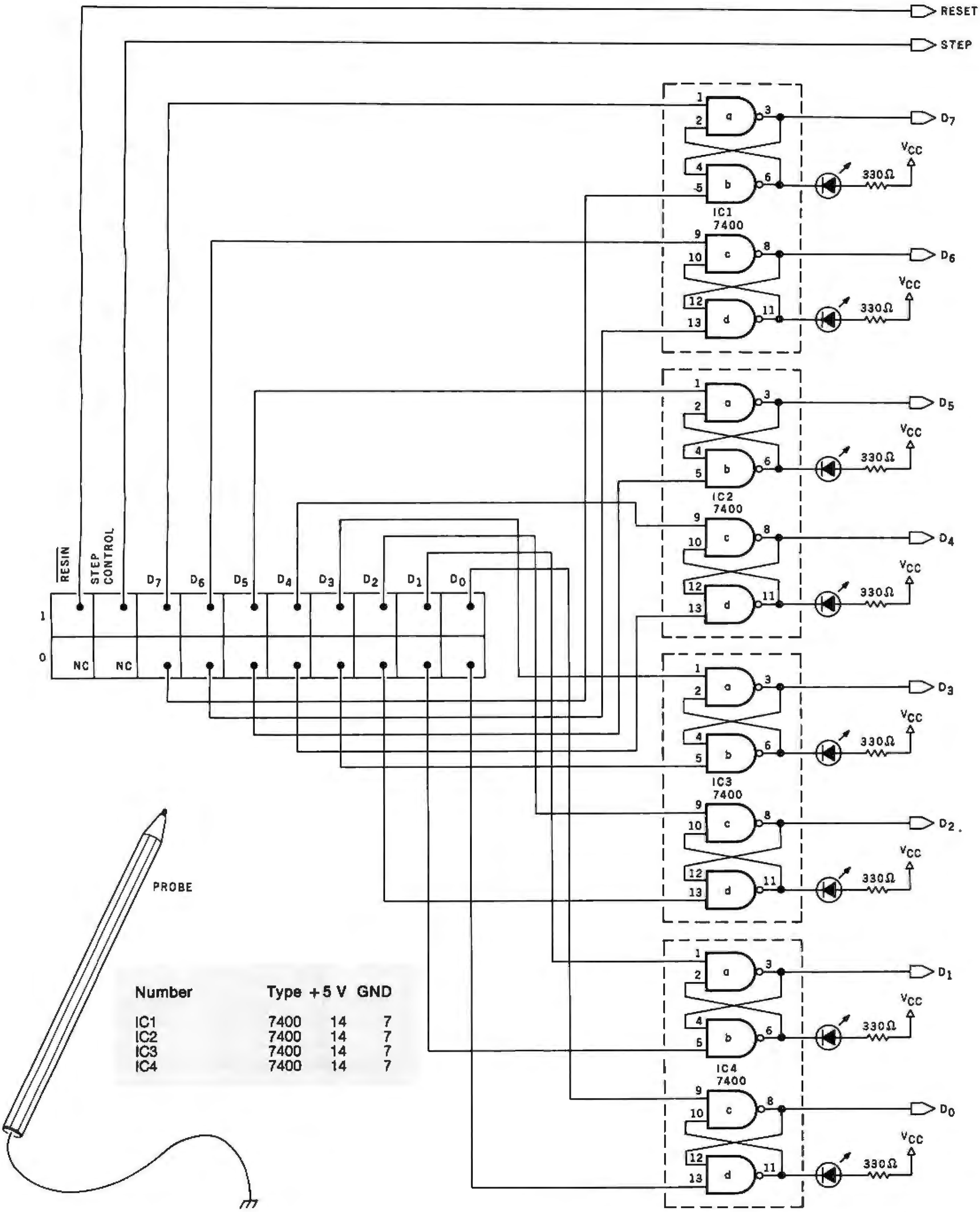
In this way I could set up any desired combination on the latches; their outputs were in turn connected to the input port of the computer. One of the extra pads was connected to the single-step pulse generator mentioned earlier, via a debouncing circuit, and another was connected to the processor RESET line.

A Few Extras

Some additions to the elementary circuits described above were incorporated into the final version. The first of these is a trick I call "double addressing." An input port is physically just a buffer; there is no reason why a single physical port cannot have multiple logical identities.

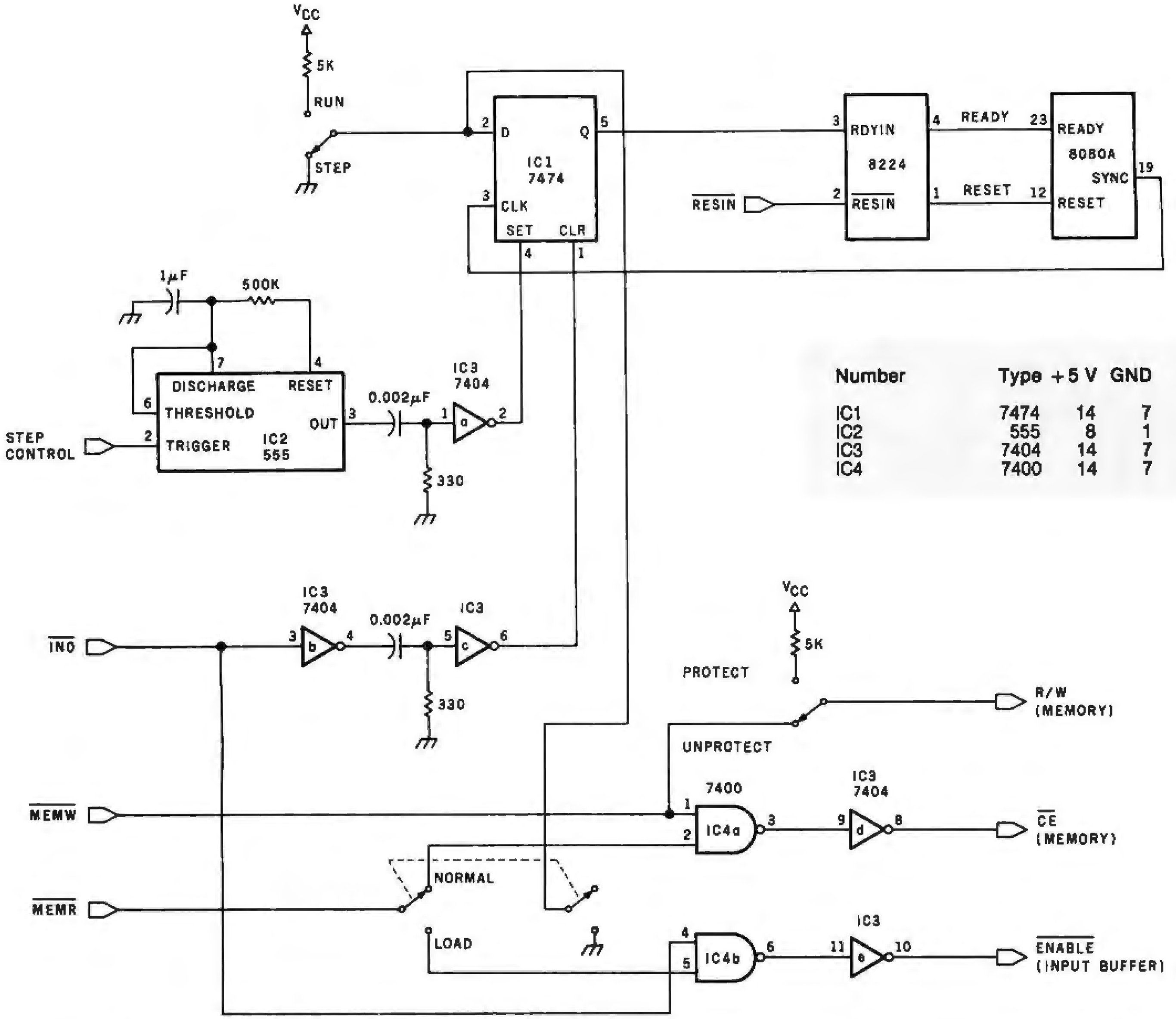
I set up some logic gates to decode the input status signal and an address, along with an additional gate, to allow either the result of this decoding or a memory-read signal from the LOAD switch to activate the input buffer. The LOAD mode is used to load a simple bootstrap program. The bootstrap routine specifies a starting address for the program to be loaded, gets the data from the input port, moves it to memory, increments the pointer to memory, and then loops back to get another byte from the input. Once this bootstrap program has been loaded, the MEMR signal is switched back to the real programmable memory, but an IN instruction can still read the input port.

Text continued on page 148



Number	Type	+5 V	GND
IC1	7400	14	7
IC2	7400	14	7
IC3	7400	14	7
IC4	7400	14	7

Figure 3: *A small scrap of printed circuit board, an old ball-point pen, and some latch flip-flop circuits make a very inexpensive input device. With a little practice, an 8-bit number can be set up as easily and quickly as on a row of toggle switches. The surface of the printed circuit board has been scored to create isolated areas of copper for sensing purposes.*



Number	Type	+5 V	GND
IC1	7474	14	7
IC2	555	8	1
IC3	7404	14	7
IC4	7400	14	7

Figure 4: *The complete control hardware package described in this article. $\overline{INO}$ is a control signal produced by getting the IN status signal from the 8080A and the address bus. Its orthodox function is to enable the input buffer; in this circuit the input buffer may also be enabled by a $\overline{MEMR}$ signal when the LOAD/NORMAL switch is in the LOAD position. $\overline{INO}$ also causes the 7474 single-step flip-flop to be cleared, thus forcing the processor into a wait state so that a human operator can set up the desired data on the input latch. Note the additional section of the LOAD/NORMAL switch which forces single-step operation in the LOAD mode, when full machine speed would be useless.*

Text continued:

In the apparatus described so far, it would be necessary to single-step through the bootstrap program loop because at full machine speed the very first byte of data entered would be rapidly written into every possible memory location. Most monitor programs for handling such inputs have some provision for ensuring that they read each keystroke on a terminal only once. This is usually done by using a second input port as a control port which signals when new data is available. The hardware and software required for this would have been inconveniently complicated for my early breadboard system.

A second unconventional trick avoided the problem. I made wait states *programmable* by adding a second pulse generator which was driven by the same decoder that activated the input buffer. The output of this pulse generator was fed to the RESET input on the single-step flip-flop. Instead of directly grounding the D input on the flip-flop, I put in a RUN/STEP switch which selects either a logic 1 or a logic 0 level for this input.

When the 0 level is selected, operation in the single-step mode proceeds as previously described. When the 1 level is selected, the processor runs at full speed *until* the program calls for data to be input. As the input port is selected, a wait state is initiated. At human speed, the required data can be set up on the input latches. A touch on the STEP pad then causes execution to resume. Figure 4 shows the circuit that incorporates all of these features, and example 1 in the text box describes in detail the procedure for loading the bootstrap program.

Text continued on page 152

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Example 1
Cold Start Bootstrap

The following sequence of operations is used with the hardware system described in the text to load a program when power is supplied to the computer:

1. *Set LOAD/NORMAL switch to LOAD.*
2. *Momentarily ground the $\overline{RESIN}$ line. This clears the program counter and ensures that the processor will interpret the first byte it reads as an instruction.*
3. *Set up the input latch with the binary data 00100001. This is hexadecimal 21, the op code for a load-immediate data into the HL register pair (LXI H) instruction. When ready, ground the STEP line.*
4. *The processor will now expect a second and third byte for the LXI H instruction. These bytes will be loaded into the L and H registers and will act as a pointer to a particular memory address. To start at address 0000, set up all zeros on the input and STEP twice.*
5. *Set up the op code for the load immediate data into a memory location pointed to by the HL pair (MVI M) instruction, hexadecimal 36, then STEP by grounding the line.*
6. *The processor will now expect a byte of data. Set up hexadecimal DB on the latches. This is the code for the IN (receive input) instruction. Then STEP twice, once for the processor to read the data, and once for it to write the data into the memory.*
7. *Now set up hexadecimal 23 and STEP. This is the op code for the INX H instruction. This operation increments the address stored in the L and H registers and prepares the processor to write a byte to the next address in memory.*

Only the last three operations of this sequence must be repeated to load additional bytes of data into the memory. Furthermore, only six more repetitions of steps 5, 6, and 7 are needed to complete the loading of the program given as listing 1.

After you enter this program, reset the program counter by grounding the $\overline{RESIN}$ line. Switch the LOAD/NORMAL control to NORMAL. The single-step mode can be used to verify that the program has been loaded properly, and then the full-speed run mode can be entered. Loading additional data into memory requires only that you set up the data on the input device and ground the STEP line. With an almost imperceptible flicker of the light-emitting diodes (LEDs), the data is read from the input and written into the memory. The processor again waits for another byte.

Example 2
Examination of a Memory Location

To examine a particular location follow this procedure:

1. *Set the LOAD/NORMAL switch to LOAD.*
2. *Momentarily ground the $\overline{RESIN}$ line.*
3. *Enter hexadecimal C3, the code for a JMP, then STEP.*
4. *Enter the low byte of the desired address, then STEP.*
5. *Enter the high byte of the desired address, then STEP.*
6. *Setting the LOAD/NORMAL switch back to NORMAL will put the data at the desired location on the data bus, thus displaying it on the data LEDs.*

After examining a location, a STEP will start execution from that location. You can then conduct another examine operation to show a new location, or the examine-next procedure of example 3 can show the next location.

Example 3
The Examine-Next Function

To look at a program or data in memory without executing it, first examine the first byte in the desired memory segment, then do the following:

1. *Set the LOAD/NORMAL switch to LOAD. Do not ground $\overline{RESIN}$.*
2. *Set up all zeros on the input latch. This is the code for a no operation (NOP) instruction.*
3. *STEP, then switch to NORMAL. The next byte in memory will be displayed on the data LEDs.*

This procedure can be repeated as desired. Note, however, that strange things can happen if you start execution while examining a byte which is the second or third byte of a multibyte instruction. This error of starting in the wrong place is also possible with most conventional front panels.

Example 4
Temporary Patches

When a program contains loops that are repeated many times, single-step debugging can be simplified by substituting instructions. For example, a subroutine that generates eight cycles of 2400 Hz audio to record a logic 1 bit on magnetic tape is shown in listing 2.

To verify that this program worked properly, you would not want to single-step through the inner loop 416 times! You might step through it once, but the next time you came to the JNZ instruction, you could use the LOAD function to make the processor see three successive NOPs. Alternately, you might change the cycle counting and timing bytes at locations 0102 and 0104 to the value 01. Since the LOAD substitution does not actually alter memory contents, this procedure can also be used for a program stored in read-only memory. There is no need to go back and undo patches after tracing the program. In these respects the LOAD function of this simple control system is more versatile than most conventional front panels. If a permanent patch is needed, you can use the LXI H and MVI M instructions.

Listing 1: *Program instructions which are loaded into the 8080 memory by manual means, and are then used to load further memory locations more quickly.*

Hexadecimal Data Loaded	Instruction Mnemonic	Explanation
DB	IN	Input
00		Input port address (hardware dependent)
77	MOV M,A	Copy data from accumulator to
	INX H	memory
23		Increment HL, the memory pointer
C3	JMP	Jump
00		Jump address, low byte
00		Jump address, high byte

Listing 2: *A routine for the 8080 which can record a logic 1 bit on a cassette tape by generating eight cycles of a 2400 Hz audio signal.*

Address	Label	Mnemonic	Explanation
0100	MARK	XRA A	Set accumulator to zero
0101		MVI B	Set up a counter
0102		10	to count 16 half cycles
0103	HALFCY	MVI C	And another counter
0104		1A	to time 26 loops
0105		OUT	Then output to
0106		00	port 0
0107	TIMELOOP	DCR C	Countdown the timer
0108		JNZ TIMELOOP	And stay in the loop
0109		07	until counter is zero
010A		01	
010B		CMA	Complement the accumulator
010C		DCR B	Countdown half cycles
010D		JNZ HALFCY	And send more until
010E		0	cycle counter is zero
010F		01	
0110		RET	Then return to main program

Text continued:

Additional Applications

The LOAD mode permits direct control of the computer at any time. Most of the functions of the front panel on an IMSAI or Altair can be simulated by causing the processor to execute instructions loaded directly from the crude printed-circuit-pad "front panel." For example, executing a JMP instruction is equivalent to the *examine* function of the usual front panel. *Examine next* is implemented by single-stepping a no-operation (NOP) instruction. A program can also be temporarily patched during single-step debugging to break out of a loop, or to try an alternative instruction. Examples 2, 3, and 4 in the text box explain these functions in more detail.

Evolution of the System

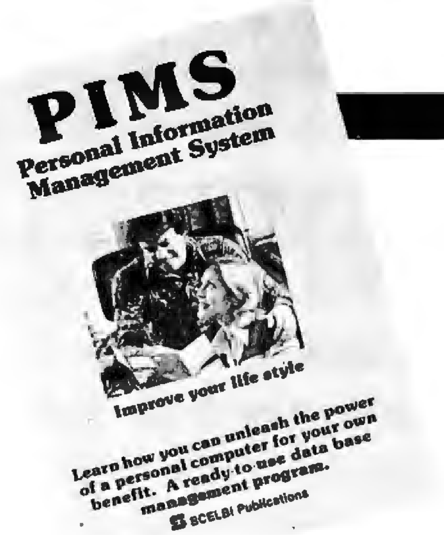
While developing the circuits I have described, I became hooked on microprocessors. What started out as a breadboard project is now a computer, but I have spent less money along the way than is ordinarily paid for a system of less capability.

To encourage others who might wish to follow a route similar to mine, I want to emphasize that all of the effort and material that went into my first experiments were useful in the larger system that grew from it. The single input port that served my printed circuit board input device was later shared by an ASCII keyboard and a cassette recorder.

The addition of a single *output* port made possible the use of software timing in a routine to generate audio tones for recording programs on tape. Another bit of the same output port can drive a printer in serial mode; again, software timing can be used.

The first 256-byte block of read-only memory that I added was adequate to hold all of the programs that I needed to read cassette tapes. During the few weeks it took me to develop those programs, not wishing to lose the programs by removing power from the programmable memory, I connected an old car battery to the memory to keep it alive.

I have now reached the point of connecting commercial S-100 cards to my system. Because I have built it and know the function of every wire, it is easy to make minor modifications when a control signal is needed for interfacing a new device. ■



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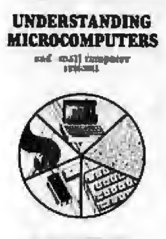

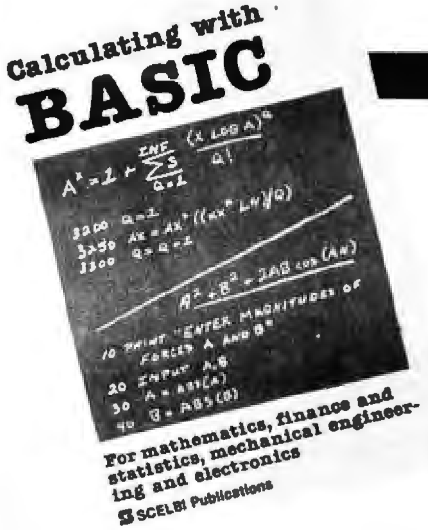

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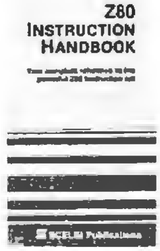

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Hydrocarbon Molecule Constructor

Randall S Matthews
The Proctor and Gamble Co
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To an organic chemist learning to program a newly acquired microcomputer (in my case, the 16 K byte Apple II), the challenge of "teaching" chemical principles to the computer naturally arises. For example: can the Apple II learn the rudiments of structural organic chemistry, and use that knowledge to assemble and draw simple molecules? This subject is usually covered early in the first semester of sophomore organic chemistry. I decided to write a BASIC program that would accept a hydrocarbon molecular formula as input, and then randomly construct a molecule fitting that formula and draw its structure using high-resolution graphics as output.

Initialization

First, the program must be initialized and the input accepted and analyzed. The user will enter a molecular formula in the form C,H (where C is the number of carbon atoms and H is the number of hydrogen atoms in the molecule).

Clearly, the program must accept only values of C and H that are positive, and less than the maximum numbers allowed by the dimension statement (line 100). However, the dictates of organic chemistry force further restrictions.

In a neutral, ground-state, hydrocarbon molecule, every carbon atom must have exactly four bonds (ie: connections to other atoms), and every hydrogen atom must have exactly one bond. In 3-methyl-1-butene, as shown in figure 1, notice that each carbon has four connections.

Carbon atom number 2 (C-2) has one bond to C-3, one bond to a hydrogen (H), and two bonds to C-1. Similarly, each H has only one bond. This *valence* restriction means that, for a given number of carbons C, the maximum number of hydrogens is $2 \times C + 2$. A little thought will verify that conclusion.

Consider the propane structure, as shown in figure 2, with a formula C_3H_8 ($8 = 2 \times 3 + 2$). No more hydrogens can be added, since each carbon already has its maximum number of connected atoms. Note that if we make a double bond (C-1 to C-2) to form 1-propene, two hydrogens must be removed. This observation leads to a second restriction: the total number of hydrogens in a hydrocarbon must always be even. A good exercise is to try to draw a counter-example, remembering the valence restrictions.

Connection Table

Having accepted and screened the input, our program must now put together carbon and hydrogen atoms to form a molecular structure that fits the formula input. This process involves the construction of a *connection table*. To illustrate this concept, consider again the molecule in figure 1. How can the information in that structure be numerically represented? One convenient

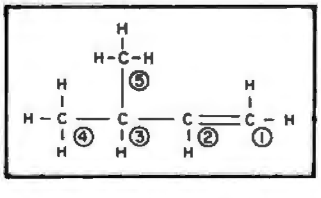

Figure 1: *In the hydrocarbon 3-methyl-1-butene, each carbon atom has four connections. This is true of any hydrocarbon molecule.*

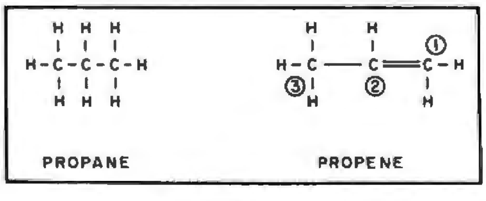

Figure 2: *Examples of propane and propene. For any given hydrocarbon with C carbon atoms, the maximum number of possible hydrogen atoms, H, is 2 × C + 2.*

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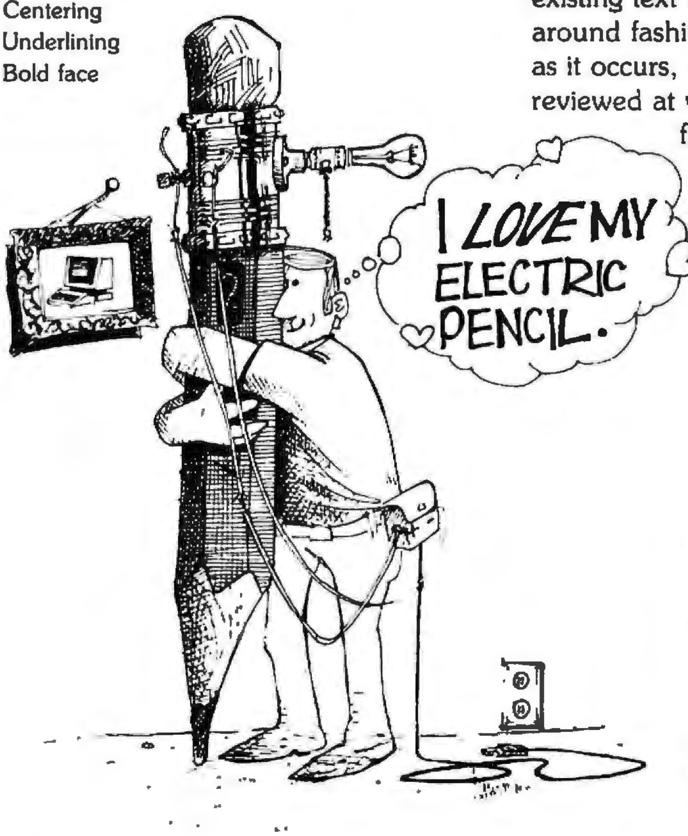

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	BOND NUMBER 1	2	3	4
C1	2	2	0	0
C2	1	1	0	3
C3	4	5	2	0
C4	3	0	0	0
C5	3	0	0	0

Figure 3: *A possible method of representing a connection table. This connection table represents every bond for every carbon atom. The information is stored by the computer in the form shown in figure 4.*

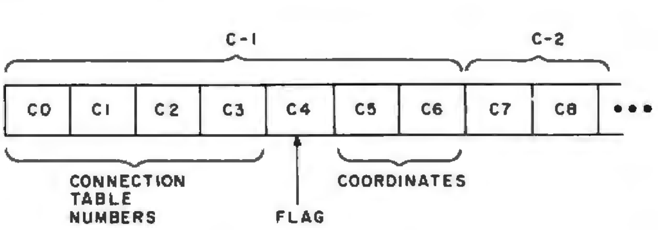

Figure 4: *The connection table is stored in array C.*

(a)

C1	2	4	0	0
C2	1	3	0	0
C3	2	4	0	0
C4	1	3	0	0

(b)

C1	4	4	0	0
C2	3	3	0	0
C3	2	2	0	0
C4	1	1	0	0

Figure 5: *Using the random method of generating connection tables may result in some difficulties. Two connection tables for C_4H_8 are shown. One possible and acceptable connection table is figure 5a. Figure 5b is an unacceptable connection table since it results in two separate molecules.*

method is shown in figure 3.

This connection table indicates every bond for every carbon atom. For example, in column 2 of row C3 is a 5, indicating that the second bond of C-3 connects to carbon atom number 5 (C-5). An entry of 0 in the table means connection to a hydrogen. Thus, the number of 0s in the table necessarily equals the number of hydrogens in the molecule. Reading across row C2, we find that carbon C-2 is connected twice to C-1, constituting a *double bond*, once to C-3, and once to a hydrogen.

In the computer, the information contained in the connection table is stored in array C, as indicated in figure 4. The information for C-1 is stored in array elements C(0) thru C(6); the information for C-2 is stored in elements C(7) thru C(13); etc. In every such block of seven elements, the first four elements contain the four numbers from the connection table for that carbon atom. Thus, using the connection table in figure 3 as an example, we have: C(0)=2, C(1)=2, C(2)=0, C(3)=0, C(7)=1, C(8)=1, C(9)=0, C(10)=3, etc. The use of the other elements in the array is explained later.

My first programming impulse was to construct the connection table entirely at random. Unfortunately, this method proved inadequate for several reasons. First, it was very slow. After each attempt at constructing the table, the program would check if the generated numbers were consistent with the input molecular formula. If they were not, as was often the case, the program recycled to try again. This process was very inefficient.

The second problem was that the connection tables generated often *did* satisfy the formula, but led to disconnected structures. For example, suppose the formula C_4H_8 (4,8) is input. Figure 5 shows two connection tables, along with their corresponding structures, that fit this formula. Clearly, the output in figure 5b is unacceptable because it is two separate structures, even though its connection table still conforms to the input.

How may these problems be solved?The answer lies in the new algorithm illustrated in figure 6, which again uses the hypothetical input C_4H_8. This method begins by connecting C-1 to C-2. A random integer between 0 and 3 is then selected, and C-3 is bound to the carbon atom with

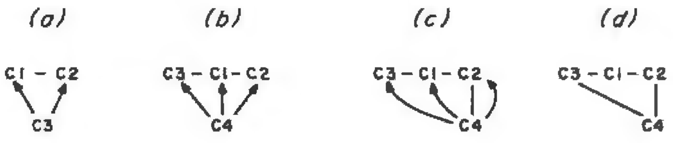

Figure 6: *A more efficient method for connecting the carbon atoms is to first connect C-1 to C-2. A random number between 0 and 3 is then selected and C-3 is bound to that carbon atom (6a,6b). C-4 is then randomly connected to one carbon atom in the range C-1 thru C-3. After all carbon atoms have been connected thus, the table is cleaned up by another routine. Two different carbon atoms are chosen randomly and a bond is formed between them if their valence restrictions allow. (Remember there may be only four bonds to a carbon atom.) In the example the final connection is between C-4 and C-3. All of the available bonds will be filled with hydrogen atoms in the final molecule.*

that number as shown in figures 6a and 6b. An integer between 0 and 4 is randomly chosen, and C-4 is connected to that atom as shown in figures 6b and 6c.

After all of the carbons have been thusly connected, another routine is used to finish the table, wherein more connections are randomly made as follows. Two different carbons in the existing structure are randomly chosen, and, if the valence restriction allows, a bond is made between them.

In our example, the final connection is made between C-4 and C-3. (See figures 6c and 6d.) After connecting all the carbons, the number of such additional bonds that must be made can be calculated beforehand from the molecular formula according to the equation:

$$EU = ((2 \times C + 2) - H)/2$$

where EU represents the number of additional bonds to be formed, and C and H are the formula input numbers. The origin of this equation is not within the scope of this article, but the enterprising reader might be able to derive it. EU stands for *elements of unsaturation*. In the example above, EU=1 (for C_4H_8), so only one additional bond had to be made to complete the connection table. (See figures 6c and 6d.)

Assigning Coordinates

Having assembled the molecule, coordinates for each carbon must now be assigned before drawing the structure. For the final drawing to be as clear as possible, the assignments need to satisfy at least two requirements. First, no two carbons should have the same coordinates; and second, carbons that are bound to each other should be plotted next to each other whenever possible.

The following algorithm was devised to assign coordinates according to the two criteria. Carbon C-1 is given the coordinates 120,75 in the Apple's 270 by 160 high-resolution graphics display. Next, all of the carbons connected to C-1 that do not already have coordinates are assigned coordinates next to C-1. These coordinates are stored in the sixth and seventh elements of the requisite block in array C as shown in figure 4. After its neighbors have been given coordinates, the flag element in C-1's block of array C is set to 1. (Again, see figure 4.) If it has already received its coordinates, the same procedure is then followed for C-2 and continued until all of the carbons have been used. This method does not always give the best or even an adequate representation, but it does offer the advantages of simplicity and speed. Also, the confusing drawings that sometimes result are in most cases easily improved.

Drawing the Structure

With all the necessary information now contained in array C, the final structure may be drawn. This straightforward process uses Apple's machine-language, high-resolution graphics subroutines (stored in hexadecimal locations C00 thru FFF prior to running the program), as well as the several vector tables given in the text box, allowing the atomic symbols to be easily drawn by the shape subroutine. These vector tables must be stored in hexadecimal locations 1000 thru 1129, and are protected by a LOMEM setting that is automatically performed by the BASIC program (line 5).

Text continued on page 166

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Listing 1: *An Apple II integer-BASIC program for generating hydrocarbon representations using the available high-resolution graphic routines. The high-resolution routines use the graphics tables in listing 2.*

```
  5 POKE 204,4400 MOD 256: POKE 205,4400/256: POKE 74,4400 MOD 256: POKE
    75,4400/256
 10 GOTO 100
 30 POKE 802,Y: POKE 800,X MOD 256
 35 POKE 801,X/256: RETURN
 40 POKE 804,X MOD 256: POKE 805,X/256: RETURN
100 DIM C(110)
110 TEXT : CALL -936: VTAB 5: TAB 8: PRINT "APPLE-CHEM II"
120 VTAB 10: PRINT "THIS PROGRAM WILL DRAW A MOLECULE": PRINT "FOR A GIVEN M
    OLECULAR FORMULA."
130 VTAB 15: PRINT "ENTER A MOLECULAR FORMULA": PRINT "IN THE FORM 'C,H' , W
    HERE"
140 PRINT "'C' = THE NUMBER OR CARBON ATOMS": PRINT "IN THE MOLECULE, ETC."

150 INPUT NC,NH
152 NF=0
155 IF NC#-100 THEN 160:NC= RND (7)+2:NH=((2*NC)/2)*2
157 NF=1: CALL -936: VTAB 22: PRINT "C-";NC;",H-";NH: GOTO 180
160 IF NC>1 AND NC<16 AND NH>-1 AND NH<=2*NC+2 AND (NH/2=NH-NH/2) THEN
    180
170 PRINT : PRINT "IMPROPER DATA!": PRINT "C MUST BE >= 2 AND < 16": PRINT
    "H MUST BE EVEN, >= 0 AND <= 2*C+2": GOTO 150
180 EU=((2*NC+2)-NH)/2
190 FOR I=0 TO NC*7:C(I)=0: NEXT I
200 C(0)=2:C(7)=1: IF NC=2 THEN 300
210 FOR I=3 TO NC
220 X= RND (I-1)+1
230 IF C((X-1)*7+1)#0 THEN 250
240 C((I-1)*7)=X:C((X-1)*7+1)=I: GOTO 290
250 IF C((X-1)*7+2)#0 THEN 270
260 C((I-1)*7)=X:C((X-1)*7+2)=I: GOTO 290
270 IF C((X-1)*7+3)#0 THEN 290
280 C((I-1)*7)=X:C((X-1)*7+3)=I
290 NEXT I
300 IF EU=0 THEN 410
310 FOR K=1 TO EU
320 X= RND (NC)+1:Y= RND (NC)+1: IF X=Y THEN 320
330 FOR I=1 TO 3: IF C((X-1)*7+I)#0 THEN 350
340 X1=I: GOTO 360
350 NEXT I: GOTO 320
360 FOR I=1 TO 3: IF C((Y-1)*7+I)#0 THEN 380
370 Y1=I: GOTO 390
380 NEXT I: GOTO 320
390 C((X-1)*7+X1)=Y:C((Y-1)*7+Y1)=X
400 NEXT K
410 FOR I=4 TO (NC-1)*7+4 STEP 7: FOR J=0 TO 2
420 C(I+J)=0: NEXT J: NEXT I
430 GOSUB 1000: GOSUB 2000
435 CALL -936: VTAB 22
437 IF NF#1 THEN 440:NC=-100: GOTO 155
440 PRINT "HIT 'D' TO DRAW THIS DIFFERENTLY"
450 PRINT "HIT 'I' FOR A NEW ISOMER (SAME FORMULA)"
460 PRINT "HIT 'F' FOR A NEW MOLECULAR FORMULA"
470 KEY= PEEK (-16384): IF KEY<128 THEN 470
480 POKE -16368,0
490 IF KEY=196 THEN 410: IF KEY=201 THEN 190: IF KEY=198 THEN 110
500 END
```

```
1000 C(5)=120:C(6)=75
1010 FOR K=1 TO NC: IF C((K-1)*7+4)=0 AND C((K-1)*7+5)#0 THEN 1030
1020 NEXT K: GOTO 1090
1030 FOR I=0 TO 3:J=(K-1)*7+I: IF C(J)=0 THEN 1080
1040 IF C((C(J)-1)*7+5)#0 THEN 1080
1050 GOSUB 1500
1060 FLAG=0: GOSUB 1600: IF FLAG=1 THEN 1050
1070 C((C(J)-1)*7+5)=TX:C((C(J)-1)*7+6)=TY
1080 NEXT I:C((K-1)*7+4)=1: GOTO 1010
1090 RETURN
1500 TX=C((K-1)*7+5):TY=C((K-1)*7+6)
1510 A1=( RND (3)*30)-30:A2=( RND (3)*30)-30
1520 TX=TX+A1:TY=TY+A2
1530 IF TX<4 OR TX>264 OR TY<4 OR TY>152 THEN 1500
1540 RETURN
1600 FOR II=1 TO NC
1610 IF C((II-1)*7+5)=TX AND C((II-1)*7+6)=TY THEN 1630
1620 NEXT II: GOTO 1640
1630 FLAG=1
1640 RETURN
2000 CALL 3072: POKE 812,255: POKE 806,1: POKE 807,0
2010 S=3805:L=3786:P=3780: POKE 28,255
2020 FOR I=1 TO NC: FOR J=0 TO 3: IF C((I-1)*7+J)=0 THEN 2160
2030 FLAG=0: IF C((I-1)*7+J)<I THEN 2160
2040 FOR K=0 TO 3: IF K=J THEN 2060
2050 IF C((I-1)*7+K)=C((I-1)*7+J) THEN FLAG=FLAG+1
2060 NEXT K:T=C((I-1)*7+J)
2070 X1=C((I-1)*7+5):Y1=C((I-1)*7+6):X=X1:Y=Y1
2080 GOSUB 30: CALL P
2090 X2=C((T-1)*7+5):Y2=C((T-1)*7+6):X=X2:Y=Y2
2100 GOSUB 30: CALL L: IF FLAG<1 THEN 2160
2110 X=X1+6:Y=Y1+3: GOSUB 30: CALL P
2120 X=X2+6:Y=Y2+3: GOSUB 30: CALL L
2130 IF FLAG#2 THEN 2160
2140 X=X1-3:Y=Y1-6: GOSUB 30: CALL P
2150 X=X2-3:Y=Y2-6: GOSUB 30: CALL L
2160 NEXT J: NEXT I
2170 FOR I=1 TO NC:X1=C((I-1)*7+5):Y1=C((I-1)*7+6)
2180 POKE 812,0:X=X1:Y=Y1+2: GOSUB 30: CALL P
2190 POKE 804,4199 MOD 256: POKE 805,4199/256: CALL S: POKE 812,255
2220 X=X1:Y=Y1: GOSUB 30: CALL P:FLAG=0
2230 FOR J=0 TO 3
2240 IF C((I-1)*7+J)=0 THEN FLAG=FLAG+1
2250 NEXT J
2260 IF FLAG#0 THEN 2280
2270 X=4096: GOSUB 40: GOTO 2330
2280 IF FLAG#1 THEN 2300
2290 X=4107: GOSUB 40: GOTO 2330
2300 IF FLAG#2 THEN 2320
2310 X=4130: GOSUB 40: GOTO 2330
2320 X=4166: GOSUB 40
2330 CALL S: NEXT I: RETURN
```

Listing 2: *The program in listing 1 uses a high-resolution shape (or vector) table which is shown here. It stores shapes for the chemical symbols. The operation of the shape table is defined in the* Apple II Programmer's Manual *and in the documentation for the high-resolution routines. These vector tables are used to draw the different parts of molecules on the video screen.*

```
1000-   22 64 2D 15 96 F2 3F 07
1008-   20 04 00 24 2D 2D 24 34
1010-   36 36 FE 1B 24 24 24 D7
1018-   E3 3F 17 36 36 0E 2D 05
1020-   20 00 2D 2D 4D 62 AD F6
1028-   17 17 36 28 2D D5 DB C3
1030-   18 08 18 24 24 24 DF 33
1038-   36 36 3E D8 1E 3F 07 20
1040-   24 64 2D 15 06 00 2E 2D
1048-   AD 09 0C AD 36 3F 2D 36
```

Listing 2 continued on page 164

Listing 2 continued:

```
1050-  1E 3F E0 D8 24 24 24 DF
1058-  33 36 36 3E D8 1E 3F 07
1060-  20 24 64 2D 15 06 00 24
1068-  24 24 24 3C 3F 3F 3F 3F
1070-  3F 2D 2D 2D 2D 2D 2D 2D
1078-  2D 2D 2D 2D 3E 3F 3F 3F
1080-  3F 3F 3F 3F 3F 3F 3F 37
1088-  2D 2D 2D 2D 2D 2D 2D 2D
1090-  2D 2D 2D 3E 3F 3F 3F 3F
1098-  3F 3F 3F 3F 3F 3F 37 2D
10A0-  2D 2D 2D 2D 2D 2D 2D 2D
10A8-  2D 2D 3E 3F 3F 3F 3F 3F
10B0-  3F 3F 3F 3F 3F 37 2D 2D
10B8-  2D 2D 2D 2D 2D 2D 2D 2D
10C0-  2D 3E 3F 3F 3F 3F 3F 3F
10C8-  3F 3F 3F 3F 37 2D 2D 2D
10D0-  2D 2D 2D 2D 2D 2D 2D 2D
10D8-  3F 3F 3F 3F 3F 3F 3F 3F
10E0-  3F 3F 3F 37 2D 2D 2D 2D
10E8-  2D 2D 2D 2D 2D 2D 2D 3E
10F0-  3F 3F 3F 3F 3F 3F 3F 3F
10F8-  3F 3F 37 2D 2D 2D 2D 2D
1100-  2D 2D 2D 2D 2D 2D 3E 3F
1108-  3F 3F 3F 3F 3F 3F 3F 3F
1110-  3F 37 2D 2D 2D 2D 2D 2D
1118-  2D 2D 2D 2D 2D 3E 3F 3F
1120-  3F 3F 3F 3F 3F 3F 3F 3F
1128-  07 00
```

Table 1.

Program Lines	Function
5	*Set LOMEM:4400*
30-40	*Subroutines used for drawings.*
100-170	*Accept and analyze input.*
180-400	*Construct connection table.*
435-500	*Special features.*
1000-1640	*Subroutine to assign coordinates.*
2000-2330	*Subroutines to draw molecule.*

Program Notes

Since remark statements were deleted from the final program to increase execution speed, the explanations provided in table 1, should prove useful when reading the program. Table 2 provides a list of all machine language accesses in the Apple II used in this program. These explanations should help implement the chemistry program on a different computer.

Table 2.

Command	Occurrence	Effect
POKEs to 204, 205, 74, 75	*line 5*	*Set LOMEM:4400. This protects the vector table in the Apple's memory from being written over.*
POKEs to 802, 801, 800	*lines 30, 35*	*These locations hold the coordinates for the next point to be plotted.*
POKEs to 804, 805	*line 40*	*These locations hold the address of the part of the vector table containing the shape about to be drawn.*
CALL 3072	*line 2000*	*Initializes high-resolution graphics mode.*
POKE 812, 255	*lines 2000, 2190*	*Set color to white.*
POKE 806, 1	*line 2000*	*Set scaling factor to 1. (full size)*
POKE 807, 0	*line 2000*	*Set rotation factor to 0. (right side up)*
CALL P	*lines 2080, 2110, 2140, 2180, 2220*	*Causes point to be plotted at coordinates set in SUB 30.*
CALL L	*lines 2100, 2120, 2150*	*Causes line to be drawn from last point plotted to coordinates set in SUB 30.*
POKE 812, 0	*line 2180*	*Set color to black.*
CALL S	*lines 2190, 2330*	*Cause shape to be drawn starting at last point plotted (line 2180). Shape is determined by which section of vector table is poked into locations 804 and 805 as shown below:*

table location	figure drawn
4199	*blank space*
4096	*C*
4107	*CH*
4130	*CH_2*
4166	*CH_3*

Text continued from page 160:

Program Description and Instructions

To run the program, load the high-resolution graphics subroutines, the vector tables, and the BASIC program (remembering to set HIMEM;8192) and type RUN. You will be asked to input a molecular formula. To test the program, type 4,8. In a few seconds, an isomer of butene should appear. At the bottom of the screen, you will note several special features. Pressing the D key will draw a new picture of the same compound; in other words, the same connection table is used, but different coordinates are assigned. This command is very useful, particularly for complicated structures, when the initial drawing is too confusing to understand. You may continue to press the D key until a satisfactory drawing results. Pressing the I key isomerizes the structure (ie: a different compound with the same molecular formula is drawn). Thus, you could investigate some of the many isomers of tetrahedrane (C_4H_4). Pressing the F key simply recycles the program to allow new input. Pressing any other key ends the run.

One other very interesting special feature is demonstrated by entering the "formula" -100,0. This input is a signal for the program to begin drawing structures from randomly chosen molecular formulae. It will continue to draw new compounds until interrupted by control-C. This feature makes a fascinating demonstration display for the Apple II.

Concluding Comments

Finally in possession of a running program, you may well inquire: what good is it? Certainly, for a practicing organic chemist, the program has little practical value. However, by exposing several of my chemist friends to the program, I have found that they do enjoy playing with it, especially the isomerization feature. It is fun!

For those who are interested in practical applications of microcomputing, I stress that this program has valuable use in chemical education. For beginning organic students, it provides an enjoyable introduction to numerous seminal concepts of structural chemistry (eg: to the ideas of structural isomerism and valence requirements). Moreover, it could be used to test comprehension of nomenclature, particularly for more advanced students. For instance, I have enjoyed entering formulae and challenging others to assign International Union of Pure and Applied Chemistry (IUPAC) names to the resulting structures.

In closing, I must point out that the program described here is only a beginning. Several potential improvements immediately spring to mind. One is the possibility of the Apple drawing three-dimensional representations. Also, anyone with much chemical background will quickly realize that many structures generated by the program are rather unlikely, if not practically impossible. For instance, the Apple does not hesitate to draw cyclopropadiene, an impossibly strained ring. It might be possible to *teach* the Apple such concepts as ring strain and Bredt's rule; however, I am not sure if that would be desirable. Much of the program's charm derives from its naive approach to molecular assemblage, yielding delightfully unexpected structures. And who knows? Recent experience in organic synthesis has demonstrated that improbable structures are not always impossible. ■

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Book Reviews

What Computers Can't Do

Hubert L Dreyfus
Harper and Row
New York 1972
hardcover, 259 pages
$10.95

Brain, Mind and Computers

Stanley L Jaki
Gateway Editions
1969
softcover, 267 pages
$4.95

What Computers Can't Do and *Brain, Mind and Computers* are two widely available critiques of artificial intelligence. Their authors bring somewhat different credentials to the task. Hubert Dreyfus is a philosopher who has worked in artificial intelligence research for well over a decade, and Dr Jaki is a theologian concerned with the philosophy of science.

What Computers Can't Do is a follow-up on a RAND Corporation paper which Dreyfus did in the mid-1960s. The question he raises is why, after the rapid advances in artificial intelligence research during the 1950s, was there such a slowdown in results during the 1960s and early 1970s? Many of the results which were forecast for the period 1969 thru 1979 never occurred (such as general-purpose language translation, innovative work in mathematics by computers, etc). Dreyfus believes that there are a number of mistaken assumptions underlying the hopes in artificial intelligence research; assumptions about how we think and about the nature of the world. His conclusion is that more attention must be paid to the ways in which humans think about things and how these differ from the ways in which computers work. He argues that the result of this is a classification of tasks into different groups, some of which are definitely fair game for machines, some of which pose serious problems, and some of which are not likely to yield human-type performance to computers as they are presently designed.

Overall, this book is very interesting reading, and contains well-thought-out discussions of many of the issues in artificial intelligence research.

Brain, Mind and Computers was originally published ten years ago and has since been reissued. It is ostensibly a discussion of artificial intelligence research; it is in fact a refutation of physicalism, which the author maintains is synonymous with determinism. While discussing artificial intelligence at length, Dr Jaki never defines what he means by it; he seems to mean a machine which will be fully equivalent to the human mind in all respects. Given this implicit definition, the task of arguing against the possibility is simplified.

Brain, Mind and Computers is an excellent guide to the history of physicalism in scientific thought. The computer is taken as a metaphor for "machine," and artificial intelligence is taken in its strongest sense— a sense that is almost unknown in the current artificial intelligence research literature.

John A Lehman
716 Hutchins #2
Ann Arbor MI 48103

Z80 Software Gourmet Guide and Cookbook

Nat Wadsworth
Scelbi Publications, 1979
softcover, 322 pages
$14.95

The *Z80 Software Gourmet Guide and Cookbook* is one in a series of such books which Scelbi has published; previous "cookbooks" have appeared for the 8080 and the 6800 processors. The primary theme behind these books is to explain how to perform common assembly-language programming tasks for the various microprocessors, and to provide tested routines for these tasks which can be included as part of larger programs.

The Z80 volume covers the Z80 instruction set, utility operations (such as multibyte arithmetic), stack operations, input/output (I/O) processing, character-code conversion, searching and sorting, decimal arithmetic, and floating point arithmetic. These topics were also covered in the 8080 volume. Additional chapters in the Z80 book include one that presents a simple space-capture game, and one entitled "Creative Programming Concepts," which discusses data structures. Appendices include the Z80 instruction set, character code and number-base tables, and hexadecimal object code dumps for the major programs in the book.

The first question that comes to mind is, "How does this book differ from the 8080 volume?" Obviously, the sections on the instruction set are changed. Besides having many more instructions to explain, the Z80 book uses Zilog mnemonics. Unfortunately, much of the rest of the book contains the old 8080 code with new mnemonics. Even the discussion of interrupts in the I/O section treats only mode 0 (8080-compatible), which is probably the least useful for anyone not trying to write 8080-executable code.

Another example of the lack of changes: absolute-jump instructions are used throughout the book where almost any Z80 programmer would use relative jumps. The major changes in the book then seem to be the discussion of the instruction set, the two new chapters, and the fact that the floating point routines appear to be shorter. If you have the 8080 volume, do not purchase this volume.

If you do not have the 8080 volume, then that is another story. Whether you want to convert American Standard Code for Information Interchange (ASCII) to Baudot code (or Selectric correspondence code), parse an input string, change number representations, fill memory, write timing loops, or whatever, you will probably find just the subroutine you are looking for. I have been taking subroutines out of the 8080 version of this book for two years now, and have yet to

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have one not work.

In conclusion, if you already have the *8080 Software Gourmet Guide and Cookbook*, just buy Scelbi's *Z80 Instruction Handbook;* the two together will give you almost everything in this volume, and you will save the cost of a floppy disk or two. If you do not have the 8080 volume, then the *Z80 Software Gourmet Guide and Cookbook* could be a good addition to your assembler reference library.

John A Lehman
716 Hutchins #2
Ann Arbor MI 48103

BASEX

Paul Warme
BYTE Books
Peterborough NH, 1979
softcover, 97 pages
$8

BASEX is an interactive compiler written for the 8080 family of computers. The book is complete with bar code, source listing and machine code listing.

Many language systems for microprocessors are written as interactive interpreters which do not convert the sentence-like statements of the language into machine code, but simply perform the command in each line of source program as the line is scanned. In short, the language system interprets statements and performs tasks via interpretative run-time routines. In contrast, a compiler does not immediately execute statements in source code, but translates the source code into object code which can be directly executed by the machine.

There are advantages to both approaches in implementing a computer language, and I simply will refer the reader to the almost never-ending discourse in any of the computer journals for the facts and opinions. My bias is towards use of compilers.

When you purchase *BASEX*, you receive a well-written document describing an interesting approach to compiler construction. First, you get a complete assembler source listing of all the run-time routines that add, subtract, multiply, and divide; and that perform memory block-move, memory read, memory write, memory compare, accumulator OR operations; plus routines that perform input and output. You also get a listing of the BASEX compiler and a relocating loader, both written in BASEX. What you do not get is floating point math, error messages, error recovery operations, and mass storage operations.

I bought *BASEX* to see if it could be used in a business environment. It simply is not sophisticated enough for business use, but it is ideal for text editors, disk operating systems, and other applications where high speed, simple math, and well-defined static applications prevail. If serious use of BASEX is contemplated, the following should be developed:

- mass storage capabilities;
- error intercept and recovery routines;
- a trace function for debug purposes;
- a binary look up routine for the symbol table; and
- routines to let the compiler perform memory

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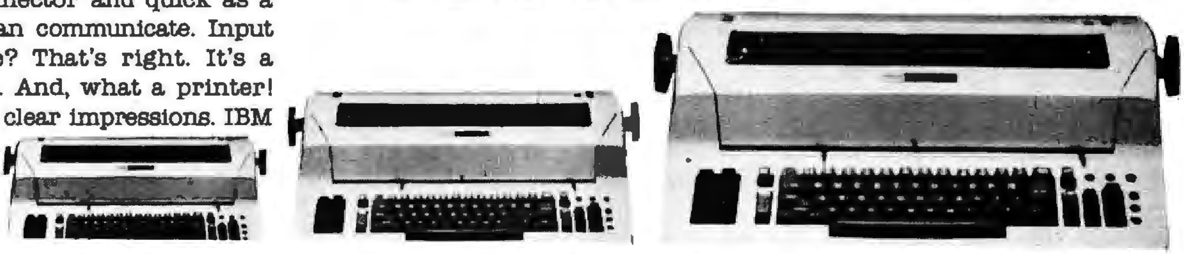

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management for line insert and delete.

Linking BASEX to CP/M

BASEX may be run as a command (COM) file under CP/M. First, enter the entire BASEX compiler into your computer. If you do not have a bar-code reader, prepare yourself for a three-hour exercise in data entry. Next, move the code residing at hexadecimal locations 0000 thru 0103 to hexadecimal locations 2000 thru 2103. Then place a JMP instruction at location 0100 which causes a branch to hexadecimal location 2105 (object code C3 05 21). At memory location 2105 assemble the following:

```
         LXI   H,2000H
         LXI   D,0H
MOVIT    MOV   A,M
         STAX  D
         INX   D
   MOV   A,D
         CPI   01H
         JNZ   MOVIT
         MOV   A,E
         CPI   03H
         JNZ   MOVIT
         JMP   0H
```

Follow the instructions in the *BASEX* book for changing I/O addresses in BASEX. Now save BASEX with CP/M as "BASEX.COM". Now type BASEX. You should be able to start using BASEX, unless you made an error somewhere.

I would be interested in hearing other readers' experiences with the BASEX compiler.

Wayne F Miller
905 Fairmont
Jefferson City MO 65101

BYTE's Bits

Wozniac Receives 1979 ACM Grace Murray Hopper Award

Stephen Wozniac, Vice President of Research and Development for the Apple Computer Co, Cupertino, California, received the Association for Computing Machinery (ACM) Grace Murray Hopper Award for "his many contributions to the rapidly growing field of personal computing and, in particular, to the hardware and software for the Apple Computer." The award acknowledges his work on programmable pocket calculators which he accomplished while employed by Hewlett-Packard. The annual award is given in recognition of achievements in the computer field made before attaining the age of 30. The $1000 award is donated by Sperry Univac, a longtime employer of Dr Hopper.

Real-Time BASIC Available Free

If you are doing process control applications in real time, you should investigate Lawrence Livermore Laboratory's (LLL) version of BASIC. It was developed with public funds, hence copies are available for just the duplication fee. Contact Harry Edwards, National Software Center, 9700 S Cass Ave, Bldg 221, Argonne IL 60439.

LLL BASIC was designed to run on an 8080-based system. The interpreter can execute BASIC source code contained in a read-only memory. A companion compiler can produce faster and more efficient object code. LLL BASIC has machine control statements and works with the Advanced Micro Devices AMD9511 mathematical-function integrated circuit for faster execution time.■

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Clubs and Newsletters

International Computer Chess Association

The International Computer Chess Association was established at the Second World Computer Chess Championship in Toronto in 1977. It currently has about 200 members, and publishes the *ICCA Newsletter* three or four times per year. The cost of membership for a single year is $10 in US funds. Contact Professor Ben Mittman, Vogelback Computer Center, Northwestern University, Evanston IL 60201.

Lincoln Micro-Computer Club

This club has changed its name from the Lincoln Computer Club to the present name. They meet on the first Wednesday of each month at 7 PM at the State Federal Savings and Loan on 40th St and South St in Lincoln, Nebraska. The club is open to users and owners of all types of microcomputers. Yearly subscription fees are $5. Contact Hubert Paulson Jr, 1209 Garber Ave, Lincoln NE 68521.

Micro

This club is open to users and owners of microcomputers. The members meet at 9:30 AM on the second Saturday of each month at the NWTI in Green Bay, Wisconsin. Contact Stuart Mong, 1824 Glenview Ave, Green Bay WI 54303.

Change in Meeting Place for Chicago Area Computer Hobbyist's Exchange (CACHE)

The CACHE group meets at the same time but now at the DeVry Technical Institute, 3300 N Campbell, Chicago IL. This is one block west of Western Ave.

New Information on the AIM-65 Newsletter

For information on AIM-65, contact Target, c/o Don Clem, RR 2, Spencerville OH 45887. Inquiries should include a self-addressed, stamped envelope and all orders must be prepaid. Sample copies are $1 each; a bi-monthly, one year subscription is $5 in the US and Canada and $12 (airmail) elsewhere.

CP/M Users Group

The Washington CP/M Users Group generally meets on the third Wednesday of each month at members' homes. Most members own S-100 disk systems with a variety of microprocessors, disks, terminals, printers, and boards. CP/M is the format of software exchange and the subject of frequent meetings. Annual dues are $6, primarily to cover postage. Contact Winston Riley III, 7315 Wisconsin Ave, Washington DC 20014.

 Circle 114 on inquiry card.

Wyoming Valley Computer Club

The TRS-80 users club in Pennsylvania is seeking new members. The Wyoming Valley Computer Club meets on the second Tuesday of every month at 7:30 PM at the Artco Electronics building in Kingston, Pennsylvania. There is a monthly newsletter for all members. For more information, contact Art Prutzman, Artco Electronics, 302 Wyoming Ave, Kingston PA 18704.

Apple Educators' Newsletter

This publication is devoted to educators and researchers using the Apple II system and other compatible systems. Articles concerning educational programs, grants for microcomputers and education, exchanges of ideas using computers in education, and general items are featured. Contact *Apple Educators' Newsletter*, 9525 Lucerne, Ventura CA 93003.

Apple Users Group in Arlington TX

The Fort Worth Apple Users Group (FWAUG) has been created to help users, owners and beginners understand and fully utilize their Apple II systems. The group meets on the third Sunday of each month at 3 PM at the CompuShop Store, 6353 Camp Bowie, Fort Worth TX. The group has a software program exchange and a library for members. The *FWAUG Newsletter* is an eight-page monthly publication, sent to all members. Dues are $9 per year. For more information, contact FWAUG, c/o Lee Meador, 1401 Hillcrest Dr, Arlington TX 76010.

OSI Superboard Club

This newsletter contains programs, ideas, technical data, hints and suggestions on the use of Ohio Scientific Challenger IP and Superboards. The newsletter will be published every two months. Send a self-addressed business envelope and $1 for further information to Superboard Club, POB 55, Agincourt, Ontario M1S 3B4 CANADA.

Dental Computer Newsletter

The DCN is a group of dentists, physicians and office management people that have interests in computers. DCN offers members a monthly newsletter, software exchange, advice and experience, and access to members in specific areas. Annual membership dues are $12 per year. Back issues of the *Dental Computer Newsletter* are $1 each and $10 per year. Membership and equipment listings are $5. Commercial software lists and DCN software exchange lists are free with a $0.28 stamped, self-addressed envelope. Contact *Dental Computer Newsletter*, E J Neiburger, editor, 1000 North Ave, Waukegan IL 60085.

Computer Law Journal

Each issue of the *Computer/Law Journal* is devoted to a single topic of computer law, and contains feature articles by experts in the field, a comprehensive bibliography on the featured topic, case digests of all significant court and administrative agency decisions on the topic, and other reference materials. Topics have included patent protection of computer software and computer-assisted legal research. Future issues will

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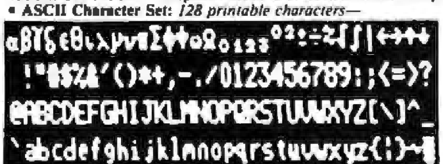

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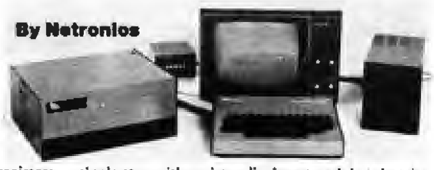

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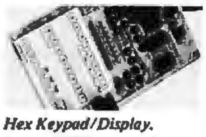
System Monitor (Hex Version): Tape load with labeling... tape dump with labeling... examine/change contents of memory...insert data...warm start...examine and change all registers...single step with register display at each break point ...go to execution address. Level "A" in the *Hex Version* makes a perfect controller for industrial applications and can be programmed using the Netronics Hex Keypad/Display.



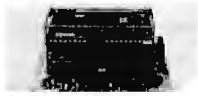
Hex Keypad/Display.

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.

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- ☐ **Level "B" (S-100) Kit,** $49.95 plus $2 p&h.
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Scampus

Articles on bus structures, software, conversion circuits and other aspects of microcomputers are covered in this monthly newsletter. The material comes from members of the group, so ideas and items are constantly needed and welcomed. There are no membership fees. A large supply of self-addressed, stamped envelopes are the only requirements. Write to *Scampus*, POB 132, Knob Noster MO 65336.

Another Apple II Club

The Adam and Eve Apple II Users Group meets at the Madison Public Library in Madison, Wisconsin on the second Tuesday of each month at 7 PM. The group wants to exchange newsletters and software with other groups and receive advice on software. Adam and Eve is a subscriber of *The Source*, an information network. The dues are $1 per meeting or $3 per year for the *Adam & Eve Newletter*. For more information, write to Adam and Eve, Apple II Users Group, 11 S Hancock St, Madison WI 53703. ■

BYTE's Bugs

Reversi Bug Makes Computer End Game Too Quickly

Several readers have pointed out a problem in the program published in "Programming Strategies in the Game of Reversi," November 1979 BYTE, page 66. In the program given in listing 1, the published code behaves in the following manner. Either after you have twice forced the computer into a position where it has no legal moves, it concedes the game and resigns; or after the computer has forced you into a moveless position twice, it declares itself to have won the game. Thanks to Darrell Pittman, Jack Guinnip, Delmer Hinrichs, Willy Verwoerd, and Betty Vogel for spotting the error.

Mr Guinnip deserves special praise, not only for spotting the error so quickly, but for doing it while working through the program with pencil and paper. He does not have access to a computer, as an inmate of the Sheridan Correctional Center in Illinois.

A simple patch suggested by Mr Pittman was published in the February 1980 BYTE on page 168, but readers may instead wish to make the somewhat more complete correction suggested by Mr Hinrichs. This includes a change to line 1382 and insertion of two other lines:

```
1382IF B(K) = THEN 1396
1396LET T3 = 0
1398RETURN
```

To improve the quality of play, Ms Vogel suggests that line 4200 be deleted, and that line 5310 be changed to read:

```
5310LET E(79) = 5
```

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Product Reviews

Lucidata P-6800 Pascal

Phil Hughes, POB 2847, Olympia WA 98507

If you own a Southwest Technical Products Corporation (SwTPC) compatible system that runs Technical Systems Consultants' FLEX 2.0 or mini-FLEX operating system, you too can use Pascal. P-6800 Pascal is a substantial subset of full Pascal, and is designed for a SwTPC with FLEX or mini-FLEX.

I mailed my order for P-6800 Pascal, and thirteen days later the manual and disk arrived. I would consider this excellent delivery if Lucidata were in Kansas, but they are in the Netherlands! Even if it had not worked, I think I would have been amazed.

Two major items missing from this Pascal subset are the REAL and RECORD data types. Also missing are some of the capabilities of other directives. For example, the TYPE directive only supports enumerated types.

Looking at the capabilities in a more positive light, files, procedures, functions, recursion, and multidimensioned arrays are supported. The branching constructs IF . . THEN . . ELSE and CASE . . OF as well as the looping constructs REPEAT . . UNTIL and WHILE . . DO are also supported. Data types that are supported are BOOLEAN, CHAR, ALFA (six-character string), INTEGER, and BYTE as well as scalars which can be made members of sets.

The standard input/output (I/O) procedures (RESET, REWRITE, READLN, WRITELN, READ, WRITE) are defined, as are the standard ordinal and predicate functions ORD, CHR, SUCC, PRED, ODD, EOF and EOLN. Additionally, the procedures HALT and POKE are defined as are the functions PEEK and USER.

The compiler generates pseudocode (p-code) that is interpreted by the run-time system. The run-time system simulates the Pascal P-machine. For those unfamiliar with Pascal, this is a standard approach. The P-machine is a theoretical, stack-oriented machine designed specifically for execution of Pascal. This makes it possible to transport the compiler to another machine by writing a p-code interpreter for the new machine.

The Lucidata run-time system allows automatic paging of the p-code file. In other words, if all of the p-code for your program does not fit in available memory, the run-time system reads it in pieces from a disk as required. Because of this feature, it is possible to run the compiler in 12 K bytes (plus 4 K or 8 K for mini-FLEX or FLEX).

The manual describes this particular subset of Pascal in detail, then discusses the run-time system. This includes a description of how to use files. The memory requirements are discussed next. This includes how to estimate memory required for p-code, stack, and file buffers, and for the run-time system. The estimation of disk storage requirements is also discussed. The final chapters cover fine tuning of your programs and the run-time system. The customizing of the run-time system includes interfacing your program to assembly language subroutines and support of non-FLEX-compatible peripheral devices.

Five appendices are included. The first is the syntax diagrams for P-6800 Pascal. Next is a list of compiler error messages. Then there is a list of run-time error messages. The fourth appendix consists of sample programs that demonstrate most of the system capabilities. These sample programs are also on the system disk so you can play with them. The last appendix is a bibliography of further reading on Pascal.

What you receive is a P-6800 Pascal compiler and run-time package, a good manual, sample programs, and excellent delivery. If you are running FLEX 2.0 or mini-FLEX, the Pascal system can be installed in a few minutes. The P-6800 package costs $150.00 from Lucidata, Oosteinde 223, 2271 EG Voorburg, Netherlands. Their telephone number in the Netherlands is 70-862387.■

Technical Forum

The Direct Impact of the Computer

Richard S Shuford, Editor

Some years ago, I was doing volunteer work for a nonprofit organization. Late one evening we were preparing an important newsletter for mailing the next day. We had used a computer at Lenoir-Rhyne College, where I was a student, to prepare our adhesive address labels. We had pasted on all the labels when we found that our rubber stamp that said "ADDRESS CORRECTION REQUESTED" had been lost.

Groaning over our misfortune, we were just about to begin the time-consuming task of writing this message on every envelope by hand, when I had the following thought: the computer printed the address labels for us; why can't it print *this* simple message?

I began to consider how the job could be handled using the computer facilities available. Adhesive labels were too expensive to print the message on and then affix to the envelopes. But wait, perhaps we do not have to use the labels. Could the computer printer print directly on the envelopes?

A time-honored principle is that if there is a simple test to be made, make it. So I gathered up several newsletter envelopes and hastened to the college's academic computer center to try it.

The particular printing peripheral I had in mind was a Centronics Model 101A, high-speed, serial character impact printer, which we loosely called a "line printer." This Centronics machine prints dot-matrix characters by driving a column of print pins into an inked ribbon held before the paper as the print head moves horizontally. (Many other printers also work in this manner.) The Centronics printer has a paper-thickness adjustment, which soon became important.

The Centronics printer was attached to a minicomputer timesharing system. I logged into the system, and quickly wrote a BASIC program. After a brief period of experimentation, I saved my program, logged out, and dashed back to the other late-night envelope-stuffers to report success.

I led a disbelieving troop of workers carrying stacks of envelopes back to the computer room to see how I was going to save them a lot of work by letting the machine do some. My demonstration worked like this.

I logged in and called up the BASIC program I had written for my experiment. This program is shown in listing 1. I typed "RUN" on my terminal, and with one hand held a newsletter envelope carefully inside the print position of the Centronics printer, just behind the ribbon. As the others crowded around to see what I was doing, I hit the carriage return key on the terminal with my free hand. The print head buzzed and moved across the envelope. I held up the letter, and all could see that "ADDRESS CORRECTION REQUESTED" was plainly printed on it in dot-matrix characters.

Well, we set up an assembly line to insert envelopes into the printer and then to stack them. We found that using the computer printer actually was faster than using the rubber stamp, but I do not recommend buying a computer if you can get by using a rubber stamp under normal conditions. The computer did allow us to get our mailing out on time. (Later on, of course, it was not so much fun to pay $0.25 for every corrected address that came back, but we got our mailing list updated).

If you want to try to use this rubber-stamp simulator, observe these points. The print head can move very fast, and you *can* hurt yourself if you are not careful as you hold the paper inside the printer. You have to be sure to hold the paper in the right place. With the Centronics, the right place is approximately 5 cm (2 inches) to the right of the print head's rest position, behind the ink ribbon. Timing is not critical with this program. Note that the program requires that you press the return key before it will print anything. There is no rush to insert the paper into the printer, since you just hit the key when you are ready.

Finally, note that the paper-thickness adjustment is fairly critical for printing on an envelope that has a newsletter in it. Adjust carefully, so that the print head neither shreds the envelope, nor fails to print, nor jams and becomes damaged.

The moral of this story is not that rubber stamps are obsolete. Rather this: a general-purpose computer system is *exactly* that—general purpose. If you buy a computer to assist you in keeping up with your tax records or the like, that is fine. But don't forget that the *program* determines the function of the computer. The next time you have a problem, whether simple or complex, perhaps the computer can help you with it.

Listing 1: *A BASIC program that uses a computer equipped with an impact printer to simulate a rubber stamp in printing a simple message many times.*

Line 10 determines what message is printed. Lines 20, 30, and 40 print the message on the terminal for verification. Line 50 is used to give the human operator time to put the paper inside the printer in the correct position. The computer will not output the message to the printer until the operator presses the return key in response to the INPUT statement in line 50. Variable B$ is merely a dummy variable.

The LPRINT statement in this version of BASIC causes output to the line printer. The TAB(10) function causes 10 spaces to be printed before the message. Line 70 causes the program to loop indefinitely. Execution must be terminated by some means provided by the system. Such a means could be typing control-C, pressing a Break key, or hitting a Reset switch.

```
 5 REM RUBBER STAMP SIMULATOR
 6 REM USE WITH COMPUTER IMPACT PRINTER
10 A$ = "ADDRESS CORRECTION REQUESTED"
20 PRINT "HIT 'RETURN' KEY TO PRINT"
30 PRINT A$
40 PRINT "WITH PRINTER."
50 INPUT B$
60 LPRINT TAB(10); A$
70 GOTO 50
99 END ■
```

Technical Forum

Cutting the Gregorian Knot

Myron Pulier MD, 101 Cedar Ln, Teaneck NJ 07666

Program development is more an artistic process of playful reshaping than it is an analytic process of systematic logic. This proved true in a search for an efficient way of handling dates in computer programs.

Using dates in Julian day-number form simplifies manipulation of date information. For example, if the Julian date of the *calendar* date January 1 is 1, then February 2 would be 33 and December 31 would be 365, or 366 on leap year. Clearly it is easier to store a single number than to wrestle with a number triplet like 9/8/79. Furthermore, the Julian concept makes finding the number of days between two dates a trivial process.

Calculation of the Julian date is complicated because Roman legislators altered Julius Caesar's orderly scheme by making the months uneven in length. This inspired Richard Grafton's famous table lookup. In the year 1570 he wrote "Thirty days hath November, April, June, and September," etc. While there's no longer much danger of copyright infringement, Grafton's method wastes memory space, rest his soul.

According to Grafton the months with thirty days are the eleventh, fourth, sixth and ninth, which seems difficult to convert into a formula. If only Grafton and his politician forebears had given the second month thirty days as well! We would then be close to the familiar sequence 2,4,6,8,10, which can be calculated by the formula $B = 2 \times A$. If we plot the numbers 2, 4, 6, 9, 11 as the first, second, third, fourth, and fifth numbers of a set (as shown in figure 1), all we need is a formula that threads a line slightly above the desired values for B. We can then throw away the fractional parts by truncating the resulting B value to an integer. In other words, we want a formula of the form:

$$B = \mathrm{INT}(C1 \times A + C2) \qquad (1)$$

The determination of suitable values for the constants C1 and C2 may not be immediately obvious. An empirical method for finding C1 and C2 is trial-and-error substitution using the following BASIC program:

```
110   INPUT C1, C2
120   FOR A = 0 TO 13
130     LET B = C1 * A + C2
140     PRINT A, INT ( B ), B
150   NEXT A
160   GOTO 110
```

I suggest you enter the above program on your own computer and try values for C1 and C2.

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for (i = 1; i < 30000; i++) x = 5;
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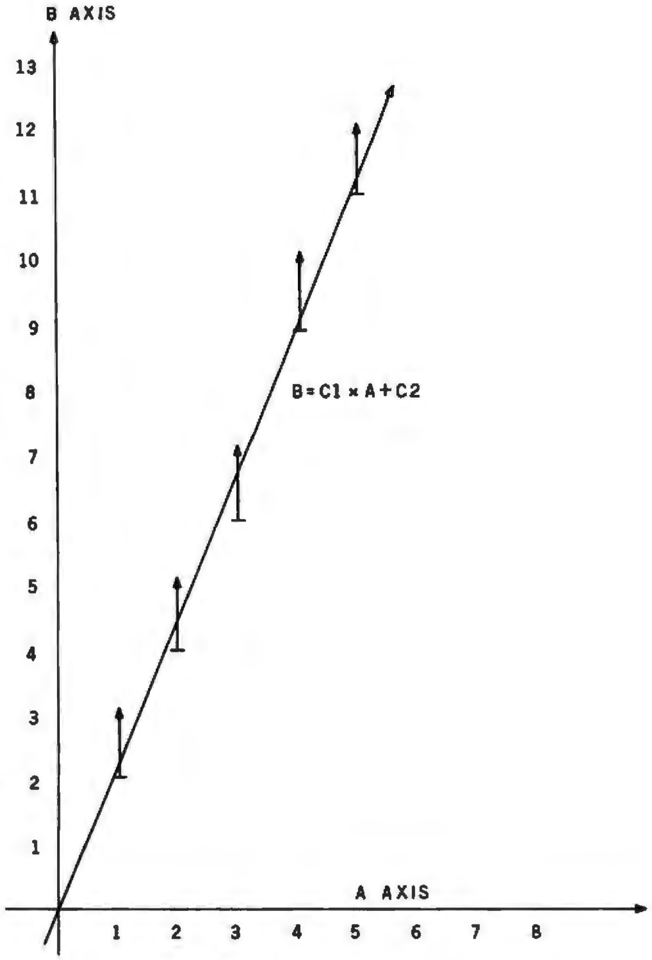

Figure 1: *Fitting the numbers 2, 4, 6, 9, 11 to the straight-line equation $B = C1 \times A + C2$. Given the sequence 2, 4, 6, 9, 11, we can represent this in two dimensions by letting the horizontal axis represent the order of the number in the sequence (first, second, etc), and the vertical axis, the value of the number (2, 4, etc). Thus, the fourth number in the sequence, 9, gives the point (4,9) to be plotted. These numbers are almost, but not quite, on a straight line. But if we stipulate that the line can go through the unit line segments extending above each point, then the integer values can be obtained by truncating the values obtained with the INT function in BASIC.*

Playing around with this program shows that C1 can range between 2 and 2.5 if C2 is suitably chosen between −0.5 and 1. For example, setting C1 to 2.25 and C2 to 0 gives the desired sequence of 2,4,6,9,11,. . . for INT(B).

Now we can turn our attention to the irregularities in the Gregorian calendar. First, let us temporarily give February thirty days (remember that month 2, February, is included in the above sequence). Next, calculate the Julian values of the last days of each month in this altered year. The numbers are 31, 61, 92, 122, 153, 183, 214, 245, 275, 306, 336, 367. (The extra two days in February give us a 367-day year). Can we find a formula that threads its way along the last days of each month?

We have 367 days divided among 12 months. That comes to a new month about every 30.58 days. If we use 30.58 for C1 in the program we wrote, we find that the output comes close to the sequence we want. A few minutes of tinkering with C2 shows that 0.5 works nicely. The expression M-1 gives us the last day of the preceding month. Substituting the values for C1 and C2, and using (M−1) in place of A in equation (1) produces the equation:

$$B = INT(30.58 \times M - 30.08) \tag{2}$$

A quick check with our BASIC program shows that we can get away with three bytes less with the following equation:

$$B = INT(30.57 \times M - 30) \tag{3}$$

If we compensate for leap years and for the 28-day February, we have the following BASIC subroutine for computing the Julian date, Z, given the month, M, day, D, and year, Y.

```
210   Z = INT ( 30.57 * M - 30 ) + D
220   IF M < 3 THEN RETURN
230   IF INT ( Y / 4 ) * 4 = Y
        THEN Z = Z - 1 : RETURN
240   Z = Z - 2 : RETURN
```

Using the constant values we found for equation (3), line 210 calculates the Julian date of the end of the month preceding month M. Adding the day of the month to this produces a first estimate of the Julian date of the given calendar date. Line 220 says that if it is before March, we are done. Otherwise, in line 230 we adjust for a 29-day February if it is leap year (until now we were crediting February with 30 days), or for 28 days if it is not leap year. Let us forget about leap centuries for now.

We can improve on this system. We have been defining the Julian date, Z, as the number of days since the previous December 31. To include information about the year, we can define a new type of Julian date, J, as the number of days elapsed since December 31 of some base year, say 1972. To calculate J, we first find Z, then add the days in each year between the present year and 1972. Years have an average of 365.25 days. If we try 365.25 for C1 and 0 for C2 in our original BASIC program tool, we get the Julian dates of the last day of each year. Taking December 31, 1972 as our base and the year, Y, in the form "yy" rather than "19yy" we modify equation (3) to:

$$B = INT(30.57 \times M - 30) + INT(365.25 \times (Y - 1 - 72)) \tag{4}$$

This may be rearranged to:

$$B = INT(30.57 \times M) + INT(365.25 \times Y - 26693.25) \tag{5}$$

bringing us to the new BASIC subroutine:

```
310   J = INT (30.57 * M) + INT (365.25
        * Y - 26693.25) + D
320   IF M < 3 THEN RETURN
330   IF INT ( Y / 4 ) * 4 = Y
        THEN J = J - 1 : RETURN
340   J = J - 2 : RETURN
```

The above will return negative values for dates before December 31, 1972.

Listing 1: *BASIC routines for converting between the Julian date and the calendar (month, day, year) date and for determining the day of the week from the Julian date. In Processor Technology BASIC, the multiple-line user-defined functions (ending with FNEND) are permitted; also, J$(A,B) is the substring of the unsubscripted string variable "J$", from Ath to Bth character.*

```
700 REM======================================
710 REM
720 REM.          DATE HANDLING PACKAGE
730 REM
740 REM======================================
750 REM--------------------------------------
760 REM.   CALENDAR TO JULIAN CONVERSION
770 REM
780 REM.Given day, D, month, M and year, Y
790 REM.returns the number of days elapsed
800 REM.since December 31, 1900.
810 REM--------------------------------------
820 DEF FNJ(D,M,Y)
830 LET X=INT(30.57*M)+INT(365.25*Y-395.25)+D
840 IF M<3 THEN  RETURN X
850 IF INT(Y/4)*4=Y THEN  RETURN X-1
860 RETURN X-2
870 FNEND
880 REM
890 REM--------------------------------------
900 REM.   JULIAN TO CALENDAR CONVERSION
910 REM
920 REM.Given D, number of days elapsed since
930 REM.December 31, 1900, returns day, D,
940 REM.month, M, and year, Y.
950 REM--------------------------------------
960 LET Y=INT(J/365.26)+1
970 LET D=J+INT(395.25-365.25*Y)
980 LET D1=2: IF INT(Y/4)*4=Y THEN  LET D1=1
990 IF D>91-D1 THEN  LET D=D+D1
1000 LET M=INT(D/30.57),D=D-INT(30.57*M): RETURN
1010 REM.
1020 REM--------------------------------------
1030 REM.         JULIAN COMPACTION
1040 REM
1050 REM.Given julian, J, returns 2-byte
1060 REM.representation of J
1070 REM--------------------------------------
1080 DEF FNJ$(J)
1090 LET J1=INT(J/256): RETURN CHR(J1)+CHR(J-J1*256)
1100 FNEND
1110 REM
1120 REM--------------------------------------
1130 REM.          JULIAN EXPANSION
1140 REM
1150 REM.Given J$, a 2-byte representation of a
1160 REM.julian, returns decimal value of julian
1170 DEF FNJ1(J$)=256*ASC(J$(1,1))+ASC(J$(2,2))
1180 REM
1190 REM--------------------------------------
1200 REM.       DAY OF WEEK CALCULATION
1210 REM
1220 REM.Returns day of week (Sunday = 1) given
1230 REM.the julian, J
1240 REM--------------------------------------
1250 DEF FNW(J)
1260 LET W=(J+1)/7: RETURN INT((W-INT(W))*7+1.1)
1270 FNEND
```


Now that we have a way of abbreviating the calendar date into a Julian date, we need a program for reversing the conversion. This is done by extracting the year, correcting for a 28- or 29-day February, then extracting the month to leave the day of the month as the remainder:

```
410    Y = INT ( J / 365.25 + 73 )
420    Z = J + INT (26693.25 − 365.25 * Y )
430    D1 = 2 : IF INT ( Y / 4 ) * 4 = Y
         THEN D1 = 1
440    IF Z > 91 − D1 THEN Z = Z + D1
450    M = INT (Z / 30.57 )
460    D = Z − INT ( 30.57 * M )
470    RETURN
```

Line 420 computes the day of the year, Z. Then D1 is set to 1 if the year is a leap year, or 2 otherwise. Z is adjusted for the proper February length in line 440, if the day is after February. The month is extracted in line 460, leaving D, the day of the month. Unfortunately, the program above is wrong for New Year's Day after a leap year because the value for Y lags a bit. This can be managed by setting the divisor in line 410 to 365.26. The resulting inaccuracy will not cause trouble for thousands of years.

You will see that selecting 1900 rather than 1972 as the base year will save two bytes each in lines 310 and 420 and one in line 410. [**Note**: *Astronomers calculate Julian day numbers using the date January 1, 4713 BC as a base; all historical dates become positive numbers. . . .*RSS]

If your version of BASIC handles character strings, it can compact each non-negative Julian date into two bytes of storage, which could speed input and output of dates by a factor of four. The following routine in Processor Technology BASIC essentially converts the decimal value of the Julian date to a base-256 number:

```
510    J1 = INT ( J / 256 )
520    J$ = CHR( J1 ) + CHR( J − J1 * 256 )
```

where CHR (J1) is the character with the ASCII code J1. Converting the string J$ back to a decimal value is done as follows:

```
610    J = 256 * ASC ( J$ ( 1 , 1 ) ) + ASC
         ( J$ ( 2 , 2 ) )
```

where J$ (n , n) is the n-th character in J$ and where ASC(C$) is the decimal value of the ASCII code for C$. The two bytes in J$ can cover a span of 256*x*256/365.25 = 179 years.

The day of the week is readily calculated from the modulo 7 value of the Julian date. We can now reshape our programs into a compact and efficient package for handling dates between 1901 and 2080.

As for leap centuries, Pope Gregory luckily decreed the year 2000 a leap year, although 1900 was not. Century years not evenly divisible by 400 are not leap years. Therefore, the routines in listing 1 will be wrong for dates before March 1, 1900, but are useful for most practical applications.■

Operation Codes of the 8080, 8085, and Z80 Processors

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Manual conversion between assembly language mnemonics and hexadecimal object code can be tedious — particularly if much code is involved. However, the task does not have to be overwhelming. A conversion table helps immensely and is also a good training aid for novice programmers. It presents the entire instruction set in compact form, revealing useful patterns, and also inconsistencies.

8080 and 8085 Operation Codes

Operation codes for the Intel 8080 and 8085 microprocessors are shown in table 1. The only difference between the instruction sets for this pair is that the 8085 has two additional instructions: the read-interrupt-mask instruction (mnemonic RIM, hexadecimal code 20), and the set-interrupt-mask instruction (mnemonic SIM, hexadecimal code 30). They allow the user to control interrupts and a serial I/O (input/ output) line, thus making them useful additions.

The position of an 8080/8085 operation code in the table does not give a reliable clue about the implied addressing mode. Table 1 is generally organized according to the operands involved. Residing in the middle eight columns of the table (columns 4 thru B) for example, are the instructions for single-byte move, arithmetic, and logical operations. (Length attributes in this article refer to data, rather than instruction length, unless otherwise noted.) Regardless of the column, progression through the eight possible choices for the source (second) operand is always in the same sequence as the user moves down a column: registers B thru L; followed by memory reference; and finally, register A, the accumulator. Then, because each column has sixteen entries, the sequence repeats. If the arithmetic and logical instruction groups do not seem to conform to this rule, note that the first operand (always register A) is implied rather than stated explicitly.

This same sequence is used for advancing through choices for the destination (first) operand. In this case, however, progression is column to column from left to right, with each successive column containing *two* of the eight possible operands. The double-byte instructions also conform to this first-operand type of arrangement. Most of these appear in the first four columns of the table; however, the stack commands to PUSH and POP double-byte data are located at the far right in the top section.

An apparent inconsistency appears in the middle of the table. Hexadecimal code 76 is the instruction to halt the processor (HLT). Expected there instead is MOV M,M, the op code meaning "move the content of the memory location whose address is in the H and L register pair into that

Text continued on page 197

Circle 139 on inquiry card.

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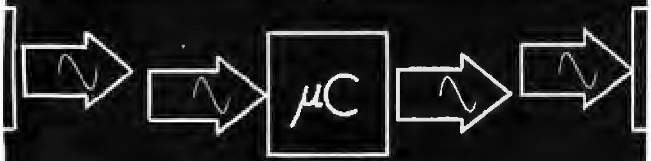

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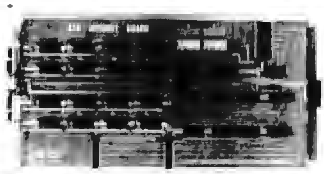

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First Nybble (columns) / Second Nybble (rows)

	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0	NOP		RIM	SIM	MOV B,B	MOV D,B	MOV H,B	MOV M,B	ADD B	SUB B	ANA B	ORA B	RNZ	RNC	RPO	RP
1	LXI B	LXI D	LXI H	LXI SP	MOV B,C	MOV D,C	MOV H,C	MOV M,C	ADD C	SUB C	ANA C	ORA C	POP B	POP D	POP H	POP PSW
2	STAX B	STAX D	SHLD	STA	MOV B,D	MOV D,D	MOV H,D	MOV M,D	ADD D	SUB D	ANA D	ORA D	JNZ	JNC	JPO	JP
3	INX B	INX D	INX H	INX SP	MOV B,E	MOV D,E	MOV H,E	MOV M,E	ADD E	SUB E	ANA E	ORA E	JMP	OUT	XTHL	DI
4	INR B	INR D	INR H	INR M	MOV B,H	MOV D,H	MOV H,H	MOV M,H	ADD H	SUB H	ANA H	ORA H	CNZ	CNC	CPO	CP
5	DCR B	DCR D	DCR H	DCR M	MOV B,L	MOV D,L	MOV H,L	MOV M,L	ADD L	SUB L	ANA L	ORA L	PUSH B	PUSH D	PUSH H	PUSH PSW
6	MVI B	MVI D	MVI H	MVI M	MOV B,M	MOV D,M	MOV H,M	HLT	ADD M	SUB M	ANA M	ORA M	ADI	SUI	ANI	ORI
7	RLC	RAL	DAA	STC	MOV B,A	MOV D,A	MOV H,A	MOV M,A	ADD A	SUB A	ANA A	ORA A	RST 0	RST 16	RST 32	RST 48
8					MOV C,B	MOV E,B	MOV L,B	MOV A,B	ADC B	SBB B	XRA B	CMP B	RZ	RC	RPE	RM
9	DAD B	DAD D	DAD H	DAD SP	MOV C,C	MOV E,C	MOV L,C	MOV A,C	ADC C	SBB C	XRA C	CMP C	RET		PCHL	SPHL
A	LDAX B	LDAX D	LHLD	LDA	MOV C,D	MOV E,D	MOV L,D	MOV A,D	ADC D	SBB D	XRA D	CMP D	JZ	JC	JPE	JM
B	DCX B	DCX D	DCX H	DCX SP	MOV C,E	MOV E,E	MOV L,E	MOV A,E	ADC E	SBB E	XRA E	CMP E		IN	XCHG	EI
C	INR C	INR E	INR L	INR A	MOV C,H	MOV E,H	MOV L,H	MOV A,H	ADC H	SBB H	XRA H	CMP H	CZ	CC	CPE	CM
D	DCR C	DCR E	DCR L	DCR A	MOV C,L	MOV E,L	MOV L,L	MOV A,L	ADC L	SBB L	XRA L	CMP L	CALL			
E	MVI C	MVI E	MVI L	MVI A	MOV C,M	MOV E,M	MOV L,M	MOV A,M	ADC M	SBB M	XRA M	CMP M	ACI	SBI	XRI	CPI
F	RRC	RAR	CMA	CMC	MOV C,A	MOV E,A	MOV L,A	MOV A,A	ADC A	SBB A	XRA A	CMP A	RST 8	RST 24	RST 40	RST 56

Table 1: *Mnemonics of the operation codes of the 8080 and 8085 microprocessors arranged conveniently for conversion to the hexadecimal object code. This task is aided by the organizational consistency of the instruction set. The two instructions (RIM and SIM) found only in the 8085 are indicated by shading.*

Text continued from page 194:
same memory location." The expected instruction is effectively just a slow equivalent of the no operation (NOP) located at hexadecimal 00. Hence, its replacement by the halt command improves, rather than degrades the power of the instruction set. Still, I wonder why an otherwise empty spot in the table was not chosen — as was done for the two additional 8085 instructions.

The right quarter of the table mainly contains program branching and data exchange instructions. Excluding the previously mentioned stack commands, none of these have explicit operands so the previously discussed organization is impossible. The miscellaneous nature of these instructions also tends to prevent predictable order.

Nonetheless, the op codes in this area have a consistent structural style. Most are arranged in complementary order, with mutually exclusive conditions placed in the same column, separated by eight rows. The group of return instructions is typical. The unconditional return from subroutine command is hexadecimal C9. Starting immediately above it and proceeding to the right, four of the eight conditional return instructions are found. The other four (the complements) are eight rows higher.

The order in which these conditions appear is uniform from group to group. To determine that this is so, compare similar elements of the call, jump, and return groups. The unconditional jump (JMP) instruction is a curious exception. Its expected code is CB, but it actually appears eight rows higher in the table. Such exceptions are few enough not to be bothersome.

Z80 Operation Codes

The Z80 is an enhanced version of the 8080. It runs faster, has twice as many general purpose registers, and has a much larger instruction set. Included as a subset in this instruction is the entire repertoire of the 8080. (This compatibility exists at the machine language level, but not the assembly language level; standard mnemonics and assembly language formats for the two processors differ considerably.) Thus, in hexadecimal object form, almost any program written for the 8080 will produce identical results when executed by a

Z80. Because of the Z80's generally higher speed, software timing loops are an exception to this upward compatibility feature. [**Editor's note:** *There is also a slight difference in the operation of the parity flag* . . . .RSS]

The similarities of the two instruction sets can be seen by comparing corresponding positions of table 1 and table 2. Table 2 is the basic conversion table for the Z80. For every valid 8080 instruction in table 1, its correspondent in table 2 produces logically equivalent results. The differences between the two instruction sets stem from the twelve positions unused by the 8080. These, which are clearly indicated in table 2, are used to greatly expand the Z80's capability.

The Zilog Corp used the seven unfilled positions on the left side of table 1 and the uppermost one on the right side to give the Z80 processor the ability to perform relative branching and to exchange the contents of its two sets of registers. However, the use of hexadecimal codes 20 and 30 for two of the jump relative instructions means that the Z80 is not as compatible with the 8085 as it is with the 8080.

The real expansion of the Z80's instruction set over that of the 8080 is the result of the interesting use of the four other empty spaces in table 1. In essence, the Z80 uses them as pointers to four additional 16 by 16 tables, thus increasing the number of possible op codes by 1532. (The Z80 does not use most of these, but flexibility for future expansion is certainly there.) Had this innovative use of the unimplemented codes not been done, the Z80 would have been limited to 256 different op codes, which is only twelve more than the 8080.

There is a penalty for this flexibility: all instructions in these expansion sets must be multibyte. The first byte identifies the appropriate expansion instruction set, after which, the second byte identifies the operation to be performed. Sometimes there is an additional third or fourth byte to provide data or addressing information.

Shift, Rotate, and Bit Manipulation Instructions

Consider these pointer instructions one at a time. All of the instructions which begin with hexadecimal CB are contained in table 3. All of the *direct-*

First Nybble (columns) / Second Nybble (rows)

	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0	NOP	DJNZ e	JR NZ,e	JR NC,e	LD B,B	LD D,B	LD H,B	LD (HL),B	ADD A,B	SUB B	AND B	OR B	RET NZ	RET NC	RET PO	RET P
1	LD BC,nn	LD DE,nn	LD HL,nn	LD SP,nn	LD B,C	LD D,C	LD H,C	LD (HL),C	ADD A,C	SUB C	AND C	OR C	POP BC	POP DE	POP HL	POP AF
2	LD (BC),A	LD (DE),A	LD (nn),HL	LD (nn),A	LD B,D	LD D,D	LD H,D	LD (HL),D	ADD A,D	SUB D	AND D	OR D	JP NZ,nn	JP NC,nn	JP PO,nn	JP P,nn
3	INC BC	INC DE	INC HL	INC SP	LD B,E	LD D,E	LD H,E	LD (HL),E	ADD A,E	SUB E	AND E	OR E	JP nn	OUT (n),A	EX (SP),HL	DI
4	INC B	INC D	INC H	INC (HL)	LD B,H	LD D,H	LD H,H	LD (HL),H	ADD A,H	SUB H	AND H	OR H	CALL NZ,nn	CALL NC,nn	CALL PO,nn	CALL P,nn
5	DEC B	DEC D	DEC H	DEC (HL)	LD B,L	LD D,L	LD H,L	LD (HL),L	ADD A,L	SUB L	AND L	OR L	PUSH BC	PUSH DE	PUSH HL	PUSH AF
6	LD B,n	LD D,n	LD H,n	LD (HL),n	LD B,(HL)	LD D,(HL)	LD H,(HL)	HALT	ADD A,(HL)	SUB (HL)	AND (HL)	OR (HL)	ADD A,n	SUB n	AND n	OR n
7	RLCA	RLA	DAA	SCF	LD B,A	LD D,A	LD H,A	LD (HL),A	ADD A,A	SUB A	AND A	OR A	RST 00H	RST 10H	RST 20H	RST 30H
8	EX AF,AF'	JR e	JR Z,e	JR C,e	LD C,B	LD E,B	LD L,B	LD A,B	ADC A,B	SBC A,B	XOR B	CP B	RET Z	RET C	RET PE	RET M
9	ADD HL,BC	ADD HL,DE	ADD HL,HL	ADD HL,SP	LD C,C	LD E,C	LD L,C	LD A,C	ADC A,C	SBC A,C	XOR C	CP C	RET	EXX	JP (HL)	LD SP,HL
A	LD A,(BC)	LD A,(DE)	LD HL,(nn)	LD A,(nn)	LD C,D	LD E,D	LD L,D	LD A,D	ADC A,D	SBC A,D	XOR D	CP D	JP Z,nn	JP C,nn	JP PE,nn	JP M,nn
B	DEC BC	DEC DE	DEC HL	DEC SP	LD C,E	LD E,E	LD L,E	LD A,E	ADC A,E	SBC A,E	XOR E	CP E	See Table 3	IN A,(n)	EX DE,HL	EI
C	INC C	INC E	INC L	INC A	LD C,H	LD E,H	LD L,H	LD A,H	ADC A,H	SBC A,H	XOR H	CP H	CALL Z,nn	CALL C,nn	CALL PE,nn	CALL M,nn
D	DEC C	DEC E	DEC L	DEC A	LD C,L	LD E,L	LD L,L	LD A,L	ADC A,L	SBC A,L	XOR L	CP L	CALL nn	See Table 4	See Table 8	See Table 5
E	LD C,n	LD E,n	LD L,n	LD A,n	LD C,(HL)	LD E,(HL)	LD L,(HL)	LD A,(HL)	ADC A,(HL)	SBC A,(HL)	XOR (HL)	CP (HL)	ADC A,n	SBC A,n	XOR n	CP n
F	RRCA	RRA	CPL	CCF	LD C,A	LD E,A	LD L,A	LD A,A	ADC A,A	SBC A,A	XOR A	CP A	RST 08H	RST 18H	RST 28H	RST 38H

Table 2: *Mnemonics of the operation codes of the Z80 microprocessor arranged for conversion to hexadecimal object code. Corresponding positions of table 1 and table 2 generally perform the identical function, despite differences in notation. Enhancements of the 8080 instruction set are indicated by shading. Mnemonics used here are those specified by Zilog.*

mode instructions to shift or rotate (in either direction) any byte in memory or in any of the eight active registers are located here. Table 3 also contains the direct-mode instructions to set, reset, or test any bit in any of these bytes. All of these operations have a length of two bytes. Interestingly, there are more valid instruction combinations derived from the ten basic instructions in this table than there are in the entire 8080 set.

Two features of table 3 are notable. The first is the absence of a "shift left logical" counterpart to the SRL command group. The shift left logical counterpart is not there because it is not needed; the "arithmetic shift left" instructions in column 2 (hexadecimal) accomplish this function. The use of the same general organizational rules indicated earlier for the 8080 is the more important of the two properties of this table. Such uniformity is a good aid in locating instructions in this table.

Indexed Instructions

Instructions beginning with hexadecimal DD are in one of two indexed classes of instructions. These use the IX and IY registers respectively in forming a data address. Those related to the former are depicted in table 4 and its associated table 5.

The analogy between tables 2 and 4 and between tables 3 and 5 is striking. The organizational patterns are identical — even to the point of using the same expansion technique. They should be identical. Each of these indexed instructions was formed by replacing the (HL) operand of an equivalent register-indirect instruction with the indexed notation (IX+d). Thus, every operation that can be performed in the register-indirect mode by the 8080 or Z80 can also be performed in the indexed mode by the Z80.

The resulting positional equivalence between the two sets of tables is most helpful in determining the required hexadecimal code for the indexed instructions. An easy way to do this without having to refer to tables 4 or 5 is to first select from table 2 or 3 (as appropriate) the hexadecimal code for the register-indirect form of the desired operation. Then place a DD prefix in front of this code if the operation was found in table 2, or a DDCB prefix, if found in table 3.

Text continued on page 207

First Nybble →, Second Nybble ↓

	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0	RLC B	RL B	SLA B		BIT 0,B	BIT 2,B	BIT 4,B	BIT 6,B	RES 0,B	RES 2,B	RES 4,B	RES 6,B	SET 0,B	SET 2,B	SET 4,B	SET 6,B
1	RLC C	RL C	SLA C		BIT 0,C	BIT 2,C	BIT 4,C	BIT 6,C	RES 0,C	RES 2,C	RES 4,C	RES 6,C	SET 0,C	SET 2,C	SET 4,C	SET 6,C
2	RLC D	RL D	SLA D		BIT 0,D	BIT 2,D	BIT 4,D	BIT 6,D	RES 0,D	RES 2,D	RES 4,D	RES 6,D	SET 0,D	SET 2,D	SET 4,D	SET 6,D
3	RLC E	RL E	SLA E		BIT 0,E	BIT 2,E	BIT 4,E	BIT 6,E	RES 0,E	RES 2,E	RES 4,E	RES 6,E	SET 0,E	SET 2,E	SET 4,E	SET 6,E
4	RLC H	RL H	SLA H		BIT 0,H	BIT 2,H	BIT 4,H	BIT 6,H	RES 0,H	RES 2,H	RES 4,H	RES 6,H	SET 0,H	SET 2,H	SET 4,H	SET 6,H
5	RLC L	RL L	SLA L		BIT 0,L	BIT 2,L	BIT 4,L	BIT 6,L	RES 0,L	RES 2,L	RES 4,L	RES 6,L	SET 0,L	SET 2,L	SET 4,L	SET 6,L
6	RLC (HL)	RL (HL)	SLA (HL)		BIT 0,(HL)	BIT 2,(HL)	BIT 4,(HL)	BIT 6,(HL)	RES 0,(HL)	RES 2,(HL)	RES 4,(HL)	RES 6,(HL)	SET 0,(HL)	SET 2,(HL)	SET 4,(HL)	SET 6,(HL)
7	RLC A	RL A	SLA A		BIT 0,A	BIT 2,A	BIT 4,A	BIT 6,A	RES 0,A	RES 2,A	RES 4,A	RES 6,A	SET 0,A	SET 2,A	SET 4,A	SET 6,A
8	RRC B	RR B	SRA B	SRL B	BIT 1,B	BIT 3,B	BIT 5,B	BIT 7,B	RES 1,B	RES 3,B	RES 5,B	RES 7,B	SET 1,B	SET 3,B	SET 5,B	SET 7,B
9	RRC C	RR C	SRA C	SRL C	BIT 1,C	BIT 3,C	BIT 5,C	BIT 7,C	RES 1,C	RES 3,C	RES 5,C	RES 7,C	SET 1,C	SET 3,C	SET 5,C	SET 7,C
A	RRC D	RR D	SRA D	SRL D	BIT 1,D	BIT 3,D	BIT 5,D	BIT 7,D	RES 1,D	RES 3,D	RES 5,D	RES 7,D	SET 1,D	SET 3,D	SET 5,D	SET 7,D
B	RRC E	RR E	SRA E	SRL E	BIT 1,E	BIT 3,E	BIT 5,E	BIT 7,E	RES 1,E	RES 3,E	RES 5,E	RES 7,E	SET 1,E	SET 3,E	SET 5,E	SET 7,E
C	RRC H	RR H	SRA H	SRL H	BIT 1,H	BIT 3,H	BIT 5,H	BIT 7,H	RES 1,H	RES 3,H	RES 5,H	RES 7,H	SET 1,H	SET 3,H	SET 5,H	SET 7,H
D	RRC L	RR L	SRA L	SRL L	BIT 1,L	BIT 3,L	BIT 5,L	BIT 7,L	RES 1,L	RES 3,L	RES 5,L	RES 7,L	SET 1,L	SET 3,L	SET 5,L	SET 7,L
E	RRC (HL)	RR (HL)	SRA (HL)	SRL (HL)	BIT 1,(HL)	BIT 3,(HL)	BIT 5,(HL)	BIT 7,(HL)	RES 1,(HL)	RES 3,(HL)	RES 5,(HL)	RES 7,(HL)	SET 1,(HL)	SET 3,(HL)	SET 5,(HL)	SET 7,(HL)
F	RRC A	RR A	SRA A	SRL A	BIT 1,A	BIT 3,A	BIT 5,A	BIT 7,A	RES 1,A	RES 3,A	RES 5,A	RES 7,A	SET 1,A	SET 3,A	SET 5,A	SET 7,A

Table 3: *Enhancement operation codes of the Z80 invoked by the hexadecimal CB instruction prefix. These CB class operations give bit manipulation, data shifting, and enhanced rotation capability to the Z80.*

Second Nybble \ First Nybble	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0								LD (IX+d),B								
1			LD IX,nn					LD (IX+d),C							POP IX	
2			LD (nn),IX					LD (IX+d),D								
3			INC IX					LD (IX+d),E							EX (SP),IX	
4				INC (IX+d)				LD (IX+d),H								
5				DEC (IX+d)				LD (IX+d),L							PUSH IX	
6				LD (IX+d),n	LD B,(IX+d)	LD D,(IX+d)	LD H,(IX+d)		ADD A,(IX+d)	SUB (IX+d)	AND (IX+d)	OR (IX+d)				
7								LD (IX+d),A								
8																
9	ADD IX,BC	ADD IX,DE	ADD IX,IX	ADD IX,SP											JP (IX)	LD SP,IX
A			LD IX,(nn)													
B			DEC IX										See Table 5			
C																
D																
E					LD C,(IX+d)	LD E,(IX+d)	LD L,(IX+d)	LD A,(IX+d)	ADC A,(IX+d)	SBC A,(IX+d)	XOR (IX+d)	CP (IX+d)				
F																

Table 4: *Operations of the Z80 invoked by the instruction prefix DD. These provide indexed-mode instructions equivalent to the indirect-mode instructions and employ the IX register.*

First Nybble

Second Nybble	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0																
1																
2																
3																
4																
5																
6	RLC (IX+d)	RL (IX+d)	SLA (IX+d)		BIT 0,(IX+d)	BIT 2,(IX+d)	BIT 4,(IX+d)	BIT 6,(IX+d)	RES 0,(IX+d)	RES 2,(IX+d)	RES 4,(IX+d)	RES 6,(IX+d)	SET 0,(IX+d)	SET 2,(IX+d)	SET 4,(IX+d)	SET 6,(IX+d)
7																
8																
9																
A																
B																
C																
D																
E	RRC (IX+d)	RR (IX+d)	SRA (IX+d)	SRL (IX+d)	BIT 1,(IX+d)	BIT 3,(IX+d)	BIT 5,(IX+d)	BIT 7,(IX+d)	RES 1,(IX+d)	RES 3,(IX+d)	RES 5,(IX+d)	RES 7,(IX+d)	SET 1,(IX+d)	SET 3,(IX+d)	SET 5,(IX+d)	SET 7,(IX+d)
F																

Table 5: *These DDCB-class operation codes are an indexed equivalent of the indirect-mode operation codes of the Z80 shown in table 3.*

Second Nybble \ First Nybble	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0								LD (IY+d),B								
1			LD IY,nn					LD (IY+d),C							POP IY	
2			LD (nn),IY					LD (IY+d),D								
3			INC IY					LD (IY+d),E							EX (SP),IY	
4				INC (IY+d)				LD (IY+d),H								
5				DEC (IY+d)				LD (IY+d),L							PUSH IY	
6				LD (IY+d),n	LD B,(IY+d)	LD D,(IY+d)	LD H,(IY+d)		ADD A,(IY+d)	SUB (IY+d)	AND (IY+d)	OR (IY+d)				
7								LD (IY+d),A								
8																
9	ADD IY,BC	ADD IY,DE	ADD IY,IY	ADD IY,SP											JP (IY)	LD SP,IY
A			LD IY,(nn)													
B			DEC IY										See Table 7			
C																
D																
E					LD C,(IY+d)	LD E,(IY+d)	LD L,(IT+d)	LD A,(IY+d)	ADC A,(IY+d)	SBC A,(IY+d)	XOR (IY+d)	CP (IY+d)				
F																

Table 6: *Indexed instructions employing the IY register. Note the similarity with table 4. These operation codes begin with the FD prefix.*

	First Nybble															
Second Nybble	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0																
1																
2																
3																
4																
5																
6	RLC (IY+d)	RL (IY+d)	SLA (IY+d)		BIT 0,(IY+d)	BIT 2,(IY+d)	BIT 4,(IY+d)	BIT 6,(IY+d)	RES 0,(IY+d)	RES 2,(IY+d)	RES 4,(IY+d)	RES 6,(IY+d)	SET 0,(IY+d)	SET 2,(IY+d)	SET 4,(IY+d)	SET 6,(IY+d)
7																
8																
9																
A																
B																
C																
D																
E	RRC (IY+d)	RR (IY+d)	SRA (IY+d)	SRL (IY+d)	BIT 1,(IY+d)	BIT 3,(IY+d)	BIT 5,(IY+d)	BIT 7,(IY+d)	RES 1,(IY+d)	RES 3,(IY+d)	RES 5,(IY+d)	RES 7,(IY+d)	SET 1,(IY+d)	SET 3,(IY+d)	SET 5,(IY+d)	SET 7,(IY+d)
F																

Table 7: *Indexed instructions of the FDCB class, again employing the IY register. Note the similarity with table 5.*

Second Nybble \ First Nybble	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0					IN B,(C)	IN D,(C)	IN H,(C)				LDI	LDIR				
1					OUT (C),B	OUT (C),D	OUT (C),H				CPI	CPIR				
2					SBC HL,BC	SBC HL,DE	SBC HL,HL	SBC HL,SP			INI	INIR				
3					LD (nn),BC	LD (nn),DE		LD (nn),SP			OUTI	OTIR				
4					NEG											
5					RETN											
6					IM 0	IM 1										
7					LD I,A	LD A,I	RRD									
8					IN C,(C)	IN E,(C)	IN L,(C)	IN A,(C)			LDD	LDDR				
9					OUT (C),C	OUT (C),E	OUT (C),L	OUT (C),A			CPD	CPDR				
A					ADC HL,BC	ADC HL,DE	ADC HL,HL	ADC HL,SP			IND	INDR				
B					LD BC,(nn)	LD DE,(nn)		LD SP,(nn)			OUTD	OTDR				
C																
D					RETI											
E						IM 2										
F					LD R,A	LD A,R	RLD									

Table 8: *The class of miscellaneous instructions invoked by the ED prefix.*

Text continued from page 200:
Finally, place after this code group a displacement suffix, d.

The Z80 also has a second index register, which is designated the IY register. Op codes which use it for addressing are contained in tables 6 and 7. It takes only a quick glance to notice the strong similarity between tables 4 and 6 and between tables 5 and 7. As might be expected, virtually everything said previously about the IX class of op codes also refers to the IY class. The sole exception to this statement is that the IY-type instructions begin with hexadecimal code FD, instead of DD.

Miscellaneous Additions

All fifty-six instructions in the last of the four expansion sets begin with hexadecimal code ED. They are listed in table 8. Though they are quite heterogeneous, they add considerably to the power of the Z80. Among these, for example, are instructions that enhance the 16-bit arithmetic capability, set interrupt modes, permit complementing the accumulator, and allow a register-indirect type of I/O to be performed. There are instructions also, which allow counting or block processing to be done during loading, comparison, and I/O operations. Even if the other three expansion sets were omitted, the instructions in this set would be highly useful additions to the basic 8080 complement.

With such a hodgepodge of function, it is rather surprising that any order at all can be made of these ED class instructions. Nonetheless, consistency with the other tables is maintained. It is evident from the arithmetic and the leftmost I/O instructions that arrangement by order of first and second operands is used whenever possible. Separation of complementary functions by eight rows in a column is also followed.

There are 696 valid op codes in the seven Z80 tables. Without organizational consistency, conversion of these instructions from mnemonic to hexadecimal form would be extremely difficult and probably ridden with error. Fortunately, these codes are very well arranged, following the pattern established for the 8080. It takes a little practice to become adept at making these transformations, but with the aid of these tables it can be accomplished successfully. ■

The Periodic Chart at Your Fingertips

Using the TI-59

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Innovative ideas that use hand-held programmable calculators are penetrating into the business and scientific communities. Concepts and ideas that previously could be tested only by large computers can today be performed in the palm of your hand.

Because of my interest in programmable calculators, I am always looking for a challenge. While I was attending a chemistry lecture, a question presented itself to me: What is a chemist without a periodic chart? [**Editor's Note:** *I have no retort. . . .* **RSS**]

Text continued on page 210

Listing 1: *Keystrokes for the periodic-table program. The TI-59 should be configured for 319 program steps and 79 data registers, and the program will require two magnetic cards for storage. When running the program, the user can recover from an error condition by pressing CLR and beginning again.*

```
000  76  LBL
001  10  E'
002  32  X:T
003  86  STF
004  03   03
005  87  IFF
006  01   01
007  02   02
008  65   65
009  22  INV
010  86  STF
011  03   03
012  86  STF
013  01   01
014  86  STF
015  02   02
016  01   1
017  69  OP
018  17   17
019  47  CMS
020  08   8
021  69  OP
022  17   17
023  01   1
024  42  STO
025  04   04
026  32  X:T
027  91  R/S
028  76  LBL
029  11   A
030  71  SBR
031  01   01
032  63   63
033  29  CP
034  67   EQ
035  00   00
036  40   40
037  42  STO
038  04   04
039  91  R/S
040  43  RCL
041  04   04
042  91  R/S
043  76  LBL
044  12   B
045  71  SBR
046  01   01
047  63   63
048  29  CP
049  67   EQ
050  00   00
051  55   55
052  42  STO
053  06   06
054  91  R/S
055  43  RCL
056  06   06
057  91  R/S
058  76  LBL
059  13   C
060  71  SBR
061  01   01
062  63   63
063  43  RCL
064  05   05
065  99  PRT
066  98  ADV
067  91  R/S
068  76  LBL
069  15   E
070  71  SBR
071  01   01
072  63   63
073  43  RCL
074  06   06
075  32  X:T
076  00   0
077  77   GE
078  00   00
079  92   92
080  01   1
081  00   0
082  06   6
083  22  INV
084  77   GE
085  00   00
086  92   92
087  87  IFF
088  02   02
089  00   00
090  96   96
091  92  RTN
092  02   2
093  94  +/-
094  34  ГX
095  91  R/S
096  43  RCL
097  06   06
098  55   ÷
099  02   2
100  85   +
101  93   .
102  05   5
103  95   =
104  42  STO
105  01   01
106  59  INT
107  42  STO
108  02   02
109  32  X:T
110  43  RCL
111  01   01
112  22  INV
113  67   EQ
114  01   01
115  19   19
116  02   2
117  42  STO
118  03   03
119  01   1
120  09   9
121  44  SUM
122  02   02
123  73  RC*
124  02   02
125  42  STO
126  00   00
127  01   1
128  52  EE
129  06   6
130  64  PD*
131  02   02
132  73  RC*
133  02   02
134  59  INT
135  22  INV
136  74  SM*
137  02   02
138  55   ÷
139  01   1
140  52  EE
141  03   3
142  95   =
143  22  INV
144  52  EE
145  97  DSZ
146  03   03
147  01   01
148  27   27
149  48  EXC
150  00   00
151  72  ST*
152  02   02
153  48  EXC
154  00   00
155  65   ×
156  43  RCL
157  04   04
158  95   =
159  44  SUM
160  05   05
161  99  PRT
162  91  R/S
163  22  INV
164  87  IFF
165  02   02
166  00   00
167  92   92
168  22  INV
169  86  STF
170  01   01
171  92  RTN
172  76  LBL
173  17  B'
174  87  IFF
175  02   02
176  00   00
177  92   92
178  29  CP
179  22  INV
180  67   EQ
181  01   01
182  88   88
183  43  RCL
184  07   07
185  61  GTO
186  02   02
187  18   18
188  55   ÷
189  01   1
190  52  EE
191  03   3
192  95   =
193  42  STO
194  00   00
195  01   1
196  52  EE
197  06   6
198  22  INV
199  64  PD*
200  01   01
201  43  RCL
202  00   00
203  74  SM*
204  01   01
205  69  OP
206  21   21
207  93   .
208  05   5
209  22  INV
210  44  SUM
211  01   01
212  69  OP
213  27   27
214  43  RCL
215  07   07
216  22  INV
217  52  EE
218  91  R/S
219  61  GTO
220  01   01
221  88   88
222  76  LBL
223  16  A'
224  42  STO
```

225	07	07	244	85	+	263	07	07
226	22	INV	245	02	2	264	91	R/S
227	87	IFF	246	00	0	265	43	RCL
228	01	01	247	95	=	266	07	07
229	00	00	248	42	STO	267	32	X!T
230	92	92	249	01	01	268	42	STO
231	22	INV	250	59	INT	269	08	08
232	86	STF	251	32	X!T	270	25	CLR
233	02	02	252	43	RCL	271	22	INV
234	71	SBR	253	01	01	272	67	EQ
235	00	00	254	22	INV	273	02	02
236	75	75	255	67	EQ	274	37	37
237	43	RCL	256	00	00	275	43	RCL
238	07	07	257	92	92	276	08	08
239	75	-	258	87	IFF	277	32	X!T
240	01	1	259	03	03	278	61	GTO
241	95	=	260	02	02	279	00	00
242	55	÷	261	75	75	280	09	09
243	02	2	262	43	RCL			

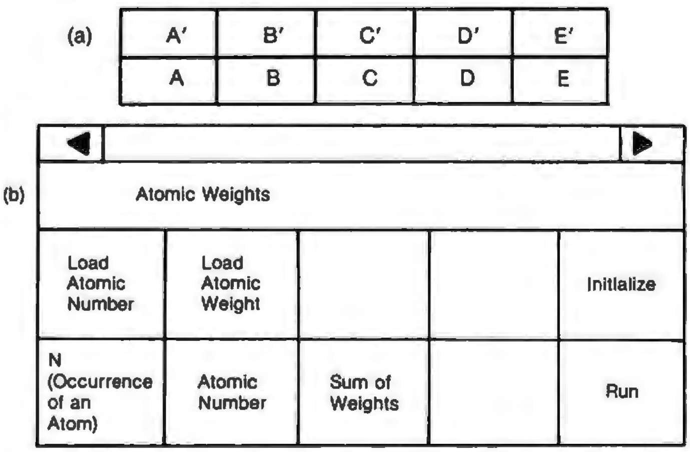

Figure 1: *Placement and definition of user-defined keys. Given the placement of the user-defined keys in figure 1a, the program tape in figure 1b shows the meaning of each key. For example, user-defined key A is used when entering the value for N. See tables 1 and 2, which describe the usage of these keys.*

Table 1: *Loading and changing atomic weight information. The first routine allows the user to enter the atomic weight for all elements, starting with element 1 and continuing through element 106. The second routine allows the user to make changes to a group of consecutive elements. Since two atomic weights are stored in a single register, both weights for an odd-even pair must be entered even if only one of the two is to be changed. Pressing the R/S button causes the calculator to request the next odd-even pair of atomic weights. The E' key, used to end this loop, can be pressed only when the atomic number showing in the display is odd.*

Steps	Procedure	Press	Display
	To load atomic weight		
1.	Initialize.	E'	does not change
2.	Enter 1.	A'	1
3.	Enter atomic weight for atomic number 1.	B'	2
4.	Enter atomic weight for atomic number 2.	R/S	3
	. . . .	. . . .	. . . .
	Enter atomic weight for atomic number 106.	R/S	107
5.	Initialize.	E'	does not change
6.	Load data into banks 2, 3, and 4. (Refer to owner's manual for TI Programmable 58/59.) (The program is now complete. The load subroutines will not be needed unless a change of data is required at a later date.)		
	To change atomic weight data		
7.	Initialize.	E'	does not change
8.	Enter n, where n = 1, 3, 5, . . . 103, 105.	A'	n
9.	Enter atomic weight for n.	B'	n + 1
10.	Enter atomic weight for n + 1. (n + 1 is even)	R/S	n + 2
	. . . .	. . . .	. . . .
11.	If the number displayed is odd, press E' to exit the "change atomic weight data" routine.	E'	does not change
12.	To recall atomic number for the next atomic weight to be entered. (Step 12 is performed when the operator initializes with n, an even integer, thereby initiating an error condition.)	CLR, B'	Atomic number
13.	Repeat steps 9, 10, and 11 to continue.		

Table 2: *Retrieval of data from the program. The first routine finds an element's atomic weight, given its atomic number. The second routine calculates the molecular weight of a molecule given a set of quantity/atomic-number pairs that describe the molecule. The quantities marked with asterisks (*) denote numbers that will be printed when a PC-100A or PC-100C printer is attached.*

Steps	Procedure	Press	Display
	To find atomic weight		
1.	Initialize.	E'	does not change
	(When program is initialized, the display is preserved.)		
2.	Enter atomic number.	B,E	value of atomic weight*
3.	Repeat step 2 for new atomic number.		
	To find molecular weight		
4.	Initialize.	E'	does not change
5.	Enter atomic number.	B	does not change
6.	Enter how many of that particular element.	A,E	A × atomic weight*
7.	Repeat steps 5 and 6 for each element.		
8.	Calculate total weight (sum weight.)	C	total weight of molecule*
	(Note: label C is a subtotal.)		
9.	To find weight of a new formula, go to step 4.		
10.	Recall last A entry (when desired)	CLR, A	Last A
11.	Recall last B entry (when desired) (Steps 10 and 11 are merely for convenience and do not interfere with program flow.)	CLR, B	Last B

Table 3: *Table showing usage of registers 00 thru 79 in the periodic-table program, listing 1. The atomic weights must be in the form of XXX.XXX; leading and trailing zeros will be automatically inserted.*

Register Number	Use
00 thru 09	Used.
10 thru 19	These registers are left open to allow the operator to store additional data during program use without altering internal program executions.
20 thru 72	Used to store atomic weights.
73 thru 79	Not used.

Text continued from page 208:

I realized that a programmable calculator could easily be used to store and retrieve data contained in the periodic chart; once this is done, the user can manipulate periodic-chart data with a small chance of error. Using the Texas Instruments TI-59, I developed the program shown in listing 1.

This program, documented in tables 1 and 2, contains two types of routines, the first for loading atomic weights, and the second for retrieving them. I decided to sacrifice speed of execution for ease of operation and protection of loaded data.

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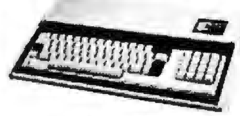

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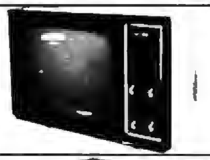

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Programming Quickies

KIM-1 Multiplication and Division

James C Couchman, General Dynamics Corp, Fort Worth Division, POB 748, Fort Worth TX 76101

When I bought a MOS Technology KIM-1 microcomputer to use in a specific control function, it arrived with a set of comprehensive instruction, programming, and hardware books. As soon as I connected a 5 V power supply, I was able to interact with the machine through the hexadecimal keyboard and light-emitting diode (LED) display. It was a bit more difficult to get our Teletype to work with the KIM-1, but with a slight adjustment to the teleprinter timing, the problem was cured.

The KIM-1 is still a real bargain, with features including the 6502 microprocessor, 2 K bytes of read-only memory (containing the Keyboard Input Monitor from which the name is derived), an interval timer, fifteen input and output lines, 1 K bytes of programmable memory (with address logic for 16 K bytes), and probably some features I have not yet discovered.

Since the KIM-1 is programmed in machine language using a set of fifty-six instructions, I believe that the best way to learn to program it is to not just read about it, but do it. One should just start writing code, and, in time, the power of the basic instruction set will really be understood and appreciated.

Once the user is familiar with the capabilities of the KIM-1, he begins to wish that it could do more. One tool that provides more capability is a set of software routines that perform sixteen-bit multiplication and division on the 6502 processor. After I searched for a suitable set of routines, I concluded that I would have to write my own.

To prevent you from having to "reinvent the wheel," I am presenting these routines here. In developing these routines, I enlisted the invaluable assistance of my associates G R Arnett and J R Williamson. These routines should work without much difficulty on other 6502-based computers.

Sixteen-Bit Routines

These routines can multiply and divide two 16-bit signed quantities together and produce a signed 16-bit result. The routines are written as relocatable subroutines.

In multiplication, the high-order byte of the first multiplicand is loaded into hexadecimal location 0000, and the low-order byte into location 0001. The high-order byte of the second multiplicand is put into location 0006, and the low-order byte into location 0007.

In division, the high-order byte of the divisor is loaded into hexadecimal location 0000; the low-order byte into location 0001. The high-order byte of the dividend is placed into location 0006, and the low-order byte is loaded into location 0007. If the value of the divisor is zero, the division routine will return control to the calling program.

For both the multiplication and the division routines, the answer is returned in hexadecimal locations 0002 (high-order) and 0003 (low-order byte). It should not be very hard to change this if need be.

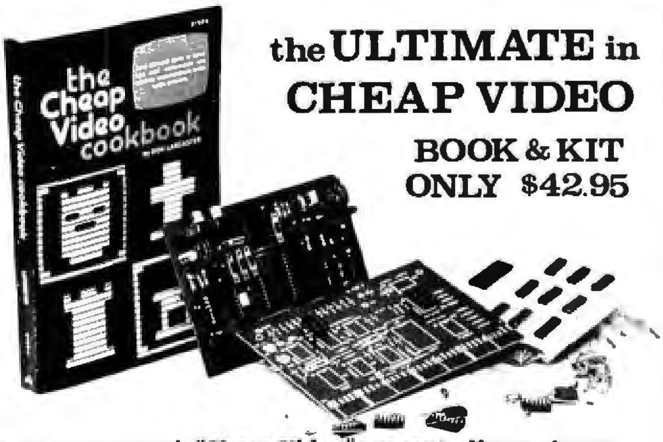
An example of a simple calling routine is shown in listing 1. The calling sequence is essentially the same for both multiplication and for division; only the value contained in the two bytes that follow the jump-to-subroutine (JSR) instruction must be changed.

Listing 1a: *Calling sequence for 16-bit multiply subroutine.*

Address	Code
0007	20 (JSR)
0008	00
0009	01 (multiply)
000A	A9 (LDA)
000B	00
000C	F0
000D	FC

Listing 1b: *Calling sequence for 16-bit divide subroutine.*

Address	Code
0007	20 (JSR)
0008	30
0009	00 (divide)
000A	A9 (LDA)
000B	00
000C	F0
000D	FC



The assembler mnemonics and hexadecimal code for the multiplication subroutine are given in listing 2. The division subroutine is given in similar form in listing 3. The multiplication subroutine is shown in hexadecimal memory-dump form in listing 4; the division code in that form in listing 5.

My collegues and I hope that these programs will help other KIM-1 users. We know that having had them prepared for us would have saved us much time.

Listing 2: *Relocatable subroutine to perform multiplication of 16-bit quantities on the 6502 microprocessor as used in the MOS Technology KIM-1. Both assembler mnemonics and hexadecimal code are given. Entry point is hexadecimal location 0100.*

Address	Mnemonic	Hexadecimal Code
0100	CLC	18
0101	CLD	D8
0102	LDA #0	A9 00
0104	TAX	AA
0105	STA 0002	85 02
0107	STA 0003	85 03
0109	LDA 0000	A5 00
010B	BNE	D0 11
010D	LDA 0001	A5 01
010F	BEQ	F0 0C
0111	CMP #1	C9 01
0113	BNE	D0 1D
0115	LDA 0006	A5 06
0117	STA 0002	85 02
0119	LDA 0007	A5 07
011B	STA 0003	85 03
011D	RTS	60
011E	BPL	10 12
0120	INX	E8
0121	LDA 0001	A5 01
0123	CLC	18
0124	EOR FF	49 FF
0126	ADC #1	69 01
0128	STA 0001	85 01
012A	LDA 0000	A5 00
012C	EOR FF	49 FF
012E	ADC #0	69 00
0130	STA 0000	85 00
0132	LDA 0006	A5 06
0134	BNE	D0 26
0136	LDA 0007	A5 07
0138	BEQ	F0 18
013A	CMP #1	C9 01
013C	BNE	D0 32
013E	DEX	CA
013F	BNE	D0 12
0141	LDA 0001	A5 01
0143	CLC	18
0144	EOR FF	49 FF
0146	ADC #1	69 01
0148	STA 0003	85 03
014A	CDA 0000	A5 00
014C	EOR FF	49 FF
014E	ADC #0	69 00
0150	STA 0002	85 02
0152	RTS	60
0153	LDA 0001	A5 01
0155	STA 0003	85 03
0157	LDA 0000	A5 00
0159	STA 0002	85 02
015B	RTS	60
015C	BPL	10 12
015E	INX	E8
015F	LDA 0007	A5 07

Listing 2 continued on page 215

Listing 2 continued:

0161	CLC	18
0162	EOR FF	49 FF
0164	ADC #1	69 01
0166	STA 0007	85 07
0168	LDA 0006	A5 06
016A	EOR FF	49 FF
016C	ADC #0	69 00
016E	STA 0006	85 06
0170	LDA 0000	A5 00
0172	STA 0004	85 04
0174	LDA 0001	A5 01
0176	STA 0005	85 05
0178	LDA 0003	A5 03
017A	CLC	18
017B	ADC 0001	65 01
017D	STA 0003	85 03
017F	LDA 0002	A5 02
0181	ADC 0000	65 00
0183	STA 0002	85 02
0185	SEC	38
0186	LDA 0007	A5 07
0188	SBC #1	E9 01
018A	STA 0007	85 07
018C	LDA 0006	A5 06
018E	SBC #0	E9 00
0190	STA 0006	85 06
0192	CMP #0	C9 00
0194	BNE	D0 E2
0196	LDA 0007	A5 07
0198	CMP #0	C9 00
019A	BNE	D0 DC
019C	DEX	CA
019D	BNE	D0 15
019F	LDA 0002	A5 02
01A1	EOR FF	49 FF
01A3	STA 0002	85 02
01A5	LDA 0003	A5 03
01A7	EOR FF	49 FF
01A9	CLC	18
01AA	ADC #1	69 01
01AC	STA 0003	85 03
01AE	LDA 0002	A5 02
01B0	ADC #0	69 00
01B2	STA 0002	85 02
01B4	RTS	60

Listing 3: *Relocatable subroutine to perform division of 16-bit quantities on the 6502 microprocessor of the KIM-1, with assembler mnemonics. Entry point is hexadecimal location 0030.*

Address	Mnemonic	Hexadecimal Code
0030	CLC	18
0031	CLD	D8
0032	LDA #0	A9 00
0034	TAX	AA
0035	STA 02	85 02
0037	STA 03	85 03
0039	LDA 00	A5 00
003B	BNE	D0 05
003D	LDA 01	A5 01
003F	BNE	D0 15
0041	RTS	60
0042	BPL	10 12
0044	INX	E8
0045	LDA 01	A5 01
0047	CLC	18
0048	EOR FF	49 FF
004A	ADC #1	69 01
004C	STA 01	85 01
004E	LDA 00	A5 00
0050	EOR FF	49 FF

Listing 3 continued on page 216

Listing 3 continued:

```
0052    ADC #0    69 00
0054    STA 00    85 00
0056    LDA 06    A5 06
0058    BNE       D0 26
005A    LDA 07    A5 07
005C    BEQ       F0 18
005E    CMP #1    C9 01
0060    BNE       D0 32
0062    DEX       CA
0063    BNE       D0 12
0065    LDA 01    A5 01
0067    CLC       18
0068    EOR FF    49 FF
006A    ADC #1    69 01
006C    STA 03    85 03
006E    LDA 00    A5 00
0070    EOR FF    49 FF
0072    ADC #0    69 00
0074    STA 02    85 02
0076    RTS       60
0077    LDA 01    A5 01
0079    STA 03    85 03
007B    LDA 00    A5 00
007D    STA 02    85 02
007F    RTS       60
0080    BPL       10 12
0082    INX       E8
0083    LDA 07    A5 07
0085    CLC       18
0086    EOR FF    49 FF
0088    ADC #1    69 01
008A    STA 07    85 07
008C    LDA 06    A5 06
008E    EOR FF    49 FF
0090    ADC #0    69 00
0092    STA 06    85 06
0094    LDA 03    A5 03
0096    CLC       18
0097    ADC #1    69 01
0099    STA 03    85 03
009B    LDA 02    A5 02
009D    ADC #0    69 00
009F    STA 02    85 02
00A1    SEC       38
00A2    LDA 01    A5 01
00A4    SBC 07    E5 07
00A6    STA 01    85 01
00A8    LDA 00    A5 00
00AA    SBC 06    E5 06
00AC    STA 00    85 00
00AE    LDA 00    A5 00
00B0    BMI       30 08
00B2    BNE       D0 E0
00B4    LDA 01    A5 01
00B6    BNE       D0 DC
00B8    BEQ       F0 0D
00BA    SEC       38
00BB    LDA 03    A5 03
00BD    SBC #1    E9 01
00BF    STA 03    85 03
00C1    LDA 02    A5 02
00C3    SBC #0    E9 00
00C5    STA 02    85 02
00C7    DEX       CA
00C8    BNE       D0 15
00CA    LDA 02    A5 02
00CC    EOR FF    49 FF
00CE    STA 02    85 02
00D0    LDA 03    A5 03
00D2    EOR FF    49 FF
00D4    CLC       18
00D5    ADC #1    69 01
00D7    STA 03    85 03
00D9    LDA 02    A5 02
00DB    ADC #0    69 00
00DD    STA 02    85 02
00DF    RTS       60
```

Listing 4: *Multiplication subroutine in hexadecimal memory-dump form.*

```
;18010018D8A900AA85028503A500D011A501F00CC901D01DA50685097A
;18011802A5078503601012E8A5011849FF69018501A50049FF6900081D
;1801308500A506D026A507F018C901D032CAD012A5011849FF69010A0B
;1801488503A50049FF6900850260A5018503A5008502601012E8A5088F
;180160071849FF69018507A50649FF69008506A5008504A5018505081B
;180178A5031865018503A5026500850238A507E9018507A506E90007C0
;1801908506C900D0E2A507C900D0DCCAD015A50249FF8502A503490BE6
;1801A8FF18690185 03A5026900850260E9008D0600C900D0D8AD070962
;0000080008    0
```

Listing 5: *Division subroutine in hexadecimal memory-dump form.*

```
;18000318D8A900AA85028503A500D005A501D015601012E8A5011808C7
;18004849FF69018501A50049FF69008500A506D026A507F018C9010992
;180060D032CAD012A5011849FF69018503A50049FF6900850260A50A00
;18007801850 3A5008502601012E8A5071849FF69018507A50649FF08A4
;1800906900850 6A5031869018503A5026900850238A501E50785010735
;1800A8A500E5068500A5003008D0E0A501D0DCF00D38A503E901850B00
;1800C003A502E9008502CAD015A50249FF8502A50349FF186901850A0E
;1800D803A5026900850260002A3F3C3B3F1E3E3E3EFE1E3E7E7A7F07B2
;0000080008 ■
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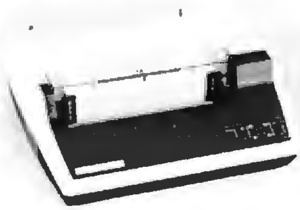

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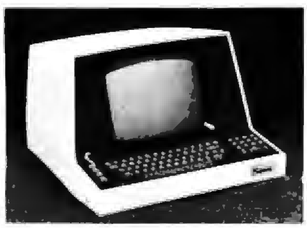

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For more information, contact Whitsed Publishing Ltd, Suite 2504, 2 Bloor St W, Toronto, Ontario M4W 3E2 CANADA.

March 11-13

SEMICON/Europa, Zurich, Switzerland.

This show and symposium is the initial step in the organization of a European forum for the exchange of information on the latest semiconductor technology. Included in the topics of presentation are semiconductor materials, device production, and technology; future trends; photovoltaic conversion of solar energy; and standardization of testing and materials. Contact the Semiconductor Equipment and Materials Institute Inc, 625 Ellis St, Suite 212, Mountain View CA 94043.

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 15

Annual PACS Computer Games Festival, LaSalle College Ballroom, 20th and Olney, Philadelphia PA. This event is sponsored by the Philadelphia Area Computer Society and the LaSalle College Physics Dept. The Festival hours are from 10 AM to 6 PM. For further information, contact Stephen A Longo, Physics Dept, LaSalle College, Philadelphia PA 19141, or call (215) 951-1255.

March 17-20

Interface '80, Miami Beach Convention Center, Miami Beach FL. This conference and exposition is devoted to data communications, distributed data processing (DDP), and networking. Approximately 1000 exhibitors are expected, and attendance is anticipated 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, power and cross-spectral density functions, and introductions to new methods in spectral analysis and rotating machinery analysis. For more information, contact UCLA Extension, 10995 Le Conte Ave, Los Angeles CA 90024.

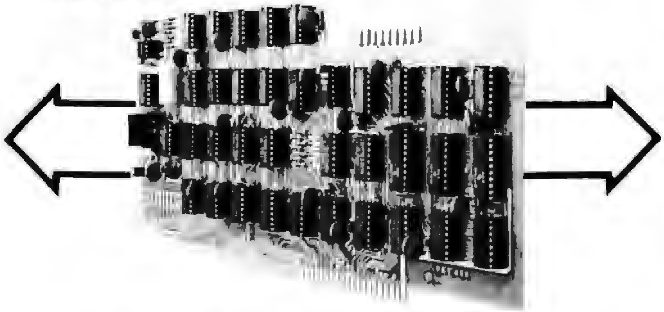
March 18-20

Electrical Power Problems: The Mathematical Challenge, Seattle WA. This conference is sponsored by the Society for Industrial and Applied Mathematics (SIAM). The program is designed to bring together experts from power engineering and applied mathematics fields to focus on electrical power problems and the applied mathematics techniques relevant to their solution. Contact SIAM, 33 S 17th St, Philadelphia PA 19103.

March 20

Electronic Road Shows, Castaways Restaurant, Bur-

From S-100 to IEEE-488



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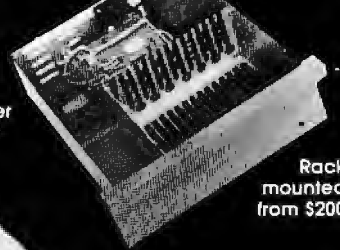

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bank CA. This traveling exhibition of components, materials, and instruments is being produced by the Electronic Representatives Association (ERA). Over eighty ERA member firms will participate, and product's from over 700 electronic companies will 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 nonsubscribers. 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 WEST 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

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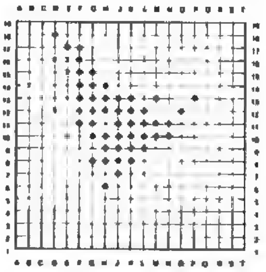
GOMOKU

Can you find black's best move in the board position on the right?



Our program can. (Black plays on the points marked 1 thru 7).

Five Stones Software announces a Gomoku program for North Star Horizon DOS and CP/M based systems. The program has been written by the current North American champion and has the following features.

- book of openings with 200 entries
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- blinking of last move by computer
- carriage return not necessary for most moves
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The program requires a minimum of 32K bytes of RAM, and is available for North Star or CP/M on double density 5¼" diskette for $29.95, Visa or Mastercharge accepted. For more information contact

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- RS232
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USR-330 Originate/ Auto-Answer Modem

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FCC certified for direct connection to phone lines via standard extension phone jack

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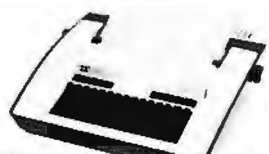

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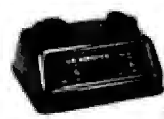

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March 30

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 the fairgrounds 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.

APRIL 1980

April 1-2

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. The 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 10

Electronic Road Shows, Anaheim Convention Center, Anaheim CA. See March 20th for details.

April 11-12

10th Annual Virginia Computer Users Conference. This conference is sponsored by the Virginia Tech Association for Computing Machinery (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 com-

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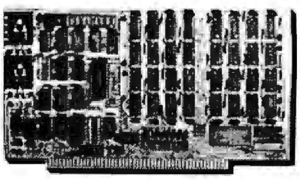

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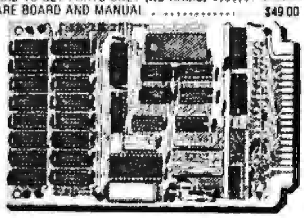

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puter organization and their use in cost-effective systems. Several designs for high-speed computers are presented and compared.

For more information, contact the 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.

April 27-30

17th Numerical Control Society Annual Meeting and Technical Conference, Hartford Civic Center, Hartford CT. This convention will offer technical sessions covering such areas as computer-aided design engineering, business management, tool design and graphics; computer-aided assembly, facilities planning, inventory control, and management information systems; numerical control in various areas; data base structure and management; and other educational programs. There is also a large exhibition being presented.

For more information, contact Numerical Control Society, 1800 Pickwick, Glenview IL 60025.

April 28-30

Managing Technical Programs and Projects, White Plains NY. For more information, contact the Institute for Advanced Professional Studies, One Gateway Ctr, Newton MA 02158.

April 30-May 2

Computerized Office Equipment Expo, O'Hare Exposition Center, Rosemont IL. The latest developments in computers, word processors, copiers/duplicators, telephone systems, and other business equipment will be featured. The seminars will cover guidelines on buying computer systems, telephone and copier systems; the use of word processors, and more. Contact Industrial and Scientific Conference Management Inc, 222 W Adams St, Chicago IL 60606.

MAY 1980

May

IEEE Computer Society Conferences and Meetings. For a list of events, contact the Executive Secretary, Harry Hayman, POB 639, Silver Spring MD 20901, or phone (301) 439-7007.

May 5-11

Engineering, Science, and Public Policy, 16th Annual Meeting, Baltimore Convention Center, Baltimore MD. Companies from around the world and the US will be exhibiting. The conference is being sponsored by the AIAA. Contact Lawrence Craner, Director of Technical Displays, AIAA, 1290 Avenue of the Americas, New York NY 10019, or the Conference General Chairman, Laurence Adams at Martin Marietta Aerospace.

May 6-8

Micro/Expo 80, Centre International de Paris, Paris France. This is one of the leading shows in Europe for microcomputer users and manufacturers. Exhibits of new equipment, presentations, games, educational materials, and more will be featured. For more information, contact Sybex Inc, 2020 Milvia St, Berkeley CA 94704.

May 6-8

The 7th International Symposium on Computer Architecture, La Baule, France. This symposium will consist of discussions and readings in the following areas: distributed architectures, special-purpose architectures, hardware description languages, fault-tolerant architectures, high-speed computers, control schema, evaluation of architecture performance, and more.

Contact, Daniel E Atkins, Dept of Electrical and Computer Engineering, University of Michigan, Ann Arbor MI 48109.

May 6-10

8th Annual Canadian Association for Information Science, Toronto, Canada. Technology, commodity, and rights are the themes of this conference. Topics will

cover information in the marketplace, information transfer and policy issues, right to access, new information technologies and applications, and other subjects. For more information, contact the Program Chairman, 8th Annual CAIS Conference, Technical Information Centre, Bell Northern Software Research, 12th floor, 522 University Ave, Toronto Ontario M5G 1W7 CANADA.

May 13-15

Electro/80 Show and Convention, Hynes Auditorium and Boston Sheraton, Boston MA. This show consists of presentations and exhibitions by manufacturers in the computer industry. Contact Electronic Conventions Inc, 99 N Sepulveda Blvd, El Segundo CA 90245.

May 13-16

9th Annual Conference of MUMPS Users Group, Islandia Hyatt House, San Diego CA. The meeting will bring together scientific, medical, and business professionals to discuss current research and application development. Areas of participation are paper presentations, workshops and tutorials, and vendor exhibits. Contact Dr Jack Bowie, MUG 80 Program Chairman, The MITRE Corp, Mail Stop 641, 1820 Dolley Madison Blvd, McLean VA 22102.

May 14-16

Carnahan Conference on Crime Countermeasures, Carnahan House, Lexington KY. This conference is devoted to the application of engineering and science to law enforcement, security, and crime prevention. Emphasis will be on effective research and development in computer security.

Contact the Office of Continuing Education, College of Engineering, University of Kentucky, Lexington KY 40506.

May 15

Electronic Road Shows, Griswold's Restaurant, Pomona CA. See March 20th for details.

May 19-22

1980 National Computer Conference, Anaheim Convention Center, Anaheim CA. The conference program will include more than 120 sessions covering computing careers and education, office automation, and auditing in the area of management; computers in earth resource management, human services, and word processing in the field of applications; programming languages, design techniques and methodology, and voice simulation and recognition in software; earth resources, education, women and minorities in the computing discipline in the area of social implications; microcomputers and minicomputers, computer architecture, and new concepts in memories in the area of hardware.

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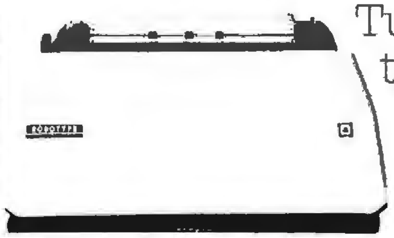

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To Err Is Human

Roger A McGregor
6933 S Allison Way
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GIGO (garbage in, garbage out) is an expression heard so often by programmers that it is accepted as truth and even offered as an excuse for poorly written programs. It is a truism that ought to be examined, especially in the area of human prepared input that is typed.

If the instructions in figure 1a are entered instead of the correct instructions of figure 1b, the great majority of microprocessor assemblers will be unable to locate any of the program symbols. This inability compels the user to go through the tedious process of calling an edit program, making corrections, calling the assembler, and trying once more to assemble the source code, hoping that no new errors have been introduced. This procedure can be very time consuming; it is always frustrating. An examination of how the errors are detected in a normal assembler or compiler may shed light on how an automated correction can be attempted.

Label	Operation	Operand
1 LOOP	CPY	SPAEC
2	JSR	PRJNT
3	CMP	STRE
4	BEQ	LOOPS
5 COPY	EUQ	LOOP

Figure 1a: A section of code which illustrates several common typing errors often made during entry of an assembly program. These particular errors can be detected and corrected by a simple algorithm which determines if the operand is "close enough" to what it is supposed to be. If the operand has two transposed letters, one character wrong, or one character too many or too few, it is automatically changed to the correct form listed in the symbol table.

Label	Operation	Operand
1 LOOP	CPY	SPACE
2	JSR	PRINT
3	CMP	STORE
4	BEQ	LOOP
5 COPY	EQU	LOOP

Figure 1b: The code from figure 1a after error detection and correction.

Normally, after a symbol has been segregated from the source text, it is passed to a symbol table lookup routine as a search argument. The function of the lookup routine is to find an entry in the symbol table whose symbol matches the search argument, and to either return that entry (a hit) or set some indicator to inform the calling routine of an unsuccessful search (a no-hit). Both hits and no hits are valid returns, depending on the pass being made on the source code.

The first pass causes two types of lookup calls; *definition* and *reference*. For a definition lookup, a symbol has been extracted from the label field. That symbol and its attributes are to be entered into the symbol table if and only if the symbol is not already present in the symbol table. However, if the symbol is already present, it is multiply defined and in error. For a reference lookup, a symbol found in the operand field is needed for a compile time computation (line 5 of figure 1b). For this lookup, the symbol must be present in the symbol table or an error condition exists.

During any other pass, a no-hit constitutes an error. It is at this point that error correction may be attempted in the form of an alternate (associated) symbol lookup.

If the lookup routine can find another symbol in the symbol table that is "close enough" to the search argument, then the entry's symbol is associated with the argument symbol and may be returned as a hit. When an alternate symbol is substituted in this fashion, the programmer must be given a warning as the substitution may not be correct. By checking the object code generated, the programmer can verify the substitution.

What constitutes "close enough" before a symbol table entry can be substituted for the search argument?

About the Author

Roger McGregor works as a systems programmer on a large IBM system. He has written or worked on many operating systems, assemblers, compilers, and interpreters, and has successfully used the techniques presented here in an assembler.

"Close enough" is defined as two characters transposed (line 1, figure 1a), one character wrong (line 2, figure 1a), one missing character (line 3, figure 1a), or an extra character (line 4, figure 1a).

Given the above criteria, only certain symbols in the symbol table need be reexamined. Those symbols are the ones possessing an equal number of characters, or one more or one less character than the search argument. An exception occurs when the search argument consists of only a single character: if this happens, error correction should be terminated and a no-hit returned. Those symbols with an equal number of characters should be compared for transposed characters or one wrong character in the string. Those symbols with one more or one less character than the search argument should be checked for a single character difference. If any symbol in the symbol table passes one of the above tests, an association has occurred and the associated entry should be returned as a hit.

Generally, making a single pass through the symbol table and returning the first entry passing a check is sufficient. However, if the keyboard layout is more conducive to wrong characters due to upper and lower case shifting than to the other common errors of transposition, addition, or deletion, then a first pass through the symbol table checking only equal character count symbols for wrong characters could prove to be more accurate. Alternate strategies do however increase memory usage and execution time. The execution time is well spent if a proper association prevents the edit and reassemble process already described. Memory usage is another matter. The less memory used by the correction routine, the better.

Besides alleviating reassembly problems, the error correction process tends to encourage better documented programs. Due to the nature of the checks made for the association, longer symbols have a better chance of being correctly associated. They are also usually more meaningful.

The above correction process is by no means limited to just the symbol table of an assembler and compiler. It can be applied to any dictionary type lookup including op codes, text processors, and console commands.

The only obvious limitation would occur when symbols intentionally differ by a transposition or length. In order to overcome this objection, we simply require an explicit declaration statement and correct spelling in such statements with the extended error correction applied to uses of a name.■

```
10 DIMC$(256),S(64),W(3,76),T(76),N(6,64),P(4),V(64)
20 C1$="0123456789"\P(0)=22\P(1)=147\P(2)=1030\P(3)=2\P(4)=3
30 OPEN#0,"A16"\LINE80
40 FORA=1TO76\READ#0,W(0,A),W(1,A),W(2,A),W(3,A)\NEXT\FORA=1TO64
50 READ#0,N(0,A),N(1,A),N(2,A),N(3,A),N(4,A),N(5,A),N(6,A)\NEXT
60 CLOSE#0\INPUT"0 TO 9 : 0 I PLAY BEST AND 9 WORST ? ",Z\Z=1+(Z/10)
100 FORA=1TO64\B=A*4\C$(B-3,B)="    "\C=INT(A/10)\D=A-(C*10)
110 C$(B-1,B-1)=C1$(C+1,C+1)\C$(B,B)=C1$(D+1,D+1)\NEXT
120!"HERE IS MY BOARD"\!""\GOSUB1000\!""\!"ENTER MOVES BY",
130!" NUMBER AND YOUR'RE X"
140 !""\INPUT"YOUR MOVE ? ",X\IFX<1ORX>64THEN140\IFS(X)<>0THEN140
150 S(X)=1\A=X*4\C$(A-3,A)="XXXX"\P=1\GOSUB900
160 Q=0\FORA=1TO76STEPZ\C=T(A)\IFC<0THEN200\IFC=15THENEXIT400
170 IFC<>0THEN180\B=1\GOSUB500\GOTO200
180 IFC>4THEN190\B=P(C-1)\GOSUB500\GOTO200
190 C=INT(C/5)+2\B=P(C)\GOSUB500
200 NEXT\FORA=1TO64\IFV(A)<QTHEN210\Q=V(A)\X=A
210 V(A)=0\NEXT\IFQ=0ANDZ=1THEN1600\IFQ<>0THEN220
215 FORA=1TO64\IFS(A)=0THENEXIT217\NEXT\GOTO1600
217 S(A)=1\X=A
220 S(X)=1\A=X*4\C$(A-3,A)="0000"\P=5\GOSUB900
230 !"I WENT",X\!""\GOSUB1000\GOTO140
400 !"THE COMPUTER WINS WITH BOXES",W(0,A),W(1,A),W(2,A),W(3,A)\GOTO2000
500 FORF=0TO3\G=W(F,A)\IFS(G)=0THENV(G)=V(G)+B\NEXT\RETURN
900 FORA=0TO6\C=N(A,X)\IFC=0THEN950\IFT(C)<0THEN950
910 T(C)=T(C)+P\IFT(C)<4THEN950\IFT(C)=4THENEXIT1700
920 D=INT(T(C)/5)\IFD*5<>T(C)THENT(C)=-1
950 NEXT\RETURN
1000 FORA=0TO3\FORB=2TO0STEP-2\FORC=0TO3\FORD=1TO4
1010 E=(((C*16)+D+(A*4))*4)-B\!C$(E-1,E),\IFD<4THEN!" = ",
1020 NEXT\IFC<3THEN!"    ",\NEXT\!""\NEXT\IFA=3THEN1040
1030 FORE=1TO3\!"=================    ",\NEXT\!"================="
1040 NEXT\RETURN
1600 !""\!"IT'S A DRAW"\GOTO2000
1700 !""\F=C\GOSUB1000\!""\C=F\!"YOU WON",W(0,C),W(1,C),W(2,C),W(3,C)
2000 INPUT"CARRIAGE RETURN ENDS, ANYTHING ELSE PLAYS AGAIN ? ",Z$
2005 IFZ$=""THENEND\FORA=1TO76\T(A)=0\NEXT\FORA=1TO64\S(A)=0\V(A)=0\NEXT
2010 GOTO100
READY
```

Listing 1: Super TIC, a three-dimensional tic-tac-toe computer game written in North Star BASIC. (All other programs in this article are also written in North Star BASIC.)

Super TIC

J Roehrig
POB 74
Middle Village NY 11379

Listing 2: Modifications to listing 1 to change the three-dimensional version into two-dimensional 4 by 4 tic-tac-toe.

```
140 !""\INPUT"YOUR MOVE ? ",X\IFX<1ORX>16THEN140\IFS(X)<>0THEN140
160 Q=0\FORA=1TO10STEPZ\C=T(A)\IFC<0THEN200\IFC=15THENEXIT400
1000 FORA=0TO3\FORB=2TO0STEP-2\FORC=0TO0\FORD=1TO4
1030 !"================="
```

Super Micro-Tic

This article describes Super TIC, a program that plays three-dimensional (4 by 4 by 4) tic-tac-toe. It was written specifically for microprocessors and has the following features:

- It is fast, despite the fact that it checks every possible move. The response time is 13 seconds per move (worst case) using an IMSAI 8080 computer with North Star BASIC, and it averages less than six seconds per move.
- It gives a graphic display of the game (designed for a 24 line by 80 character terminal) without requiring a graphics board.
- It plays at ten different levels of skill without requiring modification of the program.
- One program line can be modified to change the program's strategy so that it plays defensively or aggressively.
- The modification of four lines (see listing 2) allows the game to be played in a two-dimensional 4 by 4 format.

Listing 3 shows a sample run of the 4 by 4 by 4 version. The computer asks for the level of play desired and gives a display of the game board. The player enters a move selection (a number from 1 to 64 corresponding to the desired box) and the computer answers with its move. Next, the

entire game board is reprinted with the player's boxes represented by Xs and the computer's boxes by Os.

For those readers not familiar with three-dimensional tic-tac-toe, table 1 shows all of the 76 possible winning combinations. The first player to occupy 4 squares (or, more properly, "cubes") in a straight line wins. Note that there are ten ways to win on each of the four boards (four horizontal, four vertical and two diagonal) and 36 ways to win by occupying one adjoining square on each of the separate boards.

Table 1: The 76 possible ways to win in 4 by 4 by 4 three-dimensional tic-tac-toe. The columns labelled M1, M2, M3 and M4 given an integer identification of a particular cube in the three-dimensional 4 by 4 by 4 matrix.

COMB	M1	M2	M3	M4	COMB	M1	M2	M3	M4
1	1	2	3	4	2	5	6	7	8
3	9	10	11	12	4	13	14	15	16
5	1	5	9	13	6	2	6	10	14
7	3	7	11	15	8	4	8	12	16
9	1	6	11	16	10	4	7	10	13
11	17	18	19	20	12	21	22	23	24
13	25	26	27	28	14	29	30	31	32
15	17	21	25	29	16	18	22	26	30
17	19	23	27	31	18	20	24	28	32
19	17	22	27	32	20	20	23	26	29
21	33	34	35	36	22	37	38	39	40
23	41	42	43	44	24	45	46	47	48
25	33	37	41	45	26	34	38	42	46
27	35	39	43	47	28	36	40	44	48
29	33	38	43	48	30	36	39	42	45
31	49	50	51	52	32	53	54	55	56
33	57	58	59	60	34	61	62	63	64
35	49	53	57	61	36	50	54	58	62
37	51	55	59	63	38	52	56	60	64
39	49	54	59	64	40	52	55	58	61
41	1	17	33	49	42	2	18	34	50
43	3	19	35	51	44	4	20	36	52
45	5	21	37	53	46	6	22	38	54
47	7	23	39	55	48	8	24	40	56
49	9	25	41	57	50	10	26	42	58
51	11	27	43	59	52	12	28	44	60
53	13	29	45	61	54	14	30	46	62
55	15	31	47	63	56	16	32	48	64
57	1	22	43	64	58	5	22	39	56
59	9	26	43	60	60	13	26	39	52
61	2	22	42	62	62	14	26	38	50
63	3	23	43	63	64	15	27	39	51
65	4	23	42	61	66	8	23	38	53
67	12	27	42	57	68	16	27	38	49
69	1	21	41	61	70	1	18	35	52
71	4	19	34	49	72	4	24	44	64
73	13	25	37	49	74	13	30	47	64
75	16	31	46	61	76	16	28	40	52

For comparison of strategies, the tic-tac-toe program, written by R K Louden ("TTT3D" in *Programming the IBM 1130 and 1800*, Prentice-Hall, 1967), keeps totalling values for the 76 winning combinations after each move, tests for only three or four critical situations and always examines the 64 squares for vacant positions. The use of this technique would take a few minutes for each move using a microcomputer, and the program is considerably longer.

The key to writing a program efficient enough to operate on a microcomputer is to limit the number of operations performed. Instead of constantly totalling winning combinations after each move, a running total is maintained in Super TIC. The importance of winning combination totals is simple. A 0 is assigned to blank squares, a 1 to squares with Xs and a 5 to squares with Os. A winning combination totalling 0 represents a line that either player can still win with; a combination value less than 5 and greater than 0 is a combination in which only X can win; a combination total evenly divisible by 5 represents a possible O win; and all other values are blocked (no one can win) combinations. This same totalling method shows how many Xs or Os occupy the four squares of the winning combinations.

In order to make Super TIC execute quickly, only the 76 winning combinations are checked to determine the computer's

Listing 3: Sample printout of the beginning of Super TIC.

```
0 TO 9 : 0 I PLAY BEST AND 9 WORST ? 0
HERE IS MY BOARD

   =    =    =          =    =    =          =    =    =          =    =    =
01 = 02 = 03 = 04    17 = 18 = 19 = 20    33 = 34 = 35 = 36    49 = 50 = 51 = 52
=================    =================    =================    =================
   =    =    =          =    =    =          =    =    =          =    =    =
05 = 06 = 07 = 08    21 = 22 = 23 = 24    37 = 38 = 39 = 40    53 = 54 = 55 = 56
=================    =================    =================    =================
   =    =    =          =    =    =          =    =    =          =    =    =
09 = 10 = 11 = 12    25 = 26 = 27 = 28    41 = 42 = 43 = 44    57 = 58 = 59 = 60
=================    =================    =================    =================
   =    =    =          =    =    =          =    =    =          =    =    =
13 = 14 = 15 = 16    29 = 30 = 31 = 32    45 = 46 = 47 = 48    61 = 62 = 63 = 64

ENTER MOVES BY NUMBER AND YOUR'RE X

YOUR MOVE ? 1
I WENT 64

XX =    =    =          =    =    =          =    =    =          =    =    =
XX = 02 = 03 = 04    17 = 18 = 19 = 20    33 = 34 = 35 = 36    49 = 50 = 51 = 52
=================    =================    =================    =================
   =    =    =          =    =    =          =    =    =          =    =    =
05 = 06 = 07 = 08    21 = 22 = 23 = 24    37 = 38 = 39 = 40    53 = 54 = 55 = 56
=================    =================    =================    =================
   =    =    =          =    =    =          =    =    =          =    =    =
09 = 10 = 11 = 12    25 = 26 = 27 = 28    41 = 42 = 43 = 44    57 = 58 = 59 = 60
=================    =================    =================    =================
   =    =    =          =    =    =          =    =    =          =    =    = OO
13 = 14 = 15 = 16    29 = 30 = 31 = 32    45 = 46 = 47 = 48    61 = 62 = 63 = OO

YOUR MOVE ?
```

Combination	Variable	Value (Defensive Version)	Value (Aggressive Version)
All Blanks		1	1
One X	P(0)	22	7
Two Xs	P(1)	147	22
Three Xs	P(2)	1030	147
One O	P(3)	2	2
Two Os	P(4)	3	3
All Others	—	0	0

NOTE: The computer is O and the values described are used to determine the computer's move. A value for three Os is not needed, since the computer will select that as its winning move without additional evaluation.

Table 2: Values assigned to squares under consideration. Each time a combination of four squares is checked by the program, these values are assigned to blank squares depending upon the nearest neighbors forming the best partial pattern combination listed.

Table 3: Winning combinations for each square. The 64 squares of the board are listed under NUM, to the right of which are the winning combination numbers involved with each square (see table 1). After each combination is examined, the value shown in table 2 is assigned to any blank square in the combination. These values are accumulated as each combination is evaluated. The square with the highest value becomes the computer's next move.

NUM	C1	C2	C3	C4	C5	C6	C7	NUM	C1	C2	C3	C4	C5	C6	C7
1	1	5	9	41	57	69	70	2	1	6	42	61	0	0	0
3	1	7	43	63	0	0	0	4	1	8	10	44	65	71	72
5	2	5	45	58	0	0	0	6	2	6	9	46	0	0	0
7	2	7	10	47	0	0	0	8	2	8	48	66	0	0	0
9	3	5	49	59	0	0	0	10	3	6	10	50	0	0	0
11	3	7	9	51	0	0	0	12	3	8	52	67	0	0	0
13	4	5	10	53	60	73	74	14	4	6	54	62	0	0	0
15	4	7	55	64	0	0	0	16	4	8	9	56	68	75	76
17	11	15	19	41	0	0	0	18	11	16	42	70	0	0	0
19	11	17	43	71	0	0	0	20	11	18	20	44	0	0	0
21	12	15	45	69	0	0	0	22	12	16	19	46	57	58	61
23	12	17	20	47	63	65	66	24	12	18	48	72	0	0	0
25	13	15	49	73	0	0	0	26	13	16	20	50	59	60	62
27	13	17	19	51	64	67	68	28	13	18	52	76	0	0	0
29	14	15	20	53	0	0	0	30	14	16	54	74	0	0	0
31	14	17	55	75	0	0	0	32	14	18	19	56	0	0	0
33	21	25	29	41	0	0	0	34	21	26	42	71	0	0	0
35	21	27	43	70	0	0	0	36	21	28	30	44	0	0	0
37	22	25	45	73	0	0	0	38	22	26	29	46	62	66	68
39	22	27	30	47	58	60	64	40	22	28	48	76	0	0	0
41	23	25	49	69	0	0	0	42	23	26	30	50	61	65	67
43	23	27	29	51	57	59	63	44	23	28	52	72	0	0	0
45	24	25	30	53	0	0	0	46	24	26	54	75	0	0	0
47	24	27	55	74	0	0	0	48	24	28	29	56	0	0	0
49	31	35	39	41	68	71	73	50	31	36	42	62	0	0	0
51	31	37	43	64	0	0	0	52	31	38	40	44	60	70	76
53	32	35	45	66	0	0	0	54	32	36	39	46	0	0	0
55	32	37	40	47	0	0	0	56	32	38	48	58	0	0	0
57	33	35	49	67	0	0	0	58	33	36	40	50	0	0	0
59	33	37	39	51	0	0	0	60	33	38	52	59	0	0	0
61	34	35	40	53	65	69	75	62	34	36	54	61	0	0	0
63	34	37	55	63	0	0	0	64	34	38	39	56	57	72	74

move. Furthermore, once the combination is considered blocked (at least one X and at least one O in the four boxes making up the possible winning combination) a negative value is assigned and the combination is never checked again.

This leaves us with the problem of selecting a move. Each time a combination is checked, a value is assigned to the group of four squares making up the combination. These values are shown in table 2 for two possible versions of Super TIC, and are contained on line 20 of the program.

The next difficulty is determining which winning combinations are associated with each square. These values are calculated ahead of time using a short program and are read into the program as data. Table 3 shows the 64 game squares and which of the winning combinations use which particular squares (the winning combination numbers refer back to the combinations detailed in table 1). After each combination is examined, the value shown in table 2 is assigned to any blank square in the combination. These values are accumulated as each combination is evaluated. The square with the highest value becomes the computer's move.

In order to test the program as well as the different strategies, the program shown in listing 4 can be used to pit the computer against itself. The defensive game always plays itself to a draw. Note that line 35 in listing 4 adds a new variable Y(4) that gives a different strategy to be used for the player moving first when the computer plays against itself. To my surprise, the defensive version can be beaten.

As mentioned earlier, the game plays at ten different levels. Level 0 checks all 76 combinations, while level 9 checks only 40 combinations. Table 4 shows which levels check how many combinations and which specific combinations.

Listing 4: Program to enable the computer to play against itself in the game of Super TIC.

```
10 DIMC$(256),S(64),W(3,76),T(76),N(6,64),P(4),V(64)
15 DIMM(1,36)
20 C1$='0123456789'\P(0)=22\P(1)=147\P(2)=1030\P(3)=2\P(4)=3
30 OPEN#0,'A16'\LINE130
35 DIMY(4)\Y(0)= 2\Y(1)=147\Y(2)=1030\Y(3)=2\Y(4)=3
40 FORA=1TO76\READ#0,W(0,A),W(1,A),W(2,A),W(3,A)\NEXT\FORA=1TO64
50 READ#0,N(0,A),N(1,A),N(2,A),N(3,A),N(4,A),N(5,A),N(6,A)\NEXT
60 CLOSE#0\Z=1
90 N(0,30)=14
100 FORA=1TO64\B=A*4\C$(B-3,B)='    '\C=INT(A/10)\D=A-(C*10)
110 C$(B-1,B-1)=C1$(C+1,C+1)\C$(B,B)=C1$(D+1,D+1)\NEXT
114 FORT9=1TO64\X=T9\C9=1
115 !''\!'GAME STARTED WITH',T9
141 GOTO150
145 GOTO660
150 S(X)=1\A=X*4\C$(A-3,A)='XXXX'\P=1\GOSUB900
155 M(0,C9)=X
160 Q=0\FORA=1TO76STEPZ\C=T(A)\IFC<0THEN200\IFC=15THENEXIT400
170 IFC<>0THEN180\B=1\GOSUB500\GOTO200
180 IFC>4THEN190\B=P(C-1)\GOSUB500\GOTO200
190 C=INT(C/5)+2\B=P(C)\GOSUB500
200 NEXT\FORA=1TO64\IFV(A)<QTHEN210\Q=V(A)\X=A
210 V(A)=0\NEXT\IFQ=0THEN1900
220 S(X)=1\A=X*4\C$(A-3,A)='OOOO'\P=5\GOSUB900
230 M(1,C9)=X\C9=C9+1\GOTO145
400 !'THE COMPUTER WINS WITH BOXES',W(0,A),W(1,A),W(2,A),W(3,A)\GOTO2000
500 FORF=0TO3\G=W(F,A)\IFS(G)=0THENV(G)=V(G)+B\NEXT\RETURN
660 Q=0\FORA=1TO76STEPZ\C=T(A)\IFC<0THEN700\IFC=3THENEXIT400
670 IFC<>0THEN680\B=1\GOSUB500\GOTO700
680 IFC<5THEN690\B=INT(C/5)\B=Y(B-1)\GOSUB500\GOTO700
690 B=Y(C+2)\GOSUB500
700 NEXT\FORA=1TO64\IFV(A)<QTHEN710\Q=V(A)\X=A
710 V(A)=0\NEXT\IFQ=0THEN1900
720 GOTO150
900 FORA=0TO6\C=N(A,X)\IFC=0THEN950\IFT(C)<0THEN950
910 T(C)=T(C)+P\IFT(C)<4THEN950\IFT(C)=4THENEXIT1700
920 D=INT(T(C)/5)\IFD*5<>T(C)THENT(C)=-1
950 NEXT\RETURN
1000 RETURN
1700 !''\F=C\GOSUB1000\!''\C=F\!'YOU WON',W(0,C),W(1,C),W(2,C),W(3,C)
1900 !''\!'IT'S A DRAW'
2000 Z$=' '
2005 IFZ$=''THENEND\FORA=1TO76\T(A)=0\NEXT\FORA=1TO64\S(A)=0\V(A)=0\NEXT
2020 !'PLAYER 1'\FORA=1TO36\IFM(0,A)=0THENEXIT2030\!%3I,M(0,A),\NEXT
2030 !''\!'PLAYER 2'\FORA=1TO36\IFM(1,A)=0THENEXIT2035\!%3I,M(1,A),\NEXT
2035 !''\FORA=1TO36\M(1,A)=0\M(0,A)=0\NEXT
2040 NEXTT9\END
READY
RUN

GAME STARTED WITH 1
THE COMPUTER WINS WITH BOXES 1 2 3 4
PLAYER 1
  1 61 52 49 25 47 60 16  4 42 38 22 19 36 26  2
PLAYER 2
 64 41 58 57 13 35 17 28 46 23 27  6 34 20 50 62

GAME STARTED WITH 2
```

Listing 5: Sample printout of two-dimensional version of Super TIC (see listing 2).

```
0 TO 9 : 0 I PLAY BEST AND 9 WORST ? 5
HERE IS MY BOARD

   =     =     =
01 = 02 = 03 = 04
=================
   =     =     =
05 = 06 = 07 = 08
=================
   =     =     =
09 = 10 = 11 = 12
=================
   =     =     =
13 = 14 = 15 = 16

ENTER MOVES BY NUMBER AND YOUR'RE X

YOUR MOVE ? 9
I WENT 5


   =     =     =
01 = 02 = 03 = 04
=================
00 =     =     =
00 = 06 = 07 = 08
=================
XX =     =     =
XX = 10 = 11 = 12
=================
   =     =     =
13 = 14 = 15 = 16
```

COMB	0	1	2	3	4	5	6	7	8	9	COMB	0	1	2	3	4	5	6	7	8	9
1	X	X	X	X	X	X	X	X	X	X	2	X	X	X	X	X	X	X	X	X	X
3	X	X	X	X	X						4	X	X	X	X		X	X	X	X	X
5	X	X	X		X	X	X				6	X	X		X	X			X	X	X
7	X	X	X	X		X	X	X			8	X	X	X	X	X	X			X	X
9	X	X	X		X		X	X			10	X	X	X	X	X	X	X		X	X
11	X		X	X		X		X	X		12	X	X		X	X		X	X		X
13	X	X	X		X	X	X		X		14	X	X	X	X		X		X		X
15	X	X	X	X	X		X		X		16	X	X	X	X	X	X		X		X
17	X	X	X	X	X	X	X		X		18	X	X					X	X		X
19	X	X	X	X	X	X		X	X		20	X	X	X	X	X	X	X		X	X
21	X	X	X	X			X	X		X	22	X		X		X	X			X	
23	X	X	X	X	X	X	X	X		X	24	X	X		X	X			X	X	
25	X	X	X	X		X	X			X	26	X	X	X		X	X	X	X	X	
27	X	X	X	X	X					X	28	X	X	X	X		X	X	X	X	
29	X	X	X	X	X	X	X	X	X	X	30	X	X		X	X					
31	X	X	X		X	X	X	X	X	X	32	X	X	X	X		X				
33	X		X	X	X		X	X	X	X	34	X	X	X	X	X	X	X			
35	X	X	X			X		X	X	X	36	X	X		X	X		X	X		
37	X	X	X	X	X	X	X		X	X	38	X	X	X	X	X	X		X	X	
39	X	X	X				X			X	40	X	X	X	X	X	X		X	X	X
41	X	X	X	X	X	X	X	X			42	X	X		X			X		X	X
43	X	X	X	X	X	X		X			44	X		X		X	X	X		X	X
45	X	X	X	X	X		X	X			46	X	X	X	X		X		X	X	X
47	X	X	X	X	X	X	X		X		48	X	X			X			X		X
49	X	X	X	X		X	X		X		50	X	X	X	X	X	X	X	X		X
51	X	X	X	X	X				X		52	X	X	X		X	X	X	X		X
53	X	X	X	X		X	X	X	X		54	X	X		X	X					X
55	X		X	X	X	X	X	X	X		56	X	X	X	X		X			X	X
57	X	X	X		X		X	X			58	X	X	X	X	X	X	X	X	X	X
59	X	X	X	X	X	X				X	60	X	X		X			X	X	X	
61	X	X	X		X	X	X			X	62	X	X	X	X	X	X		X	X	
63	X	X	X	X			X	X		X	64	X	X	X	X	X	X			X	
65	X	X	X		X	X	X	X	X	X	66	X			X	X		X			
67	X	X	X	X		X		X	X	X	68	X	X	X	X	X	X	X			
69	X	X	X	X	X		X	X	X	X	70	X	X	X			X		X		
71	X	X	X	X	X	X	X		X	X	72	X	X		X	X			X		
73	X	X	X	X	X	X	X		X	X	74	X	X	X			X	X	X	X	
75	X	X	X	X	X			X		X	76	X					X				

```
FOR LEVEL  0  :1.000% OR 76/76 OF THE COMBINATIONS ARE CHECKED
FOR LEVEL  1  : .908% OR 69/76 OF THE COMBINATIONS ARE CHECKED
FOR LEVEL  2  : .829% OR 63/76 OF THE COMBINATIONS ARE CHECKED
FOR LEVEL  3  : .763% OR 58/76 OF THE COMBINATIONS ARE CHECKED
FOR LEVEL  4  : .711% OR 54/76 OF THE COMBINATIONS ARE CHECKED
FOR LEVEL  5  : .671% OR 51/76 OF THE COMBINATIONS ARE CHECKED
FOR LEVEL  6  : .618% OR 47/76 OF THE COMBINATIONS ARE CHECKED
FOR LEVEL  7  : .592% OR 45/76 OF THE COMBINATIONS ARE CHECKED
FOR LEVEL  8  : .553% OR 42/76 OF THE COMBINATIONS ARE CHECKED
FOR LEVEL  9  : .526% OR 40/76 OF THE COMBINATIONS ARE CHECKED
```

Table 4: Winning combinations checked by each level of expertise in Super TIC. Level 0 is the most proficient level, level 9 the least. An X in the column for a given combination indicates that the given combination is to be checked.

Listing 6: Modifications to listing 1 to avoid the need for a disk data file.

```
30 LINE80
40 FORA=1TO76\READW(0,A),W(1,A),W(2,A),W(3,A)\FORB=0TO3\C=W(B,A)
50 FORD=0TO6\IFN(D,C)=0THENEXIT52\NEXT
52 N(D,C)=A\NEXT\NEXT
3000 DATA 1, 2, 3, 4, 5, 6, 7, 8, 9,10,11,12,13,14,15,16, 1, 5, 9,13
3010 DATA 2, 6,10,14, 3, 7,11,15, 4, 8,12,16, 1, 6,11,16, 4, 7,10,13
3020 DATA17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,17,21,25,29
3030 DATA18,22,26,30,19,23,27,31,20,24,28,32,17,22,27,32,20,23,26,29
3040 DATA33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,33,37,41,45
3050 DATA34,38,42,46,35,39,43,47,36,40,44,48,33,38,43,48,36,39,42,45
3060 DATA49,50,51,52,53,54,55,56,57,58,59,60,61,62,63,64,49,53,57,61
3070 DATA50,54,58,62,51,55,59,63,52,56,60,64,49,54,59,64,52,55,58,61
3080 DATA 1,17,33,49, 2,18,34,50, 3,19,35,51, 4,20,36,52, 5,21,37,53
3090 DATA 6,22,38,54, 7,23,39,55, 8,24,40,56, 9,25,41,57,10,26,42,58
3100 DATA11,27,43,59,12,28,44,60,13,29,45,61,14,30,46,62,15,31,47,63
3110 DATA16,32,48,64, 1,22,43,64, 5,22,39,56, 9,26,43,60,13,26,39,52
3120 DATA 2,22,42,62,14,26,38,50, 3,23,43,63,15,27,39,51, 4,23,42,61
3130 DATA 8,23,38,53,12,27,42,57,16,27,38,49, 1,21,41,61, 1,18,35,52
3140 DATA 4,19,34,49, 4,24,44,64,13,25,37,49,13,30,47,64,16,31,46,61
3150 DATA16,28,40,52
READY
```

A sample run of the 4 by 4 version is given in listing 5. Here level 5 was used and, according to table 4, combination 3 is not checked. Therefore, combination 3 was an easy winner.

The data read into Super TIC was taken from a disk file using conventions of North Star BASIC. In order to modify this, merely take out the open file statement (line 30) and add data statements. The file designation in the line 40 and line 50 read statements should also be removed. Listing 6 shows how this can be accomplished.

Super TIC, as presented, is almost unbeatable (I believe that it is impossible to write an unbeatable version as long as the player always goes first and the computer second). You could probably play for days and never do better than a draw. However, armed with the computer generated winning combination in listing 4, you can beat the computer easily by remembering 16 exact moves.■

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Programming Quickies

The Towers of Hanoi
Solution Using BASIC Recursion

Stanley Switzer, 1019 W 27th St, Lawrence KS 66044

The Towers of Hanoi is an intriguing puzzle of the Orient. The puzzle requires three vertical rods and a given number of disks with holes in the center to be placed on the rods. Initially, all of the disks are placed on the leftmost rod, arranged by size with the largest disk on the bottom (see figure 1). The objective is to move all of the disks to the rightmost rod. There are, however, a few restrictions. Only one disk may be moved at a time, and no disk may be placed over a disk smaller than itself. The solution to this puzzle may seem difficult at first, but with the help of a recursive program, it is simple.

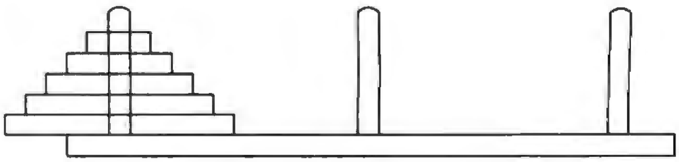

Figure 1: *Initial configuration for the Towers of Hanoi problem. The objective is to move all the disks one at a time from the left rod to the right rod without ever placing a larger disk on top of a smaller disk. Intermediate moves can be made to the center rod, of course.*

A recursive program is one that is defined in terms of itself. It is utilized when a problem can be broken into several parts, and when one of those parts is a similar problem of lesser magnitude. A common example is a definition of factorials:

$$0! = 1$$
$$n! = n(n-1)!$$

Here is a recursive program for factorials written in pseudocode:

```
factorial (n)
   if (n=0)
      return(1);
   else
      return(n × factorial(n − 1));
```

In this case an iterative definition is more practical for computational purposes, but this does illustrate the concept of recursion.

When broken into its basic parts, the solution to the Towers of Hanoi problem is as follows:

- When one disk is to be moved, the solution is ob-

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vious — move the disk from the source to the destination rod.

- When n+1 disks are to be moved:
- 1) Move n disks from the source rod to the intermediate rod;
  2) Move one disk from the source rod to the destination rod; and
  3) Move n disks from the intermediate rod to the destination rod.

Listing 1: *Recursive solution to the Towers of Hanoi problem in BASIC.*

```
010    REM Declare the stack arrays.
020    DIM S$(15),D$(15),I$(15)
030        PRINT
040        PRINT "Number of disks";
050        INPUT P
060        REM If P is too large or too small, STOP.
070        IF (P>15) THEN 170
080        IF (P<1) THEN 170
090        REM Move P disks from Left to Right.
100        LET S$(P)="L"
110        LET D$(P)="R"
120        LET I$(P)="C"
130        REM Move those disks!
140        GOSUB 180
150        REM Since that was so much fun let us do it again.
160    GOTO 30
170    STOP
180        REM This is the recursive HANOI procedure.
190        REM If P=1, move one disk from source to destination.
200        IF (P>1) THEN 230
210            PRINT "Move a disk from ";S$(P);" to ";D$(P);"."
220        RETURN
230            REM Else, move P-1 disks from Source to Intermediate.
240                LET P=P-1
250                LET S$(P)=S$(P+1)
260                LET D$(P)=I$(P+1)
270                LET I$(P)=D$(P+1)
280                GOSUB 180
290            REM Move one disk from Source to Destination.
300                PRINT "Move a disk from ";S$(P+1);" to ";D$(P+1);"."
310            REM Move P-1 disks from Intermediate to Destination.
320                LET S$(P)=I$(P+1)
330                LET D$(P)=D$(P+1)
340                LET I$(P)=S$(P+1)
350                GOSUB 180
360            LET P=P+1
370        RETURN
380    END

*run

Number of disks?4
Move a disk from L to C.
Move a disk from L to R.
Move a disk from C to R.
Move a disk from L to C.
Move a disk from R to L.
Move a disk from R to C.
Move a disk from L to C.
Move a disk from L to R.
Move a disk from C to R.
Move a disk from C to L.
Move a disk from R to L.
Move a disk from C to R.
Move a disk from L to C.
Move a disk from L to R.
Move a disk from C to R.

Number of disks?2
Move a disk from L to C.
Move a disk from L to R.
Move a disk from C to R.

Number of disks?1
Move a disk from L to R.

Number of disks?0

ready
*
```

The fact that this algorithm is correct can be proven via the principle of mathematical induction. Since a solution is defined in the case of having to move one disk and since, given a solution for n disks, a solution can be found for n+1 disks. That is, given a solution for one disk, we have a solution for two disks; given a solution for two disks, we have a solution for three disks, and so on. The proof that this algorithm produces the fewest possible moves is left to the reader.

Now that our algorithm is defined, we can implement the program. In many BASICs, recursion is allowed in function calls. In my BASIC, however, it is not. It turns out that recursion is supported in all BASICs for subroutine calls. The only limiting factor is the depth of subroutine nesting allowed. In my case, this limit was fifteen levels. The only major problem was the method of parameter passing. Each invocation of the HANOI program has different source, intermediate, and destination rods. In order to keep these straight, the names of these rods [L (left), R (right), C (center)] must be kept on separate stacks [S$ (source), D$ (destination), I$ (intermediate)]. The variable P tells the program the number of disks to move, as well as the offset into the arrays to find the current names of the rods.

Recursion, when applied effectively, is one of the most powerful tools a programmer has. Many computer languages support recursion more fully than BASIC. Among these are Pascal, LISP, and APL. These languages allow recursive functions and local variables (local variables have separate storage locations for each invocation of the function). I hope that this Programming Quickie will prompt you to try some recursive programs. If you have access to any of the above languages, I suggest that you use them. If not, BASIC will still work. ■

The Correct Order of Operations Can Shorten Code

Pointer Decrementing on the 6502

Philip K Hooper, 5 Elm St, Northfield VT 05663

Several instances of 6502 code I have come across decrement a 16-bit pointer as follows:

```
DEC POINTL      decrement low byte of the
                pointer.
LDA POINTL      move result to accumulator.
CMP $FF         test for page crossing.
BNE 02          if not FF, no page crossing
                —decrementing complete.
```

DEC POINTH	otherwise, decrement high byte of pointer to cross page.

The following code produces the same result, but requires two fewer bytes of code and executes 2 μs faster:

LDA POINTL	bring low byte of pointer into accumulator.
BNE 02	if not zero, no page crossing, so branch ahead, skipping high byte.
DEC POINTH	otherwise, decrement high byte of pointer.
DEC POINTL	and decrement low byte of pointer.

Although this might seem a minor improvement, it amounts to 20% (for a pointer on page 0), and sometimes several similar small savings substantially shrink software storage space stress. ■

Sets

Tutoring in BASIC

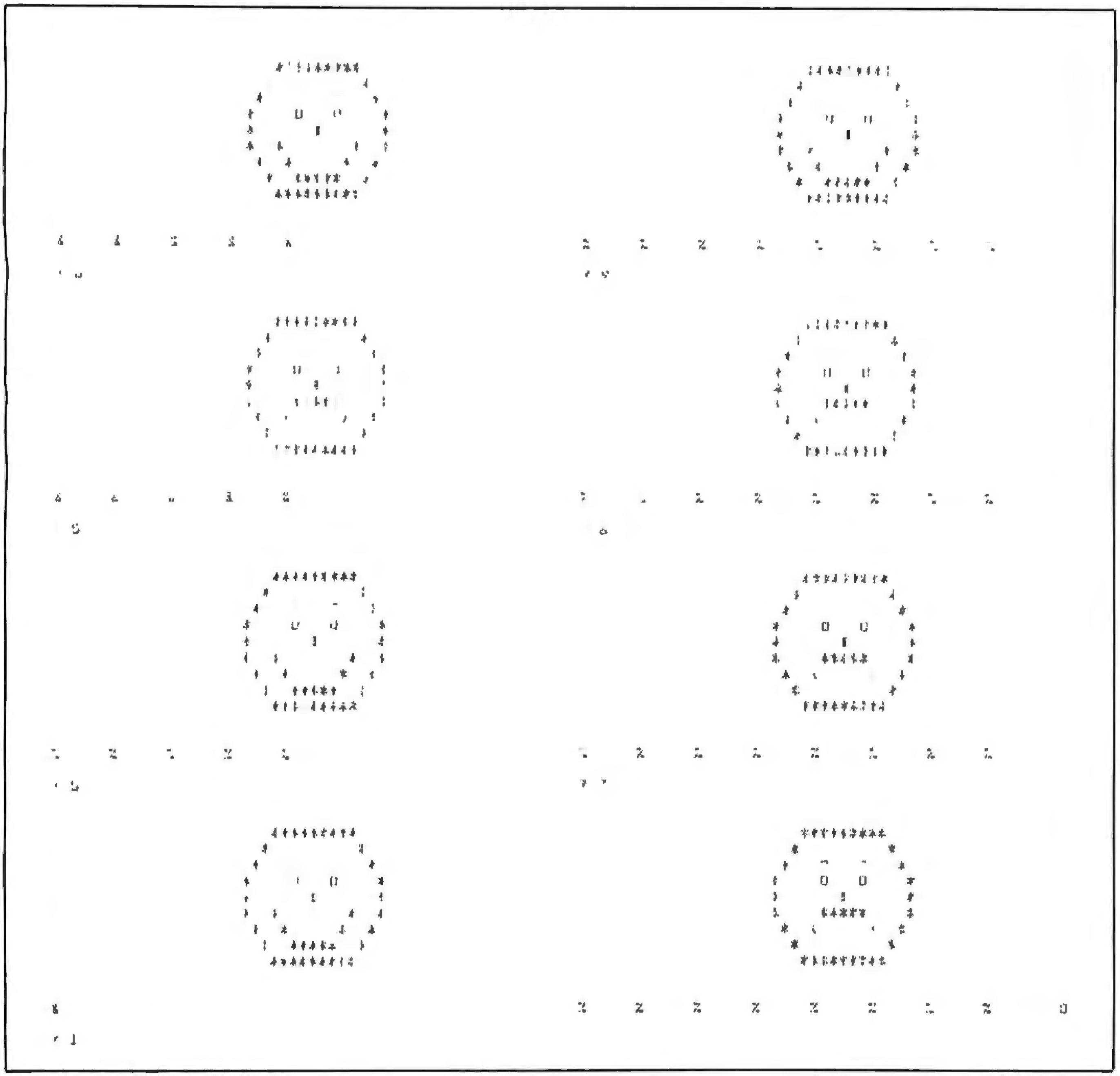
Linda M Schreiber, 29143 Carlton, Inkster MI 48141

Listing 1: *Altair Extended BASIC listing for helping children learn about sets.*

```
10 '  *****      SETS  VER. 1   *****
20 '  **     L. M. SCHREIBER       **
30 '  * 4-78  ALTAIR EXTEDED-BASIC *
40 ' PURPOSE:TO TEACH NUMBER RECOGNITION & THE NUMERICAL VALUE
50 ' OF A GIVEN SET.
60 ' MESSAGE TO AN ADULT.
70 PRINT"THE CHILD WILL BE SHOWN A SET OF CHARACTERS."
80 PRINT"AFTER COUNTING THE CHARACTERS, THE CHILD SHOULD ENTER"
90 PRINT"THAT NUMBER FROM THE KEYBOARD. IF THE CORRECT NUMBER IS"
100 PRINT"ENTERED, THE TERMINAL WILL SMILE. IF THE NUMBER IS WRONG,"
110 PRINT"THE TERMINAL WILL FROWN."
120 C=INT(RND(1)*4)+35 'CHOOSE ASCII CODE FOR CHARACTER
130 N=INT(RND(1)*9)+1 'CHOOSE A NUMBER BETWEEN 1 AND 9
140 T=T+1 'COUNT NUMBER OF SETS VIEWED
145 W=0 'CLEAR COUNTER FOR WRONG ANSWERS
150 C$=CHR$(C) 'CONVERT ASCII CODE TO CHARACTER
160 PRINT:PRINT:F$="" 'CLEAR FLAG FOR NEXT ANSWER
170 FOR P=1 TO N 'LOOP TO PRINT CHARACTERS
180 PRINT C$"      ";
190 NEXT P
195 IF W=3 THEN PRINT"="N:GOTO 120
200 PRINT:PRINT:INPUT G$ 'ENTER NUMBER OF CHARACTERS
210 IF VAL(G$)<>N THEN F$="FROWN" 'CHECK ANSWER
215 PRINT:PRINT
220 PRINTTAB(23)"**********"
230 PRINTTAB(22)"*          *"
240 PRINTTAB(21)"*    ~   ~    *"
250 PRINTTAB(20)"*     0   0     *"
260 PRINTTAB(20)"*       *       *"
270 IF F$="FROWN" THEN 330
280 PRINTTAB(20)"*  *         *  *"
290 PRINTTAB(21)"*  *       *  *"
300 PRINTTAB(22)"*  *****   *"
310 PRINTTAB(23)"**********"
320 IF T<>5 THEN 120 ELSE 380
330 PRINTTAB(20)"*     *****     *"
340 PRINTTAB(21)"*  (       )  *"
350 PRINTTAB(22)"*          *"
360 PRINTTAB(23)"**********"
365 W=W+1
370 GOTO 160
380 PRINT:PRINT:PRINT:PRINT"BYE"
390 END
OK
```

The program *Sets* (shown in listing 1) reinforces the recognition of numbers and their set values for a preschool child. Except for a message at the beginning of the program, no reading is required. All interaction be-

Listing 2: *Sample run of program Sets. The computer outputs a smiling face when the child's answer is correct and a frowning face when the answer is incorrect.*



tween the computer and the child is accomplished by the use of graphics.

The terminal prints out a set of 1 to 9 characters for the child to count (see listing 2 for sample run). The child enters the number from the keyboard. If the number entered is incorrect, a frown will appear on the terminal. When the correct number is entered, the terminal will show a smile. The child is allowed three attempts to answer each set correctly. The answer will be printed after the third attempt.

In line 200, a string variable is used for input, so that a child who mistakenly enters a letter or symbol will not become frustrated with error messages. All incorrect inputs are treated in the same manner.

The T variable in line 140 counts the number of sets the child will be shown. In this version the program will end after 5 sets. The variable can be easily increased (lines 195 and 320) for a child with a longer attention span. Similarly, the 9 in line 130 can be changed to a greater value for the child who has mastered sets from 1 to 9.

Sets is written in Altair (Microsoft) Extended BASIC and uses just over 1 K bytes of memory. ■

What's New?

SOFTWARE

Z80-Based Disk Operating System Written in PL/M

A Z80-based operating system which allows up to four simultaneous users and hard disk-drive control has been released by Altos Computer Systems. AMEX (Altos Mutli-User Executive) is written in PL/M and is compatible with CP/M versions 1.4 and 2.0. AMEX can manage up to four user-memory areas of up to 48 K bytes each. It utilizes a priority ordered interrupt-driven dispatching algorithm. Priority is given to input/output (I/O) bound tasks, while microprocessor compute-bound tasks tend to migrate to the bottom of the priority line.

Access to on-line storage on floppy or hard disk is handled for multiple users by AMEX, using direct memory address (DMA) hardware. AMEX features a dispatcher and a spooler that allocate and free various peripheral devices as requested by user programs or commands. The system is designed to carry on multitasking operations within an individual user's 48 K memory block. AMEX includes a screen-oriented text editor, an 8080 assembler, built-in utilities, file management commands and a transient command handler which allows the user to define new disk-oriented commands separate from those implemented by CP/M.

AMEX requires an Altos ACS8000 series computer and 64 K bytes for one user, 112 K bytes for two users, and 208 K bytes for four users. It is priced at $250 and comes on a single floppy disk. Contact Altos Computer Systems, 2338-A Walsh Ave, Santa Clara CA 95050.

Circle 400 on inquiry card.

Where Do New Products Items Come From?

The information printed in the new products pages of BYTE is obtained from "new product" or "press release" copy sent by the promoters of new products. If in our judgement the information might be of interest to the personal computing experimenters and homebrewers who read BYTE, we print it in some form. We openly solicit releases and photos from manufacturers and suppliers to this marketplace. The information is printed more or less as a first in first out queue, subject to occasional priority modifications. While we would not knowingly print untrue or inaccurate data, or data from unreliable companies, our capacity to evaluate the products and companies appearing in the "What's New?" feature is necessarily limited. We therefore cannot be responsible for product quality or company performance.

Apple II Animation Package

The A2-3D1 is a package of easy to use assembly language programs for three-dimensional and two-dimensional animation on the Apple II. The program allows users to view two- or three-dimensional scenes created in the standard XYZ coordinate system, zoom between wide angle and telephoto fields of view, select a location in space, and a direction of view. One feature allows users to generate an output array of line start and end points instead of plotting on the Apple screen. Other features include zero page restore which leaves all zero page variables intact after subroutine exit, page control for selective page erase, display, and draw for ping-ponging between screens for smooth animation. The load and go manual guides beginners through an orientation session with the A2-3D1 program. The technical manual is for advanced applications and describes the transformer algorithm in detail. The program requires 16 K bytes of programmable memory for the three-dimensional and two-dimensional transformer, small scenes, and small control programs. Larger scenes, control programs and the DEVELOP program require 24 K bytes of programmable memory. The program costs $45 on cassette and $55 on floppy disk. For more information, contact Sublogic, POB 5, Savoy IL 61874.

Circle 401 on inquiry card.

Intel Adds Pascal-80 to 8080/8085 Microprocessor Software Development

Intel Corp has developed Pascal-80 to support 8080 and 8085 microprocessor software development on Intellec microcomputer development systems. Similar to its PL/M, BASIC, and FORTRAN programs, the Pascal-80 package is available on floppy disk and runs under the ISIS-II operating systems on Intellec Series II and MDS-800 models. This Pascal-80 offers extensions that make the language suitable for commercial and industrial applications. The extensions include three new data types—the string type, untyped files, and interactive files—plus twenty-eight predeclared procedures and functions. Pascal-80 provides a Trace facility allowing a user to monitor program execution, and a set of compile and run-time error diagnostics. Users create Pascal source programs using the Pascal-80 software and standard Intel microcomputers. The Pascal-80 software package includes a floppy disk containing a compiler, a pseudocode interpreter and demonstration programs, a Pascal-80 user's manual and the *Pascal User Manual and Report*, second edition, by Jensen and Wirth. The software package is priced at $975 and is available from Intel Corp, 3065 Bowers Ave, Santa Clara CA 95051.

Circle 402 on inquiry card.

What's New?

SOFTWARE

Bell and Howell Introduces Software for Education

These software packages from Bell and Howell allow instructors to create courseware for students. No prior programming knowledge is needed by either instructor or students. Some of the features of the Generalized Instructional Systems (GENIS) include the authoring system which allows teachers to create curriculum material, obtain grade reports, control class enrollment, and more. A system that allows student interaction with the computer is included. The programs understand misspelled words; present lessons in words, animation, graphics, and color; grade student performance; generate drills, practice, and simulation programs; and other administrative projects. The GENIS program is price at $300. Write to Bell and Howell Audio-Visual Products Division, 7100 N McCormick Rd, Chicago IL 60645.

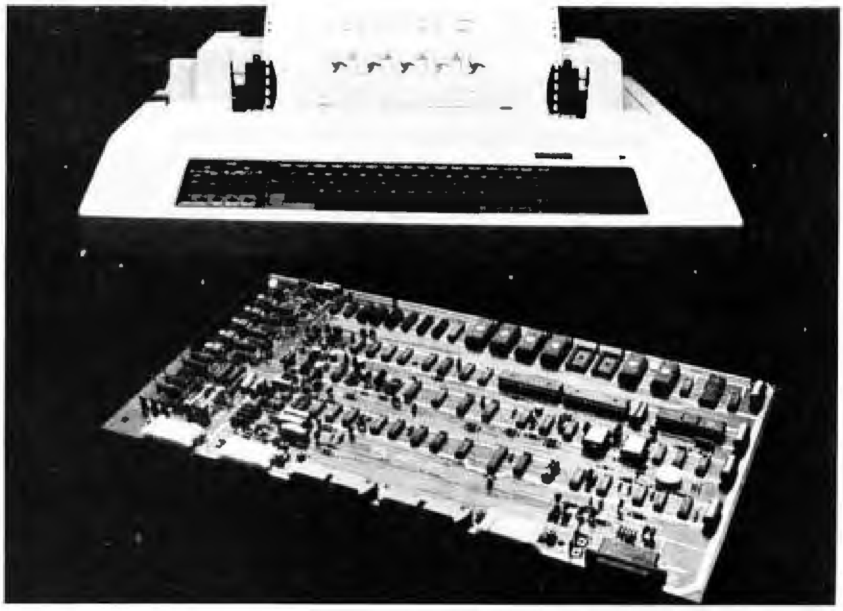
Circle 403 on inquiry card.

Information Storage and Retrieval (ISAR) for TRS-DOS

ISAR is a data base management system designed for users of TRS-DOS random file structures. The system utilizes the limited TRS-80 chaining techniques that keep as much of the program in memory as necessary to perform any given function.

The basic ISAR system consists of six modules which allow users to create new files, define all elements within each file, and manipulate each file. Each file or portion of a file can be sorted using BASIC Shell-Metzer sort. The package includes source listing, documentation, potential recovery techniques in the event of a system failure and suggested personal applications. ISAR comes on cassette for $13.95 or diskette for $16.95. For further information, contact The Alternate Source, 1806 Ada St, Lansing MI 48910.

Circle 405 on inquiry card.



DECwriter Graphics Available for Timeshare Computers

Graphics II is a modification to the DECwriter II printer for conversion to a plotter. Graphics II features APL character set, forms control, horizontal and vertical tabs, answerback, bidirectional line feed, four character sets with four different styles—characters can be printed in four directions. The average speed is 40 characters per second (cps). One inch per second for plotting and communication up to 12 bits per second (bps) is possible. The price is $850, and Graphics II is available from Selanar Corp, 2403 DeLaCruz Blvd, Santa Clara CA 95050.

Circle 404 on inquiry card.

Space Shuttle Landing Simulator

This program is modeled after the NASA Shuttle Mission Simulator in Houston. It is a real flight simulator (except for roll motion) with a visual display of the sky and ground. High resolution graphics show the cockpit view using animation, projective geometry, and graphics to depict the runway, sky, ground, and distant mountains and clouds. The paddles control the pitch control and speed brakes. Speed, altitude, sink and climb rate, distance from the threshold, speed brake setting, glide slope, and angle of attack are displayed. Warnings and messages are also displayed.

Functional features include angle of attack control, full stall capability, eject and eject warning, landing gear, speed brakes, and wheel brakes on rollout. Runway stripes on roll out give a visual indication of motion.

The program is available from Harvey's Space Ship Repair, POB 3478, University Park, Las Cruces NM 88003, for $15 on cassette. A floppy disk version is also available.

Circle 406 on inquiry card.

Multitasking Disk Operating System for 8080, 8085, and Z80 Systems

EFAMOS is a disk-operating system for 8080, 8085, and Z80 systems that supports multitasking and multiusers with memory mapping. Up to 3 M bytes of memory can be available to users through 32 K byte memory banks. EFAMOS is compatible with all software developed under MVT-BASIC. It provides full system support to each memory bank, including assembler BASIC run-time, system utilities, BASIC, utilities and word processing. BASIC support includes chaining with parameter passing and machine language calls with over ten ISAM functions. Word processing activities with several concurrent users can be completely supported in one memory bank, while program development and data processing functions are supported in other memory banks. Batch monitors can reside in any bank of memory and can process job files submitted from any other bank. One design feature of EFAMOS precludes terminal lockup during any input/output operation, which prevents the loss of characters in a busy multiuser environment. For licensing and terms, contact MVT Microcomputer Systems Inc, 9241 Reseda Blvd, Suite 203, Northridge CA 91324.

Circle 407 on inquiry card.

What's New?

SOFTWARE

Pascal for the 8080 and Z80 Processors

Built upon Whitesmiths' C compiler and libraries, the Pascal Development System provides a software environment for Pascal programming on PDP-11, LSI-11, 8080 and Z80 computers. The compilers and all support utilities run under IDRIS, UNIX, RT-11, RSX-11M, RSTS, or IAS on the PDP-11 and LSI-11, and under CP/M or CDOS on the 8080 and Z80, producing code that runs faster than Pascal interpreters. Included as part of the package are an A-Natural assembler, an 8080 linking loader, a librarian, and other utilities. Users also receive the Whitesmiths' Portable Pascal and C library and manual. Supporting these portable libraries are an operating system-specific interface library, a machine library, and 64-bit floating point arithmetic. The 8080/Z80 and PDP-11 Pascal Development Systems, are available from Lifeboat Associates, 2248 Broadway, NY NY 10024, for $750 per single microprocessor license.

Circle 408 on inquiry card.

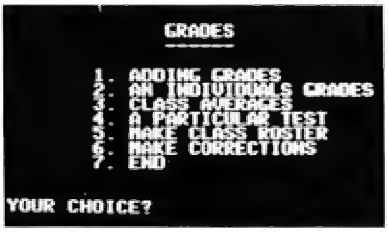
Graham-Dorian Introduces a Software Medical Package

This package was written and tested by medical professionals. It handles billing insurance forms, treatment records, charge and payment entry, patient statements, Medicare submittals, collection accounting and dunning, patient processing, patient listing, aged accounts receivables, transaction reporting, and more.

The package can be ordered on eight-inch floppy disks and includes a manual and hard copy source listing. The price for the program is $1000 and is available from Graham-Dorian Software Systems Inc, 211 N Broadway, Wichita KS 67202.

Circle 409 on inquiry card.

Machine Language Disk File Sorting Program for Apple II



Datacope, POB 55053, Hillcrest Sta, Little Rock AR 72205, has released an enhanced version of their sorting program that is compatible with either the Apple II or the Apple II Plus computer systems. The new version of the Datacope Single Disk Sort performs user-specified direct commands upon completion of the sorts, for easy use in turn-key systems. The program employs one disk drive, and sorts a single file of fixed-length records on a single floppy disk. A file may fill the entire disk because the program uses no workspace on the disk. Blocks of consecutive records may be sorted without disturbing the remainder of the file. Files may contain records with 5000 characters and may be sorted by ten key fields simultaneously, with each key field in either ascending or descending alphabetical or numerical order. The program features other necessary functions. The package includes a manual and a floppy disk with the sort programs, a test file, and test file access programs in Applesoft II for $49.95.

Circle 410 on inquiry card.

CP/M Compatible Operating System for TRS-80 Level II Computers

A fully CP/M compatible operating system for the TRS-80 II computer has been developed. The operating system works with CBASIC and all other CP/M programs, requiring no changes to the operating codes. The system sells for $249.95 from MPU, POB 808, San Carlos CA 94070.

Circle 411 on inquiry card.

More Programs for Apple II Systems

Apple Barrel Bushel #1 is a collection of twenty-five programs including Mortgage Loan, Days Between Dates, Calendar, Savings, Checkbook, Addition, Subtraction, Metric Conversion, Luna C, Apple LeMans, Alien, and more. The package is available on cassette tape for $24.95 or on floppy disk for $29.95. Contact CDS Corp, 550 N Main St, Logan UT 84321.

Circle 412 on inquiry card.

Language Translator Program

This program translates from English to any foreign language, from any language back to English, or from one foreign language to another. Simple commands bring in the correct vocabulary or words. The program checks the entire sentence for the proper verb conjugation and word contractions. New words may be added at any time and saved as part of the vocabulary. One mode lets the translator receive data in one language from a reader, and then sends the translation to a printer. Display formatting commands show vocabulary words alphabetically or in categories. Spelling errors are caught and corrected.

The Language Translator from Practical Programming Corp, POB 3069, N Brunswick NJ 08902, is available on CP/M or North Star floppy disk with one extended language for $30. Additional languages are $10 each.

Circle 413 on inquiry card.

A Forth Software Development Tool

The XL5 is an interactive programming system with compiler, interpreter, assembler, disk operating system, and a library of procedures. It is written in XL5 and is based on the recommendations of the 1977 Forth Standards Committee. A host-executable code kernel, a source code kernel, and a system generation program (SYSGEN) are provided. SYSGEN regenerates the kernel from the source or generates read-only memory (ROM) modules. An XL5 development system requires less than 32 K bytes of memory. The $100 package includes source code and a reference manual. XL5 is available with a CP/M boot loader for the 8080 and the Z80. For information, contact XL Computer Products, 321 E Kirkwood Ave, Bloomington IN 47401.

Circle 414 on inquiry card.

1979 Federal Tax Programs for Microcomputers

Aardvark Software Inc, POB 26505, Milwaukee WI 53213, is marketing a software program which will calculate an individual's federal tax liability. The program displays the tax information as it would appear on an IRS form. It also calculates the tax liability using the tax tables, tax rate schedules, income averaging, maximum tax on earned income, and alternative minimum tax choosing the most favorable method. A manual is included to organize the tax information for input. Three programs are available at $22, $35, and $50.

Circle 415 on inquiry card.

What's New?

PUBLICATIONS

Guidebook for the TRS-80 Level II Microcomputer

Learning Level II, written by Dr David A Lien, is a step-by-step guide to help users of the Level II TRS-80. It contains a section updating the Level I manual to Level II. Readers are guided through the fundamentals and special characteristics of Level II BASIC, beginning with setting up the system. The book explains how to properly use the Editor to change and correct BASIC programs. Another section is devoted to the conversion of Level I programs to Level II. The book also explains dual cassette operation, using the expansion interface box with the real-time clock, printers and other peripheral devices. It is available from Computer Books Division, Compusoft Inc, 8643 Navajo Rd, San Diego CA 92119, for $15.95, plus $1.45 for postage and handling.

Circle 416 on inquiry card.

1980 Computer Catalog

Sara Tech Electronics Inc, POB 692, Venice FL 33595, is offering their sixteen-page 1980 computer catalog featuring more than 1000 products. All major brands of computers and equipment are carried. Write for a free copy.

Circle 417 on inquiry card.

Catalog Features Articles on Classroom Computing

Creative Publications is publishing a color newsletter/catalog of computer materials for the classroom. The publication features an article on the television documentary "Don't Bother Me, I'm Learning," which discusses computers in education. All products in the catalog are described with the educational user in mind. The catalog is available from Creative Publications, POB 10328, Palo Alto CA 94303.

Circle 418 on inquiry card.

TRS-80 Software Source

This catalog contains over 5000 software listings that are available from 380 suppliers. The publication lists business, education, games, home, math, and utility software with a section of addresses of the suppliers. A one-year subscription is $15 and a single issue is $6. Contact Computermart, POB 1664, Lake Havasu AZ 86403.

Circle 419 on inquiry card.

Computer Book Catalog Released by Sams

The Howard W Sams and Co Inc has released a catalog featuring a large selection of computer and computer related titles. It is organized for quick reference into five areas—basics, programming, computer technology, reference, and computer related. This free catalog details books that are directed to a wide range of people and interests, from the home hobbyist to the technically oriented professional.

For a catalog, contact the Advertising Director, Howard W Sams and Co Inc, 4300 W 62 St, POB 558, Indianapolis IN 46206.

Circle 420 on inquiry card.

New Renaissance!

New Renaissance! is a bimonthly magazine for lighting and laser artists and technicians who desire to share their works, events, goals, and discoveries with others in the field. It features performance news and reviews; projects, plans and schematics; new techniques and products; interviews; books and other data sources, and more. A one-year subscription is $25 and is available from *New Renaissance!*, 5267 11th Ave NE, Seattle WA 98105.

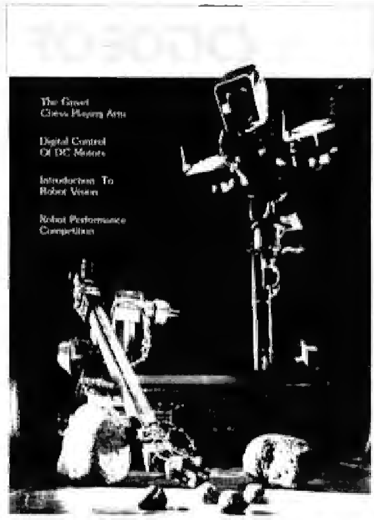
Circle 421 on inquiry card.

Documentation Standards for Computer Systems

Norman L Enger's *Documentation Standards for Computer Systems*, Second Edition, is a reference manual that shows how to document a computer application to utilize the full potential of the computer resources. The book includes revised and expanded material that describes the evolution of a system through the stages of initiation, analysis, design, development, implementation, and operation. The section on "Techniques and Tools for Analysis" facilitates the analyst's work. This book aids in determining the amount of documentation needed for specific types of projects. Procedures can be established to employ documentation standards adopted by the organization. Dr Enger's book is useful to computer professionals, students and novices in the computer industry. It is available by mail for $25 from The Technology Press Inc, POB 125N, Fairfax Station VA 22039.

Circle 422 on inquiry card.

Magazine on Robotics



Robotics Age magazine contains readable articles of high technical content that present the latest results of research in robotics and artificial intelligence. The contents include well-documented electromechanical circuit designs, microcomputer interfaces, and programming techniques suitable for economical applications to small systems. Abstracts of research papers are also featured. New products items describe new commercially available kits and robotics related products. The quarterly publication is available at $8.50 for one year from *Robotics Age*, POB 801, La Canada CA 91011.

Circle 423 on inquiry card.

Publication of Sorting Subroutines

Creative Computer Consultants Inc, POB 2111, 1 Quarry Ln, Norwalk CT 06851, has published volume 4 of *Sortmaster* in the Standard Software Library. *Sortmaster* contains listings of five BASIC subroutines designed to sort numeric data in memory. The subroutines have been designed to be integrated into the user's main line program. Numeric fields are sorted by designating that field as the sorting key. This makes it possible to sort records of any length and also permits multiple sorting keys. By adjustment of certain variables, all of the routines can handle alphanumeric data as well. *Sortmaster* includes an introduction to basic sorting concepts as an aid to beginners. The programs work with the TRS-80, PET, and Apple II. The book costs $8.95.

Circle 424 on inquiry card.

What's New?

PERIPHERALS

Eight-Inch Winchester Disk Up to 20 M Bytes

The Series 7000 hard disk drives have unformatted capacities of 4 megabytes in the single disk version, 12 megabytes in the double-density version and 20 megabytes in the three-disk unit. Data transfer rates are 5.5 million bits per second (bps). The Series 7000 employs the Winchester technique, using an ironless rotary actuator to position the heads in response to prerecorded servo-tracks on the lower side of the bottom disk.

Each 21 cm diameter surface has a 350-track cylinder with an inner track recording density of 5280 bits per inch. The interface is designed for use with microprocessor-based controllers. The drives utilize eight-bit bidirectional bus transfers. Line transceivers enable daisy-chain connection of other disks to the bus.

The 4 megabyte drive, the 7000-4, is $2100; the 7000-12 is $2300; and the 7000-20 is $2650. The units are manufactured by Kennedy Co, 1600 S Shamrock Ave, Monrovia CA 91001.

Circle 425 on inquiry card.

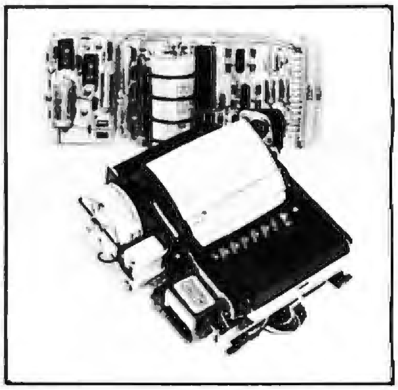
Stockey Series of Keyboards

The Stockey Series offers ten general-purpose standard keyboard designs, including six with American Standard Code for Information Interchange (ASCII) encoded alphanumeric formats. These are available in ASR33, ANSI teletypewriter, IBM 3278 ASCII typewriter, IBM 3278 data entry, and IBM Selectric I and II typewriter formats. An eleven- and fifteen-Key Expander pad can be added via a flex-strip jumper to any of the six alphanumeric designs to provide high-speed numeric entry.

The 53-key SK053 for the Model 33 teletypewriter features uppercase, but no lowercase, and costs $139. The 67-key model includes uppercase and lowercase, a full ASCII set, and is priced at $173. For additional information, contact Advanced Input Devices, POB 1818, Coeur d'Alene ID 83814.

Circle 426 on inquiry card.

12 VDC Alphanumeric Printer System



The PR6024 printer controller and any SODECO PR Series print mechanism comprise a print system operable from a 12 V power source. The controller accepts a 7-bit parallel ASCII format and features an integral voltage regulator and adjustable input thresholds for immunity from environmental noise. The unit features a 54-character alphanumeric set. Applications include mobile electronics, such as truck-mounted fuel-dispensing systems, police cars, security systems, and battery sustained instrumentation and systems. The price for the 15-column tape printer and PR6024 controller is $363 in unit quantity. For more information, contact the Sales Manager, Print Products, SODECO, Landis and Gyr Inc, 4 Westchester Plz, Elmsford NY 10523.

Circle 427 on inquiry card.

Eight-Color Digital Plotter with Microprocessor Control

Soltec's Model 281 Digital Plotter provides graphic representation of measured values, design data and calculated data using up to eight different color pens. A Z80 microprocessor controls the system, the automatic pen changing, off-scale data handling, and coordinate transformation. The programmable pen changing feature incorporates up to eight pens using multicolor fiber-tip pens or Rapidograph drafting pens. Firmware features include circle interpolation, character plotting, generation of axes and grids, various line types, window plotting and more. Model 281 also features character plotting in five fonts, automatic or interactive point digitizing, programmable offsets and programmable limits. The graph paper is standard DIN-A3 format or smaller. Interfaces include a choice of serial RS-232C/V .24 and 20 mA current loop. The plotter costs $4725 and is available from Soltec Corp, 11684 Pendelton St, Sun Valley CA 91352.

Circle 428 on inquiry card.

What's New?

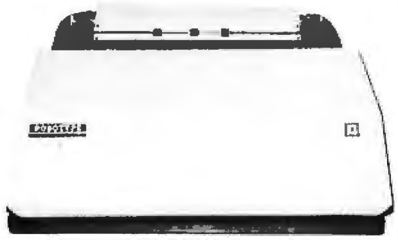
PERIPHERALS

Miniature Alphanumeric Thermal Printer

The APP-20A2 twenty-column, panel-mount thermal printer uses only two input data wires for interfacing. It features serial 20 mA current loop and RS-232C ports. The printer can be used in data systems, factory data acquisition units, and industrial data loggers with a full alphanumeric printer. It can be used with a remote control unit or in medical systems, and as a portable test and measurement tool for laboratory or field use. The unit prints 1.2 lines per second. It measures 20 cm by 7 by 11.3 cm (8 by 2.76 by 4.44 inches) and weighs 1.9 kg (4.25 pounds). It is available from Datel Intersil, 11 Cabot Blvd, Mansfield MA 02048. The cost for the printer is $880.

Circle 429 on inquiry card.

Robotype Converts Typewriter to Printer



The Robotype Model 2100 is capable of interfacing with a Centronics-compatible parallel interface, RS-232C serial interface, and a 20 mA current loop. The RS-232C serial interface has 110, 134.5 or 150 switch-selectable data rates. The Robotype can be attached to the IBM Selectric, Remington Rand, Olympia and Facit typewriters. The Robotype is placed over the keys of the typewriter. Plungers rest on the keys and push the keys down on command from the computer input. The unit types the maximum speed of the typewriter in use. The unit is available for under $1000 from Applied Computer Systems Inc, 77 E Wilson Bridge Rd, Worthington OH 43085.

Circle 430 on inquiry card.

Alphanumeric Thermal Printers

Priced at approximately $440, the United Systems 6450 and 6460 alphanumeric thermal printers produce easy-to-read letters, numbers, and symbols on thermal paper with first-line-up printout. They print a set of 64 different characters with 21 characters per line and approximately 6500 lines per roll of paper. The Model 6450 provides a serial input with selectable RS-232C or 20 mA current loop format with data rates of 110 and 300 bits per second (bps). The Model 6460 is 8-bit parallel bus-compatible with data rates up to 1000 characters per second (cps). Both models respond to ASCII input. For more information, contact United Systems Corp, 918 Woodley Rd, Dayton OH 45403.

Circle 431 on inquiry card.

Corvus Disk System for Apple Pascal Microcomputer

The Corvus model 11AP disk system being delivered for Apple Pascal is entirely compatible with the Apple system. No modifications are needed for the Apple Pascal disk-operating system, or any applications designed to run on the Apple floppy disks. Corvus has incorporated a utility called "dynamic volume management" that allows the ten million byte data base to be used as a single large block or to be broken into smaller blocks. Applications of the Apple Pascal equipped with the Corvus 11AP system include: customer and prospect mailing lists, accounting data, payroll and personnel records, courses in computer programming and usage, science applications, medical office use, and more. The system is priced at $5350. The controller can handle up to three additional disks, which are priced at $3690. Contact Corvus Systems, 900 S Winchester Blvd, Suite 4, San Jose CA 95128.

Circle 432 on inquiry card.

What's New?

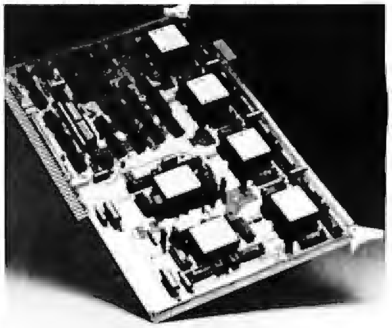
SYSTEMS

The 9000 Computer System from Compal

The Compal Model 9000 is designed for business and office environments. The system includes a 16-bit microNova 602 processor, 64 K bytes of programmable memory, video display terminal with a detached keyboard that can support up to three additional keyboards, a 10 M byte hard disk with a 5 M byte removable cartridge, and a high-speed matrix printer. Included with the system are BASIC and assembly languages, manuals, training, starter supplies, and delivery. Programs for inventory control, sales analysis, accounts payable and receivable, general ledger, payroll, and other business applications are available. The system sells for $19,995 from Compal Inc, 6300 Variel Ave, Woodland Hills CA 91604.

Circle 433 on inquiry card.

TM990 Compatible Bubble Memory Module



A TM990-compatible board with up to 69 K bytes of non-volatile magnetic bubble memory storage has been announced by Texas Instruments Inc, POB 225012, M/S 308 (ATTN: TM990/210), Dallas TX 75265.

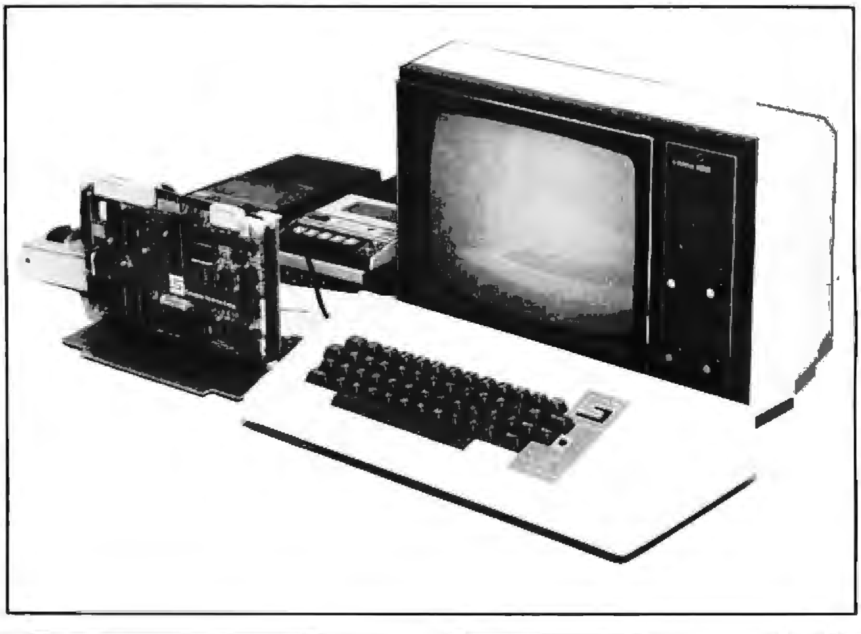
The TM990/210 board is supplied with two, four, or six 92 K bit TIB 0203 bubble memories for 23 K, 46 K, or 69 K bytes of storage, respectively. Data transfers from the module are via a memory-mapped mode. Access time is 4 ms, and data transfer rate is 45,000 bits per second (bps). The price for the TM990/210-1 two-bubble device is $775; $1150 for the TM990/210-2 four-bubble device; and $1535 for the TM990/210-3 six-bubble device.

Circle 434 on inquiry card.

Development Tool for 6500 Series Microprocessors

The MDT 1000 enables users to write programs and debug hardware and software. The MDT 1000 includes a 54-key keyboard and case; 12-inch video display; dual cassette interface; power supply; erasable-programmable read-only memory programmer; 4 K byte static programmable memory-board; sockets for extra boards; and a four-slot motherboard. Software support comes as 12 K bytes of read-only memory resident firmware; a 4 K byte monitor with debug features; and an 8 K byte assembler and editor, which operates on line-numbered text. A floating point BASIC and software for printer interfacing and other controls are available. The MDT 1000 is available for $1495 from Synertek, 3001 Stender Way, Santa Clara CA 95051.

Circle 435 on inquiry card.



What's New?

MISCELLANEOUS

TRS-80 Printer Controller

The Printer Timer works with the TRS-80 and the Centronics 779 line printer by automatically turning the printer on and off using signals relayed over the printer cable. The device does not require software or hardware modification other than the soldering of three wires and the mounting of the timer inside the printer cabinet. The timer reduces motor wear and excess noise. It is available for $95 from National Software Marketing Inc, 4701 McKinley St, Hollywood FL 33021.

Circle 436 on inquiry card.

Voice Terminal for the Exidy Sorcerer Talks and Listens

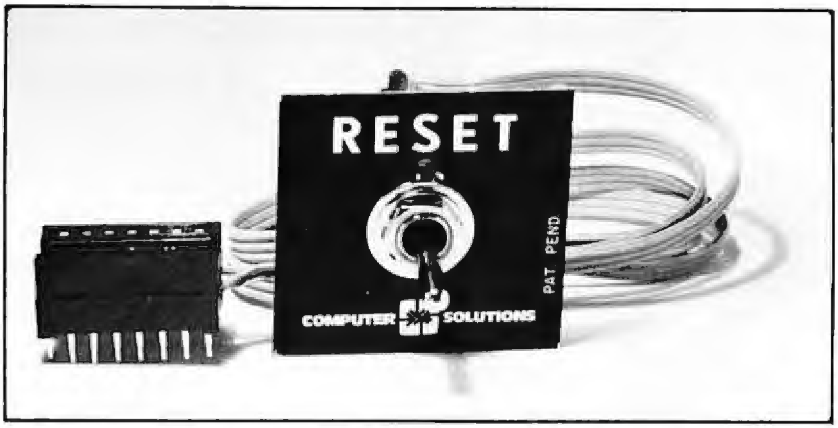
Cognivox plugs into the Sorcerer and offers a sixteen-word recognition vocabulary plus voice response with up to sixteen words or phrases. Recognition accuracies of up to 98% are possible. The unit includes a microphone and amplifier and speaker, making it a complete voice terminal. A software library is provided with Cognivox. It includes Voicetrap, a voice-operated video game, and Vothello, a voice input version of the game Othello. A talking calculator program allows using the Sorcerer as a four-function calculator, and a vocal memory dump program can read its memory out loud. Cognivox is priced at $149 from Voicetek, POB 388, Goleta CA 93017.

Circle 437 on inquiry card.

Anti-Glare Device for Video Screens

The product is a black woven nylon mesh stretched on a flexible plastic frame. It is designed to be sandwiched behind the video bezel and to conform against the surface of the tube. This device performs by blocking and absorbing ambient light with a honeycombing effect. The contrast is enhanced by the black matrix effect of the fabric background, while the display characters are transmitted undistorted through the pores in the material. The filters are available in 120 sizes, and each size can be equipped with different optically-graded fabrics to vary the intensity of the video display. The filters improve the image, lower maintenance, and reduce eye strain and related stress. For more information, contact Sun-Flex Co Inc, 3020 Kerner Blvd, San Rafael CA 94901.

Circle 438 on inquiry card.



Reset Option for the Apple

Model B is a three-position switch giving the user the option of completely disabling or enabling the reset key on the keyboard. It is easily installed between the keyboard plug and the Apple's board. When the switch is in the down position, the keyboard is functional. With the switch in the middle position, the reset key on the keyboard is disabled, and the user must flip the switch up to reset the computer. The switch automatically returns to the middle position when released from the up position.

It is available from Computer Solutions, 5135 Fredericksburg Rd, San Antonio TX, 78229, for $29.95.

Circle 439 on inquiry card.

Standardized Computer Forms

New England Business Service (NEBS) is offering a line of continuous-form computer checks, statements, and invoices. The forms are available with the name of the firm, address and phone number in six quantities from 500 to 6000 forms. Prices start at $14.95 for 500 statements; $32.50 for 500 two-part invoices and $29.95 for 500 of either the payroll or all-purpose checks. At 6000-piece order levels, prices per thousand drop to $12.50, $33 and $22.50 respectively. The firm also offers custom personal checks for home computer systems users. For ordering information and free samples write to the New England Business Service Inc, N Main St, Groton MA 01450.

Circle 440 on inquiry card.

What's New?

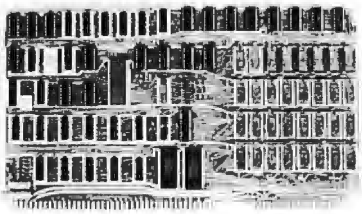
MISCELLANEOUS

Simple Machines for Erasing and Winding Cassettes

Two battery-powered machines offer longer life for cassettes and reduced wear on standard cassette players. The Erase-Sure passes the cassette through a rotating magnetic field that erases the tape and leaves an extremely low residual noise level. The user slides the cassette through the unit once. This single pass completely erases the tape. The Rapid Rewind stabilizes cassette tape tension, eliminates tape binding, helps control wow and flutter, and winds a 60-minute tape in approximately 30 seconds. Both units permit the use of a 115 V AC adapter to reduce battery costs. The machines are available from Magnesonics Sales and Manufacturing Co, POB 758, Ventura CA 93001. They cost $24.50 each.

Circle 445 on inquiry card.

Prototyping Kit for High-Resolution Graphics



The SVB-80P prototyping kit is a dual-board system with stand-alone capability in an Intel multibus configuration. The graphics package features displays of 640 by 409 or 576 by 455 pixels, alphanumeric characters displayed over 80 by 40 or 72 by 44 lines, and intermixable characters with graphics. It interfaces with other multibus-compatible products. The SVB-90 Soft Video Board and the MIB-85 Memory Intensive Board can also be used individually in computer graphics, text editing, scientific applications, and industrial environments. The price for the SVB-80P is approximately $1600. Contact DOSC Inc, 175 I U Willets Rd, Albertson NY 11507.

Circle 446 on inquiry card.

Computer Cables for the TRS-80

Matchless Systems, 18444 Broadway, Gardena CA 90248, manufactures cables for floppy disk and tape drives, printers and other peripherals for the TRS-80 computer. The price for the two-drive cable is $24.50 and the four-drive cable is $34.50. The cable for the MS-204 printer or any other Centronics-compatible printer, sells for $34.50.

Circle 447 on inquiry card.

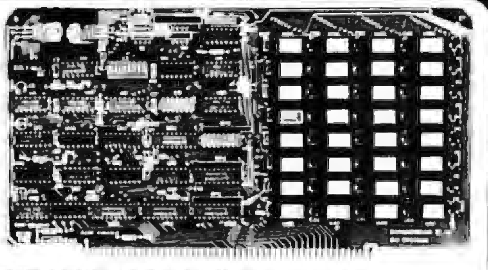
SEND $1.00 FOR 52 PAGE CATALOG

SEE OUR 52 PAGE DETACHABLE AD IN JANUARY BYTE

4 MHZ EXPANDORAM II KIT

The S-100 Memory Board for the 80's

NEW



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)

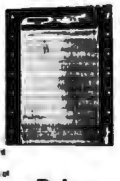
SDS - EXPANDOPRAM II KIT (4116)

	List Price	Sale Price		List Prica	Sale Price
16K	$460.00	$295.00	48K	$960.00	$445.00
32K	$710.00	$370.00	64K	$1210.00	$520.00

VCT-8803

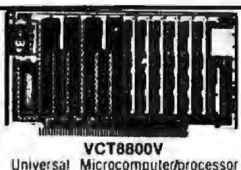
Vector

MOTHER BOARD FOR S100 BUS MICRO-COMPUTERS



- Kit includes 12 tantalum capacitors for +5, +12, −12 buses and insulated mounting spacers
- Wiring side shown. Component side bare epoxy glass with white markings for component locations
- G10 epoxy glass board with 2 ounce copper, solder plated and .038 diameter holes for leads
- Solder mask with solder windows on etched circuits to avoid accidental short circuits
- Mounts 11 receptacles with 100 contacts (2 rows) on .125 centers with .250 row spacing. Vector part number R681-2, or mounts 10 receptacles plus interconnections to another mother board for expansion
- Includes etched circuits and instructions for option of active, pull up or floating terminations
- Large buses: +5V and GND (10 AMPS), ± 12V or 16V (7 AMPS). Current ratings are per MIL STD 275 with 10°C rise
- Fits in Vector-pak enclosures
- Fits in IMSAI 8080 microcomputer as expander board

Price: $29.50



VCT8800V

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	$15.96

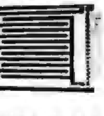
VCT8801-1

Same as 8800V except plain, less power buses & heat sink

1-4	5-9	10-24
$15.22	$13.79	$12.16

Vector

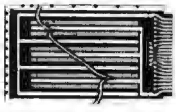
Plugboards



VCT3682 9.6"x4.5" $12.97

VCT3682-2 6.5"x4.5" $9.81

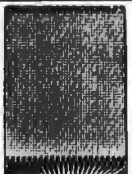
Hi-Density Dual-In-Line Plugboard for Wire Wrap with Power & Grd. Bus Epoxy Glass 1/16" 44 pin con. spaced .156



VCT3677 9.6"x4.5" $10.90

VCT3677-2 6.5"x4.5" $9.74

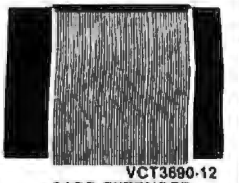
Gen. Purpose DIP Boards with Bus Pattern for Solder or Wire Wrap. Epoxy Glass 1/16" 44 pin con spaced .156



VCT3662 6.5"x4.5" $8.95

VCT3662-2 9.6"x4.5" $11.45

P pattern plugboards for IC's Epoxy Glass 1/16" 44 pin con spaced .156.



VCT3690-12

CARD EXTENDER

Card Extender has 100 contacts 50 per side on .125 centers-Attached connector is compatible with S-100 Bus Systems $25.83

VCT3690 6.5" 22/44 pin... .156 ctrs.Extenders..$13.17

S-100 BUS EDGE CONNECTORS*

SALE

CG 1 (MSA) Style Card Guides 5/$1.00

SALE

Texas Instruments GOLD S-100 CONNECTORS

TI-S100-STG SOLDER TAIL 5/$10.00 or TI S100 WWG WIRE WRAP 3/$10.00

S100SEG 50/100 Cont .125 ctrs. PIERCED SOLDER EYELET Tails GOLD

1-9	10-24	25-99
$6.80	$6.10	$5.45

SUL-S100ALT 50/100 Cont .125 ctrs. DIP SOLDER TAIL on 140 spaced rows for ALTAIR motherboards, GOLD plated.

1-9	10-24	25-99
$4.95	$4.45	$3.95

Other Popular Edge Connectors

SUL-D2244-5WWG 22/44 Cont .156 ctrs.WIRE WRAP tails GOLD.

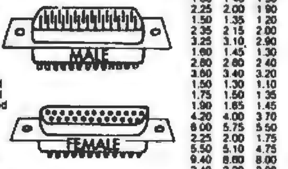
1-9	10-24	25-99
$3.98	$3.50	$3.00

SUL-D2244-5SEG 22/44 Cont .156 Ctrs.PIERCED SOLDER EYELET tails GOLD plated.

1-9	10-24	25-99
$2.98	$2.90	$2.75

RS232 and "D" SUB-MINIATURE CONNECTORS*

P = Plug, Male Type - S = Socket, Female Type - C = Cover, Hood



PART NO.	DESCRIPTION	PRICE 1-9	10-24	25-99
CND-DE9P	9 Pin Male	1.60	1.40	1.30
CND-DE9S	9 Pin Female	2.25	2.00	1.90
CND-DE9C	9 Pin Cover	1.50	1.35	1.20
CND-DA15P	15 Pin Male	2.35	2.15	2.00
CND-DA15S	15 Pin Female	3.25	3.10	2.90
CND-DA15C	15 Pin Cover	1.60	1.45	1.30
CND-DB25P	25 Pin Male	2.80	2.60	2.40
CND-DB25S	25 Pin Female	3.60	3.40	3.20
CND-DB51212-1	1 pc.Grey Hood	1.50	1.30	1.10
CND-DB110963-3	2 pc.Grey Hood	1.75	1.50	1.35
CND-DB1226-1A	2 pc.Black Hood	1.90	1.65	1.45
CND-DC37P	37 Pin Male	4.20	4.00	3.70
CND-DC37S	37 Pin Female	6.00	5.75	5.50
CND-DC37C	37 Pin Cover	2.25	2.00	1.75
CND-DD50P	50 Pin Male	5.50	5.10	4.75
CND-DD50S	50 Pin Female	9.40	8.60	8.00
CND-DD50C	50 Pin Cover	2.40	2.20	2.00
D20418-S	Hardware Set 2 pr	1.00	.80	.70
CND-RS232-8FT	RS232, DB25P, EIA class 1 cable 8 con 8 ft long	18.00	16.00	14.00
CND-57-30360	Centronics 700 Series printer connector	9.00	7.50	6.00

1/16 Vector BOARD .042 dia holes on 0.1 spacing for IC's

Vector

Phenolic PART NO.	SIZE	PRICE 1-9	10-19
VCT64P44XXXP	4.5x6.5"	$1.56	$1.40
VCT169P44XXXP	4.5x17"	$3.69	$3.32
Epoxy Glass			
VCT64P44	4.5x6.5"	$1.79	$1.61
VCT84P44	4.5x8.5"	$2.21	$1.99
VCT169P44	4.5x17"	$4.52	$4.07
VCT169P84	8.5x17"	$8.83	$7.95

3 LEVEL GOLD WIRE WRAP SOCKETS

PRICE*

PART NO.	PINS	1-9	10-24	25-99	100-249	250-999
RNS-08WWG	8	.40	.36	.34	.31	.27
RNS-14WWG	14	.50	.39	.37	.35	.32
RNS-16WWG	16	.55	.42	.40	.37	.34
RNS-18WWG	18	.75	.65	.60	.55	.50
RNS-20WWG	20	.90	.80	.70	.65	.62
RNS-22WWG	22	1.00	.90	.85	.80	.75
RNS-24WWG	24	1.00	.90	.85	.80	.75
RNS-28WWG	28	1.40	1.30	1.25	1.16	1.00
RNS-40WWG	40	1.65	1.45	1.35	1.25	1.20

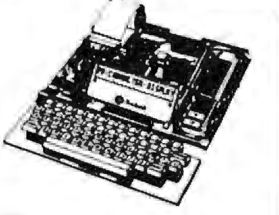
*Price based on gold not exceeding $400.00 per oz.

3M SCOTCH® BRAND DISKETTES

Part No	Sides/ Density	Sectoring	Price Box of 10
		8"	
740 OK	1/single	Soft IBM	$39.95
740/2 OK	2/single	Soft IBM	$75.00
740 32K	1/single	32	$39.95
740 2 32K	2/single	32	$75.00
741 0	1/double	Soft	$59.00
		5"	
744 OK	1/single	Soft (TRS-80)	$39.95*
744 10K	1/single	Soft/10	$39.95*
744 16K	1/single	Soft/16	$39.95*

"DON'T SETTLE FOR ANYTHING LESS THAN SCOTCH"

ROCKWELL AIM-65



The Rockwell AIM 65 with 4K RCK-AIM65-4K 8 lbs..................Price....$445.00

The Rockwell AIM 65 with 1K RCK-AIM65 1K 8 lbs..................$395.00

4K Assembled--RCK-AIM65-010..........$ 85.00

8K Basic in ROM--RCK-AIM65-020.......$100.00

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$174.95 Regular $198.00

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- Bell 103
- Answer, Originate

TRS-80/APPLE MEMORY EXPANSION KITS

from Leading Manufacturers (16Kx1 200/250ns)

4116's RAMS

8 for $65.00

Add $3.00 for programming Jumpers for TRS 80 Keyboard

DEALERS CALL FOR 1 PRICING

MEMORY MEMORY

2102LIPC	Low Power 450ns in lots of 20	$1.10
2102AL-2	Low Power 250ns in lots of 20	$1.25
2114-3L	1Kx4 300ns Low Power	8/$50.00
5257-3L	4Kx1 300ns Low Power	8/$55.00
2708	8K 450ns EPROM	8/$60.00 - $8.50 ea
2716	16K 5 Volt only EPROM	8/$240-$32.00 ea

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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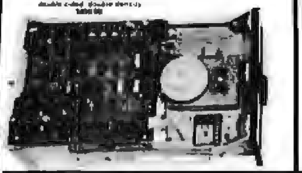
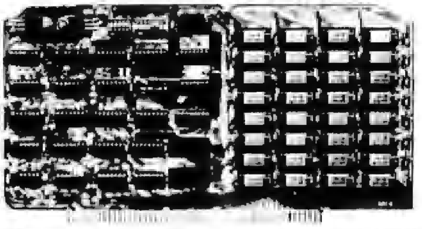
DISC DRIVES



SD EXPANDORAM *The Ultimate S-100 Memory*



EXPANDO 64 KIT (4116)

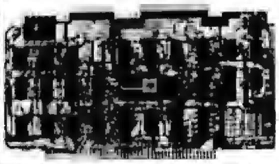
	List Price	Sale Price
16K	$385.00	$239.00
32K	$550.00	$309.00
48K	$715.00	$379.00
64K	$880.00	$449.00

The EXPANDORAM is available in versions from 16K up to 64K, so for a minimum investment you can have a memory system that will grow with your needs. This is a dynamic memory with the invisible on-board refresh, and IT WORKS!

- Interfaces with Altair, IMSAI, SOL-8, Cromenco, SBC-100, and others.
- Bank Selectable
- Phantom
- Power 8VDC, ± 16VDC, 5 Watts

Lowest Cost Per Bit
Uses Popular 4116 RAMS
PC Board is doubled solder masked and has silk-screen parts layout.

Extensive documentation clearly written
Complete Kit includes all Sockets for 64K
Memory access time: 375ns, Cycle time: 500ns.
No wait states required.
16K boundries and Protection via Dip Switches
Designed to work with Z-80, 8080, 8050 CPU's



FEATURES: IBM 3740 Soft Sectored Compatible. S-100 BUS Compatible for Z-80 or 8080. Controls up to 4 Drives (single or double sided). Directly controls the following drives:
1. Shugart SA400/450 Mini Floppy
2. Shugart SA800/850 Standard Floppy
3. PERSCI 70 and 277
4. MFE 700/750
5. CDC 9404/9406
6. Siemens FDD120-8

34 Pin Connector for Mini Floppy. 50 Pin Connector for Standard Floppy. Operates with modified CP/M operating system and C Basic Compiler. The new VersaFloppy from SD Computer Products provides complete control for many of the available Floppy Disk Drives. Both Mini and Full Size. FD1771B-1 Single Density Controller Chip. Listings for Control Software are included in price.
CP/M for SD VersaFloppy $100.00

DISC CONTROLLER SD "VERSAFLOPPY" KIT

The Versatile Floppy Disk Controller

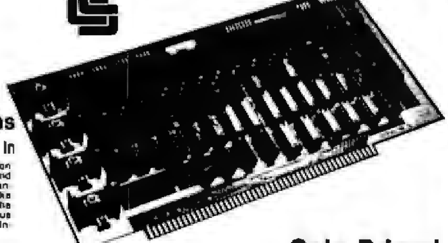
List Price $250.00

SALE PRICE **$189.95**

SHOP & COMPARE SPECIAL

M-XVI The true 16K Static Ram module for S-100 bus systems

Assembled & Tested 100% Burn In



The M-XVI gives you unbelievable expansion capability for your S-100 bus system even beyond 64K. Manufactured to the highest industry standards documented and designed to make assembly use and programming a snap. The M-XVI board is a true revelation for the serious hobbyist and use in practical business or industrial applications.

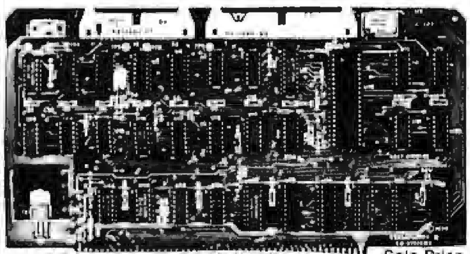
FEATURES:
- Fully static
- Uses popular 2114 static RAMS
- +5 volt operation only
- Bank Select available by bank port and bank byte
- Phantom line capability
- Addressable in 4K blocks
- 4K blocks can be addressed anywhere within 64K in 4k increments
- Meets IEEE proposed S-100 signal standards
- LED indicators for board selection and bank selection
- FR-4 epoxy PC boards
- Solder masked on both sides
- Silk screen of part number and part designator

Sale Priced

2016BA 450ns 2MHZ.......... Reg. $349.95 **$279.95**
2016BB 300ns 4MHZ.......... Reg. $389.95 **$309.95**
2016BX Bare Board only.................... **$29.95**

VERSAFLOPPY II

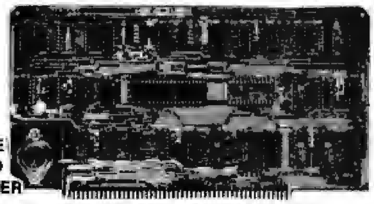
DOUBLE DENSITY, DOUBLE SIDED, DISC.CONTROLLER



SDS-VERSAFLOPPY II KIT List Price **$350.00** Sale Price **$325.95**

GENERAL DESCRIPTION
Versafloppy II is a flexible disk drive controller that incorporates a wide range of capabilities into one board. It operates with double density soft sectored format which provides 985,600 bytes of storage on a double sided 8 inch diskette and 129,920 bytes per side on a five inch mini-diskette. The Versafloppy II directly controls many popular disk drives. These include Shugart SA400 and SA450, Shugart SA800 and SA850, Mayflower MFE500 and MFE700, Per Sci 70 and 277 and Siemens, BSI 105

- S-100 Bus IEEE Standard Compatible
- IBM-3740 Compatible Soft Sectored Format for Single Density Drives
- Operates with both Standard (8") and Mini (5") Drives Simultaneously
- Provides Control for Double Sided Operation
- Operates with Z80, 8080, and 8085 Central Processing Unit
- Controls up to four drives
- Vectored Interrupt Operation Optional
- Control and Diagnostic Software Available in PROM
- SDOS Disk Operating System Compatible



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STANDARD FEATURES: • 50 Characters/second • Characters/line • 10 characters/inch • 3-way paper handling system • 7 x 7 dot matrix • 96 character ASCII • microprocessor electronics • unidirection print at 5.0 ips • high speed return approximately 10 ips • 21 lpm with 80 columns printed • 58 lpm with 20 columns printed • 80 character buffer • 6 lpi vertical • Centronics Colors and logo

FORMS HANDLING: Roll Paper 8.5 in. x 5.0 dia. with 1 in. core maximum dimension. 3.5 in. wide with .38 in. core minimum dimension. Fan Gold: 9.0 in. /22.9 cm. wide pin to pin 9.5 in /24.1cm wide overall. Up to 3 ply paper with 2 carbons (total thickness not to exceed .012 inches) Cut Sheet: Maximum width 8.5 inches

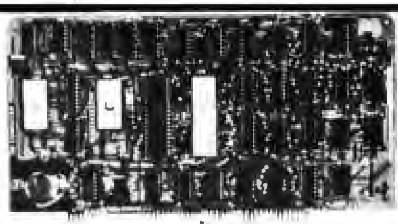
RIBBON SYSTEM: Continuous ribbon 9/16" (14mm) wide, 20 yards (18.3 meters) long, Mobius Loop allows printing on upper and lower portion on alternate passes.

OPERATOR CONTROLS: Power on/off. Reset Switch - allows disabling of printer without dropping AC

DATA INPUT: 7 or 8 bit ASCII parallel, TTL levels with strobe. Acknowledge pulse indicates that data was received

PHYSICAL DIMENSIONS: Weight: less than 10 lbs/5 kg -Width: 14.5 inches/37 cm -Depth: 11.0 inches/28cm -Height: 4.88 inches/13cm -Dimensions exclusive of roll paper holder.
SHIPPING WEIGHT: 14 lbs.

CEN-730-1 (Parallel Int.)............ LIST PRICE: $995.00



VDB-8024 VIDEO DISPLAY BOARD

With on-board Z80 Microprocessor

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- 2K Bytes Independent On-Board RAM Memory
- Glitch-Free Display

	List Price	Sale Price
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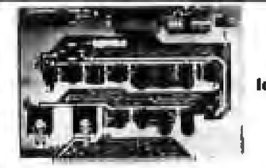

PROM-100

Programming Board for PROM Development

NEW

SD SYSTEMS' PROM-100 is a versatile PROM programming board offering complete EPROM programming capability. The board operates on the Industry standard S-100 Bus. Support software verifies the erasure of EPROM and verifies the loaded program. SD SYSTEMS' PROM-100 offers a support-software listing with its operations manual.

- S-100 Bus Compatible
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- 25 VDC Programming Pulse Generated On Board
- Maximum Programming time: 16,384 Bits in 100 Seconds
- Power Requirement: +8VDC at 300 ma.; +16 VDC at 100 ma.; −16 VDC at 60 ma.
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- Zero Insertion Force Socket

	List Price	Sale Price
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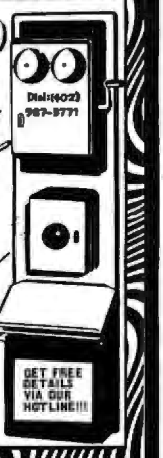

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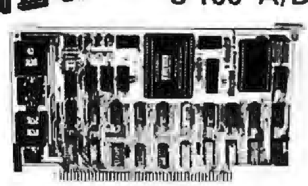

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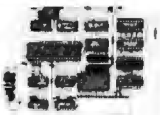

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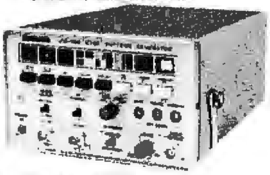

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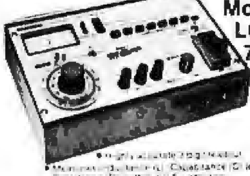

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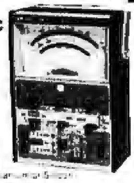

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600	.11	.30	.80	2.00	8.50	12.50
800	.15	.35	1.00	2.50	10.50	16.50
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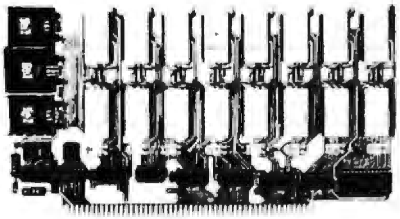

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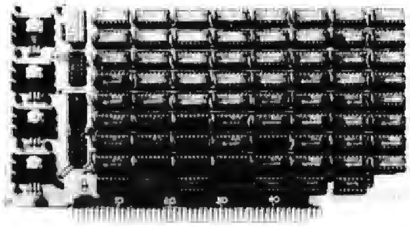

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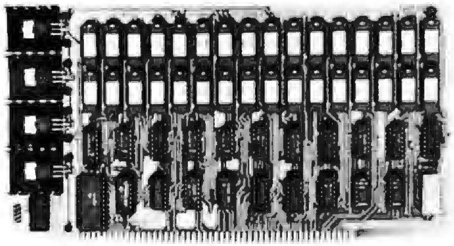

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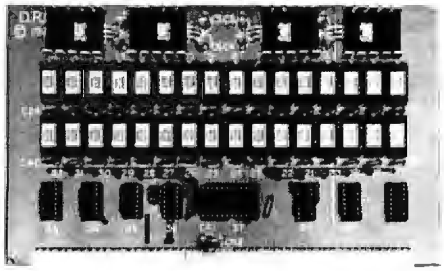

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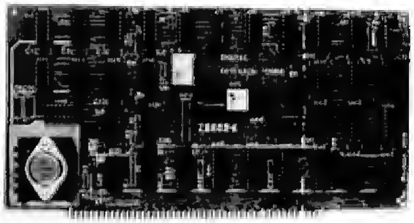

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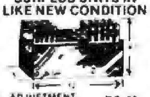

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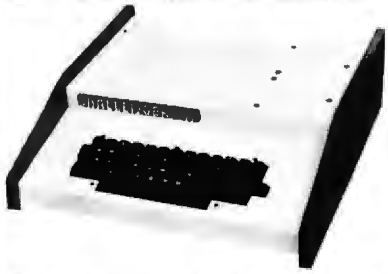

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The Challenger 4P MF. Mini Floppy version of the 4P. Two to three times faster than competitors. More I/O built-in than any other in its class. 24K RAM. Real time clock. Modem interface. Printer interface. Foreground/Background operation and much, much more. **$1695.**

Ohio Scientific C1P Series.

The Challenger 1P. The best bargain in personal computer anywhere! 8K BASIC-in-ROM. 4K RAM. Cassette based with 53-key keyboard. B&W video display, 30 rows x 30 columns. Upper and lower case. **$349.** C1P with 8K RAM $399.

Ohio Scientific C1P MF. Mini-floppy version of the C1P. 8K BASIC-in-ROM, 12K RAM. Fully expandable. **$995.** C1P MF with 20K RAM and OS-650 software $1198.

Accessories

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AC-15P 12" Color monitor	$ 450
AC-16P 2-8 Axis Joysticks with cable	$ 39
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AC-17P Home Security Starter Set. 1 fire detector, 2 window alarms, 1 door unit.	$ 249
AC-18P 8½" aluminized paper printer. Upper/lower case.	$ 695
AC-9TP Centronics 799 110cps tractor feed, business printer with interface	$ 1250
AC-12P AC-Remote starter set. Console. 2 lamp modules, 2 appliance modules, OS 65D home control operating system	$ 175
Disk Drives	
CD 3P Single 5" mini floppy	$ 499
CD 2P Dual 8" Disk with interface and OS-650 DDS	$ 1599
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CM-6 48K Dynamic memory board.	$ 499
4KP. 4K static RAM kit	$ 69
CA12. 96 line parallel I/O	$ 175
Books:	
How to Program Microcomputers, By William Barden	$ 8.95
Basic and Personal Computer By Dwyer & Critchfield	$12.95
Howard Sams C1P Service Manual	$ 7.95
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Ohio Scientific 8P Series.

Challenger 8P. Ohio Scientific's mainframe-class. Personal computer. 8 slots with 6 open. Cassette based with 8K BASIC-in-ROM. 8K static RAM, expandable to 32K RAM, and dual 8-inch floppy disk drive. **$895.**

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SOFTWARE

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Baseball I	$ 6.00
Battleship	$ 6.00
Bowling	$ 6.00
Destroyer	$ 6.00
Space War	$ 6.00
Star Trek	$ 6.00
Tiger Tank	$12.00

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MDMS Aux File Systems	$29.00
MDMS Checking and Savings Account	$29.00
MDMS Personal Calendar/Address Book	$29.00
Home Control II	$29.00
DAC I Music Generation	$39.00
Baseball I & II, Golf, Bowling, Hockey	$39.00
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- Compatible with TRS-80, Apple, and most small computers!
- High resolution!

Low cost, yet high resolution (650 line). Compares favorably with monitors costing twice as much. Because of the fact that standard composite video input is utilized no RF modulator is needed an extremely sharp and stable picture is achieved. The video bandwidth is 12MHz + 3db with a 75ohm input impedance.

Cat No. 1204 Leedex Monitor, $139 18 lbs.
Cat No. 1937 TRS-80/Leedex Cable kit, 6 oz $3

$139

Novation "Cat" Acoustic Modem

The first quality compact modem designed specifically for the small computer user. Designed to transmit data over standard telephone lines, the Cat has many uses for business and hobbyist. Allows one terminal or computer to interact with others, permitting one access to data from remote locations. Hobbyists can exchange data and programs. Compatible with any Bell 103 modem and, of course, all other Cats! Also perfectly compatible with the new Radio Shack modem (it's the same unit). Data exchange can occur at any speed up to 30 char/sec. Low profile case features switches for mode selection and operation, also for LED's displaying unit status. Acoustic self-test is standard. Complete and ready-to-use. Requires 110 VAC, 60Hz.

Cat No. 1480 **$169**

S-100 TYPE EDGE CONNECTORS

- Imsai and Altair type spacing!
- Gold plated contacts
- Top USA makers!

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as low as $2.95

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- Protects disks and diskettes from wear!
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2075	8" disk tool	3 oz.	$6.95
2076	8" disk protector rings	4 oz.	50 for $11.95

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The most popular diskette in the world!

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Organizes and protects your data files! 5¼" disks fit two per insert 8" fit one per insert. Binders includes 10 inserts

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1652	extra 5¼" inserts	.95

8" Disks

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- Single density
- Individually certified

Cat No. 1145 Type 32-1000
Description
32 sector holes, 1-index hole

Cat No. 1146 Type 34-1000
interchangeable with IBM32, 3740, 3770, 3790, etc.

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Pay by check, Mastercharge, Visa, or COD. Charge orders please include expiration date. Foreign pay in U.S. funds. Order by phone or mail, or at our retail. MINIMUM ORDER $10. please include phone number and magazine/issue you are ordering from. Prices valid thru last day of cover date. SHIPPING USA: add $2.00 for the first 2 lbs. For ground add 35¢ for addt'l lb. For air add 75¢ for addt'l lb. FOREIGN: surface: add $3.00 for first 2 lbs, 60¢ per addt'l lb. Air: add $11.00 for first 2 lbs, $5 for each addt'l lb. CODs $1 addt'l. Guaranteed satisfaction for 120 days or your money back! Not responsible for typographical errors. Some items subject to prior sale. We reserve the right to limit quantities.

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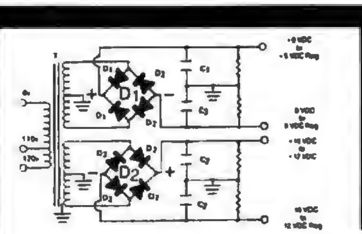

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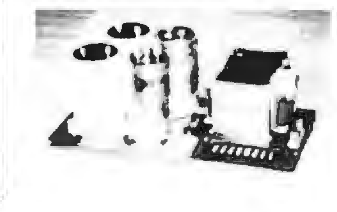

POWER TRANSFORMERS (WITH MOUNTING BRACKETS)

ITEM NO.	USED IN KIT NO.	PRI. WINDING TAPS	SECONDARY WINDING OUTPUTS 2×8 Vac	2×14 Vac	2×24 Vac	SIZE W×D×H	UNIT PRICE
T_1	1	0V, 110V, 120V	2×7.5A	2×2.5A	——	3¾"×3⅝"×3⅛"	21.95
T_2	2	0V, 110V, 120V	2×12.5A	2×3.5A	——	3¾"×4⅜"×3⅛"	27.95
T_3	3	0V, 110V, 120V	2×9A	2×2.5A	2×2.5A	3¾"×4⅜"×3⅛"	29.95
T_4	4	0V, 110V, 120V	2×4A	——	2×3A	3¾"×3⅝"×3⅛"	21.95

POWER SUPPLY KITS (OPEN FRAME WITH BASE PLATE, 3 HRS. ASSY. TIME)

ITEM	USED FOR	@+8 Vdc	@−8 Vdc	@+16 Vdc	@−16 Vdc	@+28 Vdc	SIZE W×D×H	UNIT PRICE
KIT 1	15 CARDS SOURCE	15A	——	2.5A	2.5A	——	12"×6"×4⅞"	51.95
KIT 2	SYSTEM SOURCE	25A	——	3A	3A	——	12"×6"×4⅞"	58.95
KIT 3	DISC SYSTEM	15A	1A	2A	2A	4A	14"×6"×4⅞"	66.95
KIT 4	DISC SOURCE	8A	1A	——	——	5A	10"×6"×4⅞"	49.95

EACH KIT INCLUDES: TRANSFORMER, CAPACITORS, RESIS., BRIDGE RECTIFIERS, FUSE & HOLDER, TERMINAL BLOCK, BASE PLATE, MOUNTING PARTS AND INSTRUCTIONS.

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Super Color S-100 Video Kit $99.95
Expandable to 256 x 192 high resolution color graphics. 6847 with all display modes computer controlled. Memory mapped. 1K RAM expandable to 6K. S-100 bus 1802, 8080, 8085, Z80 etc.

Gremlin Color Video Kit $59.95
32 x 16 alpha/numerics and graphics; up to 8 colors with 6847 chip. 1K RAM at E000. Plugs into Super Elf 44 pin bus. Not expandable to high resolution Graphics.

Elf II Adapter Kit $24.50
Plugs into Elf II providing Super Elf 44 and 50 pin bus plus S-100 bus expansion (With Super Expansion). High and low address displays, state and mode LED's optional $18.00.

1802 16K Dynamic RAM Kit $149.00
1802/S-100 expandable to 32K. Hidden refresh w/clocks up to 4 MHz w/no wait states. Addl. 16K RAM $79.00.

Quest Super Basic

Quest, the leader in inexpensive 1802 systems announces another first. Quest is the first company worldwide to ship a **full size Basic** for 1802 systems. A complete function **Super Basic** by **Ron Cenker** including floating point capability with scientific notation (number range ±.17E^{38}), 32 bit integer ± 2 billion. Multi dim arrays, String arrays; String manipulation, Cassette I/O, Save and load, Basic, Data and machine language programs, and over 75 Statements, Functions and Operators.

Easily adaptable on most 1802 systems. Requires 12K RAM minimum for Basic and user programs. Cassette version in stock now. ROM versions coming soon with exchange privilege allowing some credit for cassette version.

Super Basic on Cassette $40.00

Tom Pittman's 1802 Tiny Basic Source listing now available. Find out how Tom Pittman wrote Tiny Basic and how to get the most out of it. Never offered before. $19.00

S-100 4-Slot Expansion $ 9.95

Super Monitor VI.I Source Listing $15.00

Coming Soon: **Assembler, Editor, Disassembler, DA/AD, Super Sound/Music, EPROM programmer, Stringy Floppy Disc System.**

RCA Cosmac Super Elf Computer $106.95

Compare features before you decide to buy any other computer. There is no other computer on the market today that has all the desirable benefits of the **Super Elf** for so little money. The Super Elf is a small single board computer that does many **big** things. It is an excellent computer for training and for learning programming with its machine language and yet it is easily **expanded** with **additional memory, Full Basic, ASCII Keyboards, video character generation, etc.**

Before you buy another small computer, see if it includes the following features: ROM monitor; State and Mode displays; Single step; Optional address displays; Power Supply; Audio Amplifier and Speaker; Fully socketed for all IC's; Real cost of in warranty repairs; Full documentation.

The **Super Elf** includes a **ROM** monitor for program loading, editing and execution with **SINGLE STEP for program debugging** which is not included in others at the same price. With **SINGLE STEP** you can see the microprocessor chip operating with the **unique Quest** address and data bus displays **before, during and after** executing instructions. Also, CPU mode and instruction cycle are decoded and displayed on 8 LED indicators.

An RCA 1861 **video graphics** chip allows you to connect to your own TV with an inexpensive video modulator to do graphics and games. There is a **speaker system** included for writing your own music or using many music programs already written. The speaker amplifier may also be used to drive relays for control purposes.

A 24 key **HEX keyboard** includes 16 HEX keys plus **load, reset, run, wait, input, memory protect, monitor select** and **single step**. Large, on board displays provide output and optional **high and low address**. There is a 44 pin standard connector slot for PC cards and a 50 pin connector slot for the Quest Super Expansion Board. Power supply and sockets for **all** IC's are included in the price plus a detailed 127 pg. instruction manual which now includes over 40 pgs. of software info. including a series of lessons to help get you started and a music program and graphics target game. Many schools and universities are using the Super Elf as a course of study. OEM's use it for training and R&D.

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. Issues 1-12 bound $16.50.

Tiny Basic Cassette **$10.00**, on ROM **$38.00**, original Elf kit board **$14.95. 1802 software;** Moews Video Graphics **$3.50.** Games and Music **$3.00**, Chip 8 Interpreter **$5.50.**

Super Expansion Board with Cassette Interface $89.95

This is truly an astounding value! This board has been designed to allow **you** to decide how you want it optioned. **The Super Expansion Board comes with 4K of low power RAM** fully addressable anywhere in 64K with built-in memory protect and a **cassette interface**. Provisions have been made for all other options on the same board and it fits neatly into the hardwood cabinet alongside the **Super Elf**. The board includes slots for up to 6K of **EPROM** (2708, 2758, 2716 or TI 2716) and is **fully socketed. EPROM** can be used for the monitor and Tiny Basic or other purposes.

A **1K Super ROM Monitor $19.95** is available as an on board option in 2708 EPROM which has been preprogrammed with a program loader/editor and error checking multi file cassette read/write software, (relocatible cassette file) another exclusive from Quest. It includes register save and readout, block move capability and video graphics driver with blinking cursor. Break points can be used with the register save feature to isolate program bugs quickly, then follow with single step. The Super Monitor is written with subroutines allowing users to take advantage of 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 $15.25 for easy connection between the **Super Elf** and the **Super Expansion Board.**

Power Supply Kit for the complete system (see Multi-volt Power Supply below).

Same day shipment. First line parts only. Factory tested. Guaranteed money back. Quality IC's and other components at factory prices.

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74LS14N	1.10	NE565A	1.00	74C48	1.95
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LM301AN/AH	.35	CD4013	.39	8T98	1.69
LM305H	.87	CD4014	1.00		
LM307N	.35	CD4015	1.00	**MOS/MEMORY RAM**	
LM308N	.89	CD4016	.45	2101-1	3.95
LM309K	1.50	CD4017	1.05	2102-1	.95
LM311H/N	.90	CD4018	.84	2102AL-4	1.25
LM317T/K	3.75	CD4019	.45	2102AN-2L	1.60
LM318	1.35	CD4020	1.02	21L02-1	1.10
LM320H-5	1.50				

2104A-4	4.95	82S129	3.75
2107B-6	3.75	82S129	3.75
2111-1	3.75	82S131	3.75
2112-2	3.95	82S136	8.75
2114L 300ns	7.40	82S137	8.75
4116 200ns	9.50	DM8577	2.90
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25138	6.30	8-2716 Intel	240.00
MM5262	.40		
MM5280	3.00	**CONNECTORS**	
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MM5330	5.94	44 pin edge	2.75
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MCM66751A	9.95		
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416	16.00		

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Solder Tin Low Profile

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8	15	22	30
14	14	24	35
16	16	28	47
18	27	36	58
20	29	40	57

2 level 14 pin ww .33

WIRE WRAP LEVEL 3

PIN		PIN	
14	32	24	86
16	33	28	1.00
18	57	40	1.23

CLOCKS		**CRYSTALS**	
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MM5312	3.90	2 MHz	4.50
MM5314	3.90	4 MHz	4.25
MM5369	2.10	5 MHz	4.25
MM5841	14.45	10 MHz	4.25
MM5865	7.95	18 MHz	3.90
CT7001	5.80	20 MHz	3.90
CT7010	8.95	32 MHz	3.90
CT7015	8.95	32768 Hz	4.00
MM5375AA/N	3.90	1.8432 MHz	4.50
MM5375AG/N	4.90	3.5795 MHz	1.20
7205	16.50	2.0100 MHz	1.95
7207	7.50	2.097152 MHz	4.50
7208	15.95	2.4576 MHz	4.50
7209	4.95	3.2768 MHz	4.50
DS0026CN	3.75	5.0688 MHz	4.50
DS0056CN	3.75	5.185 MHz	4.50
MM53104	2.50	5.7143 MHz	4.50
		6.5536 MHz	4.50
		14.31818 MHz	4.25
		18.432 MHz	4.50
		22.1184 MHz	4.50

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6850	17.95	HD0165-5	6.95
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8085	27.00	**D Connectors RS232**	
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8251	8.50		
8253	15.00		
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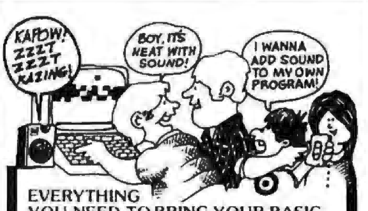

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129875	50/100 W/W Imsai	.250	5.25	4.75	4.20
129885	50/100 S/T Altair	.140	4.85	4.45	3.85
129990	50/100 S/T Cromem.	.250	4.75	4.25	3.80
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12305	22/44 S/E No Ears	.140	4.15	3.75	3.35
12759	36/72 S/T	.140	5.40	4.85	4.35
12790	40/80 W/W	.250	6.30	5.65	5.00
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10280	25/50 S/E TRS 80	.140	4.50	4.05	3.60
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15270	10/20 S/E	.140	2.15	1.85	1.70
15275	10/20 S/T	.140	2.00	1.86	1.60
15435	12/24 S/E PET	.140	2.80	2.35	2.10
15440	12/24 S/T PET	.140	2.85	2.40	2.15
15445	12/24 S/T PET	.200	2.75	2.50	2.20
15505	15/30 S/E GRI Key	.140	2.60	2.25	2.00
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15515	15/30 W/W GRI Key	.200	2.80	2.35	2.10
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15700	22/44 S/E KIM/VEC	.140	2.98	2.80	2.75
15705	22/44 S/T KIM/VEC	.140	3.98	3.30	3.00
15710	22/44 W/W KIM/VEC	.200	3.49	3.20	2.65
15875	25/50 S/E	.140	4.65	4.20	3.75
15880	25/50 S/T	.140	4.65	4.10	3.65
15885	25/50 W/W	.200	4.65	4.35	3.90
16115	36/72 S/E	.140	6.50	5.65	5.20
16120	36/72 S/T	.140	6.55	5.80	5.25
16125	36/72 W/W	.200	6.75	6.10	5.40
16145	36/72 S/T	.200	6.50	5.65	5.20
16235	43/86 S/T Mot 6800	.140	6.60	5.95	5.30
16240	43/86 W/W Mot 6800	.200	7.80	7.05	6.25
16280	43/86 S/T Mot 6800	.200	6.50	5.65	5.20
16725	43/86 S/E Mot 6800	.140	7.20	6.60	5.75

'D' TYPE SUBMINIATURE CONNECTORS.

PART NUMBER		DESCRIPTION.	QUANTITY 1-9pcs.	10-24pcs.	25-99pcs.
DE	9P	Male	$1.60ea.	$1.40ea.	$1.30ea.
DE	9S	Female	2.25ea.	2.00ea.	1.90ea.
DE	110963-1	2 pc. Grey Hood.	1.50ea.	1.35ea.	1.20ea.
DA	15P	Male	2.35ea.	2.15ea.	2.00ea.
DA	15S	Female	3.25ea.	3.10ea.	2.90ea.
DA	51211-1	1. pc. Grey Hood	1.40ea.	1.20ea.	1.15ea.
DA	51226-1	2 pc. Black Hood	2.50ea.	2.25ea.	2.00ea.
DA	110963-2	2 pc. Grey Hood	1.80ea.	1.35ea.	1.30ea.
DB	25P	Male	2.80ea.	2.60ea.	2.40ea.
DB	25S	Female	3.60ea.	3.40ea.	3.20ea.
DB	61212-1	1 pc. Grey Hood	1.50ea.	1.30ea.	1.10ea.
DB	51226-1	2 pc. Black Hood	1.90ea.	1.65ea.	1.45ea.
DB	110963-3	2 pc. Grey Hood	1.75ea.	1.50ea.	1.35ea.
DC	37P	Male	4.20ea.	4.00ea.	3.70ea.
DC	37S	Female	6.00ea.	5.75ea.	5.50ea.
DC	110963-4	2 pc. Grey Hood	2.25ea.	2.00ea.	1.75ea.
DD	50P	Male	5.50ea.	5.10ea.	4.75ea.
DD	50S	Female	9.40ea.	8.80ea.	8.00ea.
DD	51216-1	1 pc. Grey Hood	2.40ea.	2.20ea.	2. 00ea.
DD	110963-5	2 pc. Grey Hood	2.60ea.	2.40ea.	2.10ea.
D	20418-2	Hardware Set (1 Hood Set)	.90ea.	.80ea.	.70ea.

I.C. SOCKETS GOLD. W/WRAP 3 TURN

14 pin	$0.40 ea.
16 pin	0.44 ea.

8080A PRIME.

$5.00 ea.

EIA 8 CONDUCTOR CABLES 8ft. Long. CLASS #1 Type Cables.

1. to 4 pcs.	$23.00
5 to 9 pcs.	20..00

I.C. SOCKETS TIN.

14 pin	$0.15 ea.
16 pin	0.17 ea.

CONNECTORS FOR CENTRONICS 700 SERIES.
Amphenol 57-30360

1 to 4 pcs.	$8.00 ea.
5 to 9 pcs.	7.00 ea.

COOLING FANS.
Extra Quiet.

1 to 4	$18.00 ea.
5 to 9	17.00 ea.

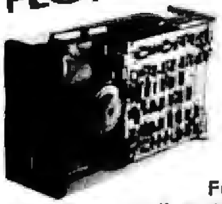
TERMS: MINIMUM ORDER: $15.00 ADD $1.35 For Handling & Shipping. Orders over $30.00 in the U.S.A. We Pay the Shipping. CALIF. RESIDENTS: Please Add 6% Sales Tax.

NOTE: NO C.O.D. OR CREDIT CARD ORDERS WILL BE ACCEPTED.

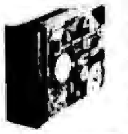
MAIL ORDERS TO: **BECKIAN ENTERPRIES**
P.O. BOX #3089
SIMI VALLEY, CA 93063

Circle 271 on inquiry card.

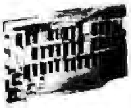
FLOPPY SYSTEMS



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.



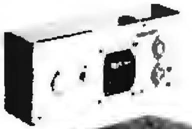
5¼" BASF Magical Miniature Mini drive only 2/3 the size of others is reliable and durable and quickly gaining in popularity with our customers. Single or dual density fast access times $259.00



Tarbell... single density. A&T, $265 $265, kit, $179. A&T $219 w/ purch. of 2 drives. Tarbell double density, DMA, $399. Delta Double density, $399. Micromation double density w/programmable UART for RS-232 port $495. Sorrento Valley single density for Apple, $399.

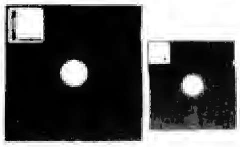
Cable Kits For 8" Drives with 10' 50 cond. cable and connectors. Also power cable and connectors. Flat cable assem if you wish. For one drive 27.50, two 33.95, three 38.95

Cable Kits for 5¼" Drives as above, but 34 cond. For one drive 24.95, two 29.95.

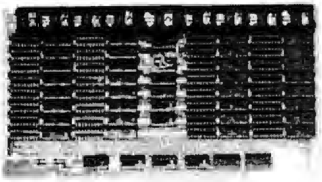


"Power One" Model CP206 Power Supply adequate for at least two drives. 2.8A/24V 2.5A/5V, 0.5A/-5V beautiful quality. $99.00

CABINETS for FDD120 and 801R drives, or CP206 supply. Matte finish in mar resistant black epoxy paint and stacking design 29.95



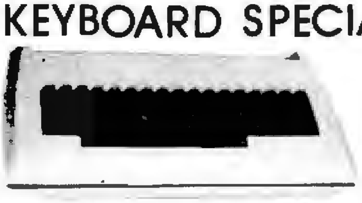
DISKETTES
(Mrx, Verbatim, Georgia Magnetics)
8" $39.95/10
5¼" $34.95/10



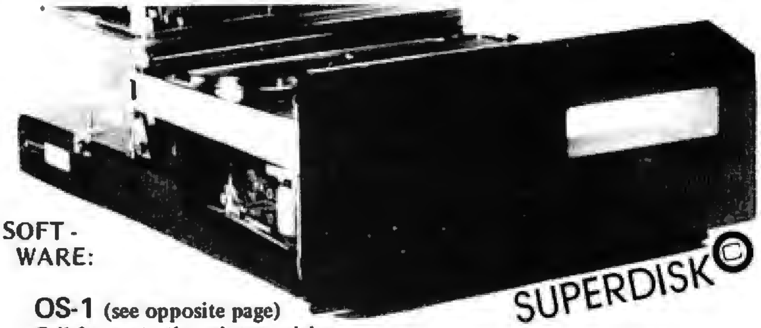
STATIC RAM MEMORY, S-100

32K - $549.00 16K - $349.00

"BACK TO SCHOOL" KEYBOARD SPECIAL



CHERRY "PRO" Keyboard $119.00
Streamlined Custom Enclosure $34.95
BOTH ONLY $134.95 !!!!!!!!!



10MBy DRIVE $3300

S-100 DMA CONTROL

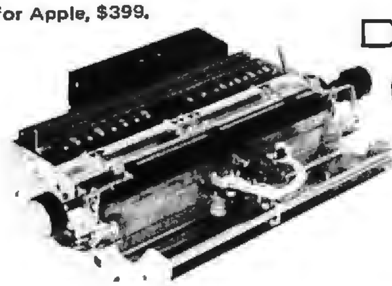
POWER UNIT $395.00

SOFT-WARE:

OS-1 (see opposite page)
Call for up to the minute pricing on S-100 DMA controller, LSI-11 controller,cabinetry, etc.

PS: OS-I 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.



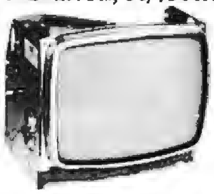
Daisy Wheel Printers

Qume Sprint 3\45

PRINTER (factory warr.)	$1499.00
POWER SUPPLY (Boschert)	349.00
(shown mounted on rear of printer)	
COMBINATION SPECIAL	$1699.00
Cases available	200.00
S-100 interface card	149.00

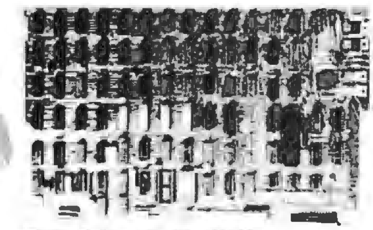
DATA DISPLAY MONITORS

Used 12" Sylvania monitors. Composite Video, 15 MHz, 120VAC. Rebuilt with NEW P39 anti-glare tube $119.00 New P4, 109.00, used P4 79.00.
U-fix model, 10/$300.00



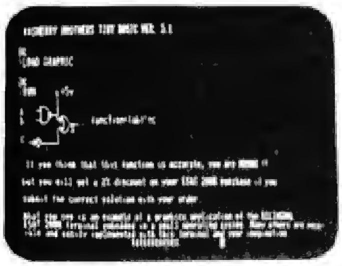
"OEM STYLE" as above, will fit any case. (Both versions serviced by qualified tech). Identical to above but subtract $12.00

Electrolabs
POB 6721, Stanford, CA 94305
415-321-5601 800-227-8266
Telex: 345567 (Electrolab Pla)
Visa MC Am. Exp.



ESAT 200B

BI-LINGUAL 80x24 COMMUNICATING TERMINAL
Scrolling, full cursor, bell, 8x8 matrix, 110 - 19,200 baud, Dual Font Applications. Arabic & Hebrew, Multilingual Data Entry Forms Drawing, Music, & Switchyards. $349.00



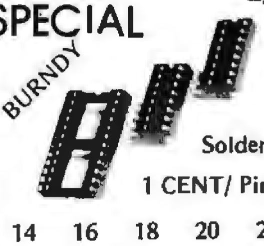
Televideo 912B ($860.00) Televideo 920C ($1020.00)

New!

TELEVIDEO 912B
- Upper & lower case
- Adjustable baud rate
- 80 x 24
- Editing capabilities
- Printer port
- Second page memory & much much more

TELEVIDEO 920C
- Same features as 912B PLUS
- Line & character insert/delete
- Special function keys

SOCKET SPECIAL



"Won't Let Go"
Low Profile
Solder Tail
1 CENT/ Pin !! (0.75/1000's)
8 14 16 18 20 22 24 28 40

Circle 272 on inquiry card.

CP/M* Source Code – FREE! *when you purchase* **"OS-1"**

Electrolabs' new operating system for the Z-80 designed to have exactly the appearance of UNIX, including virtual I/O, "set TTY", a tree and a shell, filters and pipes PLUS total compatability with CP/M software!**

OS-1 FEATURES

(Because OS-1 is truly a comprehensive "OS", and not merely a file handling "DOS", we have changed the name from "Superdos" to "OS-1")

VIRTUAL I/O - copy with a single command between floppy and hard disk, or from TTY to printer to tape to disk... etc., etc. No messy I/O routines to write, & no awkward transfers.

SECURITY - 9 modes of file protection, user and login protection.

MULTI-USER - up to 256 passwords. (non-simultaneous users)

16MBy FILE SIZE - but no limit to no. of directories per device, thus allowing EASY implementation of gigantic storage devices.

"SET TTY" - for printer or crt: tabs, page width, buffer, cursor, UC/LC, fonts, formfeed, arbitrary control characters etc., etc.

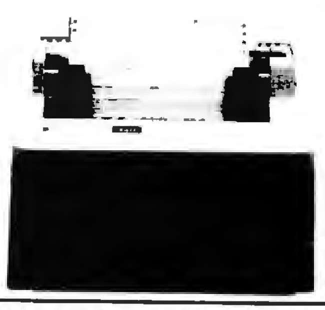
"LOGIN" - automatically executes user selected programs and "set TTY".

OCCUPIES 12KBy - only 50% larger than CP/M, but 500% more features.

CP/M & CDOS COMPATABLE - your library is guaranteed to run!

*(Naturally, we are not giving away the version of CP/M written by Digital Research, Please pardon our pun, but they might object. What we ARE giving you is a greatly enhanced version of CP/M which resides on OS-1, and allows the user of OS-1 to run any and all of his programs, packages or system utilities which are already running on CP/M. We give you the source code at no charge so that you may modify any part of the CP/M to suit your own system requirements. At no charge, you also receive the enhancement allowing 4MBy files instead of 256K.)

OS-1 (with debugger, linker and screen oriented editor	**$199.00**
Update service, per year	**29.00**
Symbolic Debugger	**150.00**
MACRO-Assembler (Creates relocatable code)	**150.00**
"C" Compiler	**660.00**
FORTRAN Compiler	**100.00**
BASIC Compiler (very fast)	**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 $949.00

Graphics option with 2K CRT screen buffer add $199.00

DYNAMIC DEVICES MODEM

- Acoustically coupled modem assembly set
- Asynchrous 0-300 Baud
- Switchable originate or answer modes
- Operates full or half duplex mode
- 15 minute assembly $149.95

SPRINGTIME IC SPECTACULAR

(While Supply Lasts)

MEMORY & EPROM

2114	$ 5.99
2114-2	6.99
pd 411	2.50
2107	2.00

4116 (set of 8, 16K, memory expansion for TRS-80, Apple, Exidy) $69.00

2708	8.95
2716	35.00
2516	35.00
2732	95.00
8748-8	49.00
8755-8	49.00

CPU

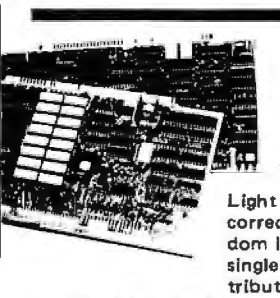
6502	6.25
Z-80	9.95
Z-80A	12.05
8080A	8.99
8085	22.00
8741	79.00

FLOPPY CONTROLLERS

1771	$26.95
1791	37.95
Pd372	39.00

MISCELLANEOUS (CALL US!!)

ELECTROLABS
POB 6721 Stanford, CA 94305
415-321-5601 800-227-8266
Telex: 345567 (Electrolab Pla)



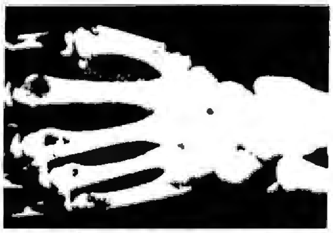
Graphics

High Resolution 480 x 512
for B&W and Color Imaging and Graphics

Light pen, A-D, D-A, TV synchro (needs no time base correction or adjustment with anything between random Interface & NTSC commercial standard). T.V. single frame grabber ("snapshot"). Up to 1 Byte of attributions per pixel.

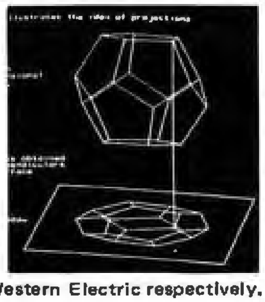
LSI-100 & S-100 applied to:

Graphic Presentation — such as computer generated animation & other graphic displays up to 256 colors & up to 256 b&w gray scales. **Image Analysis** — using built-in FRAME GRABBER, for medical image enhancement, contour analysis, & pattern recognition. **Commercial TV Tilting & Advertising** — using synchronization capability. **Interactive graphics** — using light pen accessory.



BASIC CONFIGURATION —
LSI-11 $1995. S-100 $1265.
For TRS-80/Exidy Add $595.00
Includes: Data Board - 32K (480 x 512 x 1 pixel) D-A 16 level video generator. Video Synchronization Circuitry. Address Control & Timing Board.

FEATURES — High speed. DMA or 2KBy window memory mapped interface. Full NTSC commercial color capability. Low power consumption. Excellent Software



Options — Accessories — Software
Options include: light pen, auxilliary outputs, text mode, memory and much more. Accessories include: b&w and color cameras and monitors. Software: "Plot" 2D or 3D, "Tilting", "Contour", "Image Enhancement", "Vector Curve Generation".

Call for price and details

*CPM and **UNIX
trademarks of Digital Research and Western Electric respectively.

Circle 272 on inquiry card.

MATCHMAKER TECHNOLOGY

TURNKEY DISK SUBSYSTEMS

DISK IS IN!!!

✓ SORCERER
✓ TRS-80
✓ APPLE
✓ HPIB
✓ PET

For those who wish to avoid the aggravation, fussing, irritation, annoyance etc., of assembling your own subsystem, plug in and GO!!!

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
- 10 MBY Removeable Hard Disk — Call for Details

ANOTHER Fine Product brought to you exclusively by the folks at:

In California: 415-321-5601
Outside Cal: 800-227-8266

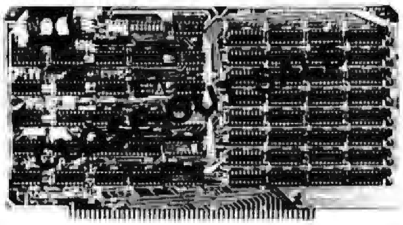
Electrolabs
POB 6721, Stanford, Ca. 94305

Worldwide:
TLX: 345567 Electrolabs PLA

JADE Computer Products

SEND FOR OUR NEW 1980 CATALOG TODAY

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
MEM-32131K (32K KIT)	$309.95
MEM-32131A (32K A&T)	$359.95
MEM-48132K (48K KIT)	$379.95
MEM-48132A (48K A&T)	$429.95
MEM-64133K (64K KIT)	$449.95
MEM-64133A (64K A&T)	$499.95

SOLID STATE MUSIC
PB-1
EPROM PROGRAMMER FOR 2708 OR 2716

MEM-99510K(KIT)	$125.00
MEM-99510A(A & T)	$175.00

VECTOR GRAPHICS
HI-RES GRAPHICS
256X240 S-100 HI—RES GRAPHICS BOARD

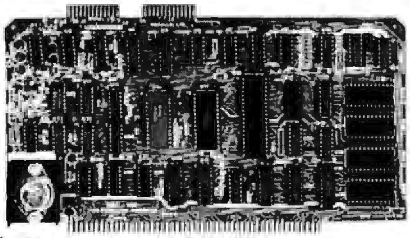
IOV-1070K(KIT)	$150.00
IOV-1070A(A & T)	$199.95

LIMITED TO STOCK ON HAND

SOLID STATE MUSIC
I/O-4
2 SERIAL & 2 PARALLEL I/O PORTS

IOI-1010K(JADE KIT)	$149.95
IOI-1010A(A & T)	$199.95

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 accomodates 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

GET THE INSIDE TRACK
JADE DOUBLE-D
DOUBLE DENSITY DISK CONTROLLER

Read/write single or **double density**, 8" or 5¼" 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
IOD-1200A (DOUBLE-D A&T)	$349.00
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
259840 bytes on double sided 5¼" diskettes
S-100 bus (IEEE) standard compatible
IBM 3740 format in single density
8" and 5¼" 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
IOD-1169A (A&T)	$385.95

S D SYSTEMS
VERSAFLOPPY
VERSATILE FLOPPY DISK CONTROLLER

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

IOD-1150K (KIT)	$189.95
IOD-1150A (A&T)	$239.95

NEW DISK OPERATING SYSTEM
SDOS IS HERE
WE THINK IT'S SUPERIOR

SDOS is a CP/M compatible operating system designed for the S.D Sales Versafloppy I or II. It requires the SBC-100/Versafloppy board set and functions as a superset of CP/M, giving 19 additional functions including file attributes, disk label, and read/write logical blocks. It provides additional protection features, and is expandable to a multi-user real-time system.
SDOS sells for $200.00

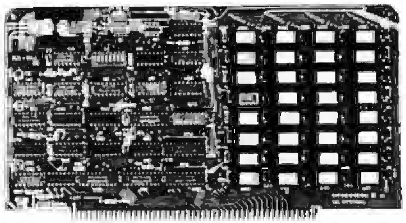
CALL FOR SALE PRICES !!!
32K STATIC RAM
EXPANDABLE 8K/32K, 2/4MHz, KIT/A&T

NEW 2 OR 4 MHz REV. C BOARD
THE JADE BIG Z
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
CPU-30201A (A & T)	$209.00

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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Z-80 SIO/PIO, 2 CTCs, expands to 2 SIOs, 4 CTCs
4 serial ports (async, sync, bisync, SDLC/HDLC)
2 parallel ports **with full handshake**
Software baud rate generators, interval timers, counters, and generates 32 vectored interrupts
Designed especially for MP/M multi-user multi-tasking operating systems. For use with Z-80 only

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2N4348	3/$5.00
2N5088	5/$2.00
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F8	$16.95
Z80 (2MHz)	$10.95
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8080-A	$10.00
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8212	$5.00
8214	$4.65
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8224 (2MHz)	$4.30
8226	$2.75
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8243	$8.00
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8253	$20.00
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8259	$19.95
8275	$69.95
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USRT	
S2350	$10.95
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AY5-1013A	$5.25
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2101-1	$2.95
2111-1	$3.25
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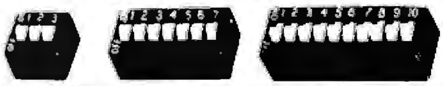
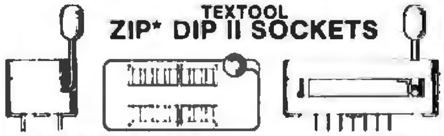
SPST DIP SWITCHES



SALE

PART NUMBER	NUMBER OF SWITCHES	PRICE	
SWD-103	3	$1.00	~~$1.18~~
SWD-104	4	$1.05	~~$1.20~~
SWD-105	5	$1.10	~~$1.24~~
SWD-106	6	$1.15	~~$1.26~~
SWD-107	7	$1.20	~~$1.30~~
SWD-108	8	$1.25	~~$1.34~~
SWD-109	9	$1.30	~~$1.36~~
SWD-110	10	$1.35	~~$1.38~~

TEXTOOL
ZIP* DIP II SOCKETS



16 PIN ZIP* DIP II	$5.50
24 PIN ZIP* DIP II	$7.50
40 PIN ZIP* DIP II	10.25

* ZERO INSERTION PRESSURE

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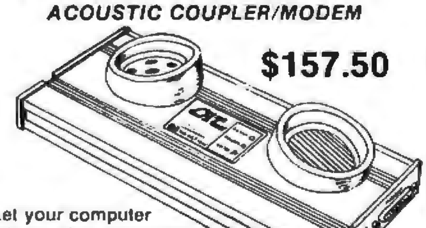

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Bell Systems 103 compatible
300 baud, answer or orginate

IOM-5200A (SALE PRICED) $157.50

page

DIGITAL ELECTRONICS

IDH Series - Headers

PC Mounting

Pins	Straight	Right Angle	1-9	10-24	25-99
10	IDH-10S	IDH-10SR	.95	.72	.70
20	IDH-20S	IDH-20SR	1.30	1.15	1.10
26	IDH-26S	IDH-26SR	1.75	1.50	1.35
34	IDH-34S	IDH-34SR	2.25	1.95	1.75
40	IDH-40S	IDH-40SR	2.55	2.35	2.15
50	IDH-50S	IDH-50SR	3.25	2.95	2.75

Wire Wrap

Pins	Straight	Right Angle	1-9	10-24	25-99
10	IDH-10W	IDH-10WR	1.95	1.65	1.55
20	IDH-20W	IDH-20WR	2.75	2.50	2.40
26	IDH-26W	IDH-26WR	3.50	3.25	3.15
34	IDH-34W	IDH-34WR	4.25	3.95	3.75
40	IDH-40W	IDH-40WR	4.75	4.50	4.25
50	IDH-50W	IDH-50WR	5.95	5.60	5.40

Ejector Ears for above. 4/$1.00 20/$3.00 100/$10.00

- Header is permanently mounted on PCB and accepts IDS socket connectors.
- Straight or right angle mounting options available for both solder and wrap pin terminations.
- Solder termination length for either .062" or .125" PCB.
- Ejector/Latch available, latches IDS socket in place when closed, serves as ejector when open.

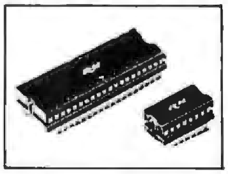
IDC Card Edge Connectors

Pins	1-9	10-24	25-99
20	4.15	3.75	3.30
26	4.75	4.30	3.80
34	5.70	5.10	4.50
40	6.50	5.80	5.25
50	7.00	6.30	5.40

25 Pin 'D' Subminiature

	1-9	10-24	25-99
Plug	6.00	5.25	4.70
Socket	6.35	5.60	5.00

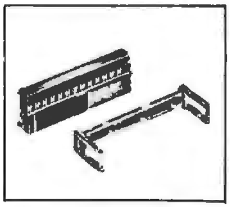
Cable Plugs



Pins	1-9	10-24	25-99	100
14	1.30	1.25	1.10	.95
16	1.50	1.40	1.25	1.10
24	2.25	2.15	2.00	1.75
40	3.75	3.50	3.25	2.95

- Provides pluggable termination of cable to PCB thru IDP plugs and standard DIP sockets such as RN ICN series DIP sockets.
- Single piece design for easy handling and assembly.
- Cover latch allows cover swivel for easy cable insertion.
- Tapered pin tip permits easy insertion into IC sockets.
- Strong leads for multiple insertions without damage.

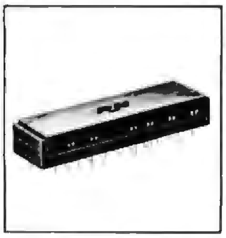
Insulation Displacement Sockets



Pins	Socket Connector	1-9	10-24	25-99	Strain Relief
10	IDS10	1.40	1.20	1.10	.25
20	IDS20	2.00	1.85	1.75	.25
26	IDS26	2.50	2.40	2.30	.25
34	IDS34	3.25	3.10	2.95	.25
40	IDS40	3.95	3.70	3.55	.25
50	IDS50	5.00	4.60	4.40	.25

- Provides pluggable termination of cable to PCB thru IDS sockets and IDH headers
- Single piece body construction for easy assembly, strain relief attached after assembly
- Rugged cover latch and optional strain relief for dependability
- Strain relief can be purchased separately.
- Molded orientation tab.

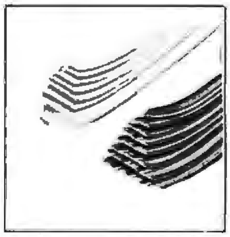
Transition Connectors



	1-9	10-24	25-99
10	1.50	1.35	1.25
20	1.75	1.60	1.50
26	2.25	2.00	1.75
34	2.50	2.40	2.30
40	3.00	2.80	2.60
50	3.60	3.45	3.15

- Connector used to permanently attach cable to PCB.
- Lead length options for .062" and .125" thick PCB.
- Rugged single piece design for easy assembly and dependability.
- Cable can be attached before or after soldering connector to PCB.

Cable



Conductors	Solid Color		Color Coded	
	10 ft.	100 ft.	10 ft.	100 ft.
10	2.90	17.00	4.00	30.00
14	3.40	23.80	5.00	42.00
16	3.70	27.20	5.60	48.00
20	4.40	34.00	7.00	60.00
24	5.00	40.80	8.00	72.00
26	5.40	44.20	8.60	78.00
34	6.80	57.80	11.00	102.00
40	7.80	68.00	13.00	120.00
50	9.50	85.00	16.00	150.00

- Compatible with all RN IDC products.
- Wire spacing .050" ± .002", 28 ga stranded
- 10 thru 50 Conductor Laminated Cable Solid Color (with wire one mark) or Color Coded
- Available in 100 foot rolls, or 10 foot lengths
- Meets UL FR-1 Vertical Flame Test

Note: Custom crimping available on all products for proto-type quantities at 50¢/connection.

Gold: All parts on this page except Cable are gold plated. Because of the volatility of gold pricing, orders may be subject to a gold surcharge.

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Circle 326 on inquiry card.

7400 TTL

SN7400N	.16	SN7470N	.29	SN74160N	.89
SN7401N	.18	SN7472N	.29	SN74161N	.89
SN7402N	.18	SN7473N	.35	SN74162N	1.95
SN7403N	.18	SN7474N	.35	SN74163N	.89
SN7404N	.18	SN7475N	.49	SN74164N	.89
SN7405N	.20	SN7476N	.35	SN74165N	.89
SN7406N	.29	SN7479N	5.00	SN74166N	1.25
SN7407N	.29	SN7480N	.50	SN74167N	1.95
SN7408N	.20	SN7482N	.99	SN74170N	1.59
SN7409N	.20	SN7483N	.59	SN74172N	6.00
SN7410N	.18	SN7485N	.79	SN74173N	1.25
SN7411N	.25	SN7486N	.35	SN74174N	.89
SN7412N	.25	SN7489N	1.75	SN74175N	.79
SN7413N	.40	SN7490N	.45	SN74176N	.79
SN7414N	.70	SN7491N	.59	SN74177N	.79
SN7416N	.25	SN7492N	.43	SN74179N	1.95
SN7417N	.25	SN7493N	.43	SN74180N	.79
SN7420N	.20	SN7494N	.65	SN74181N	1.95
SN7421N	.29	SN7495N	.65	SN74182N	.79
SN7422N	.29	SN7496N	.65	SN74184N	1.95
SN7423N	.25	SN7497N	3.00	SN74185N	1.95
SN7425N	.29	SN74100N	.89	SN74186N	9.95
SN7426N	.29	SN74107N	.35	SN74188N	3.95
SN7427N	.25	SN74109N	.59	SN74190N	1.25
SN7429N	.39	SN74116N	1.95	SN74191N	1.25
SN7430N	.20	SN74121N	.35	SN74192N	.79
SN7432N	.25	SN74122N	.39	SN74193N	.79
SN7437N	.25	SN74123N	.49	SN74194N	.89
SN7438N	.25	SN74125N	.49	SN74195N	.69
SN7439N	.25	SN74126N	.49	SN74196N	.89
SN7440N	.20	SN74132N	.75	SN74197N	.89
SN7441N	.89	SN74136N	.75	SN74198N	1.49
SN7442N	.49	SN74141N	.79	SN74199N	1.49
SN7443N	.75	SN74142N	2.95	SN74S200	4.95
SN7444N	.75	SN74143N	2.95	SN74251N	.99
SN7445N	.75	SN74144N	2.95	SN74279N	.79
SN7446N	.69	SN74145N	.79	SN74283N	2.25
SN7447N	.59	SN74147N	1.95	SN74284N	3.95
SN7448N	.79	SN74148N	1.29	SN74285N	3.95
SN7450N	.20	SN74150N	.89	SN74365N	.69
SN7451N	.20	SN74151N	.59	SN74366N	.69
SN7453N	.20	SN74152N	.59	SN74367N	.69
SN7454N	.20	SN74153N	.59	SN74368N	.69
SN7459A	.25	SN74154N	.99	SN74390N	1.95
SN7460N	.20	SN74155N	.79	SN74393N	1.95
		SN74156N	.79		
		SN74157N	.65		

C/MOS

CD4000	.23	CD4028	.89	CD4070	.55
CD4001	.23	CD4029	1.19	CD4071	.23
CD4002	.23	CD4030	.49	CD4072	.49
CD4006	1.19	CD4035	.99	CD4076	1.39
CD4007	.25	CD4040	1.19	CD4081	.23
CD4009	.49	CD4041	1.25	CD4082	.23
CD4010	.49	CD4042	.99	CD4093	.99
CD4011	.23	CD4043	.89	CD4098	2.49
CD4012	.25	CD4044	.89	MC14409	14.95
CD4013	.39	CD4046	1.79	MC14410	14.95
CD4014	1.39	CD4047	2.50	MC14411	14.95
CD4015	1.19	CD4048	1.35	MC14419	4.95
CD4016	.49	CD4049	.49	MC14433	19.95
CD4017	1.19	CD4050	.49	MC14506	.75
CD4018	.99	CD4051	1.19	MC14507	.99
CD4019	.49	CD4053	1.19	MC14562	14.50
CD4020	1.19	CD4056	2.95	MC14583	3.50
CD4021	1.39	CD4059	9.95	CD4508	3.95
CD4022	1.19	CD4060	1.49	CD4510	1.39
CD4023	.23	CD4066	.79	CD4511	1.29
CD4024	.79	CD4068	.39	CD4515	2.95
CD4025	.23	CD4069	.45	CD4518	1.29
CD4026	2.25			CD4520	1.29
CD4027	.69			CD4566	2.25

74C00

74C00	.39	74C85	2.49	74C163	2.49
74C02	.39	74C90	1.95	74C164	2.49
74C04	.39	74C93	1.95	74C173	2.60
74C08	.49	74C95	1.95	74C192	2.49
74C10	.39	74C107	1.25	74C193	2.49
74C14	1.95	74C151	2.90	74C195	2.49
74C20	.39	74C154	3.00	74C922	7.95
74C30	.39	74C157	2.15	74C923	6.25
74C42	1.95	74C160	2.49	74C925	8.95
74C48	2.49	74C161	2.49	74C926	8.95
74C73	.89			80C95	1.50
74C74	.89			80C97	1.50

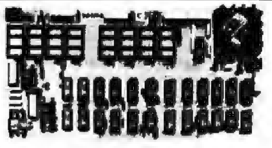
LINEAR

78MG	1.75	LM340K-18	1.35	LM710N	.79
LM106H	.99	LM340K-24	1.35	LM711N	.39
LM300H	.80	LM340T-5	1.25	LM723N/H	.55
LM301CN/H	.35	LM340T-6	1.25	LM733N	1.00
LM302H	.75	LM340T-8	1.25	LM739N	1.19
LM304H	1.00	LM340T-12	1.25	LM741CN/H	.35
LM305H	.60	LM340T-15	1.25	LM741-14N	.39
LM307CN/H	.35	LM340T-18	1.25	LM747N/H	.79
LM308CN/H	1.00	LM340T-24	1.25	LM748N/H	.39
LM309H	1.10	LM358N	1.00	LM1310N	1.95
LM309K	1.25	LM370N	1.15	LM1458CN/H	.59
LM310CN	1.15	LM373N	3.25	MC1488N	1.95
LM311N/H	.90	LM377N	4.00	MC1489N	1.95
LM312H	1.95	LM380N	1.25	LM1496N	.95
LM317K	6.50	LM380CN	.99	LM1556V	1.75
LM318CN/H	1.50	LM381N	1.79	MC1741SCP	3.00
LM319N	1.30	LM382N	1.79	LM2111N	1.95
LM320K-5	1.35	NE501N	8.00	LM2901N	2.95
LM320K-5.2	1.35	NE510A	6.00	LM3053N	1.50
LM320K-12	1.35	NE529A	4.95	LM3065N	1.49
LM320K-15	1.35	NE531H/V	3.95	LM3900N(3401)	.59
LM320K-18	1.35	NE536T	6.00	LM3905N	1.49
LM320K-24	1.35	NE540L	6.00	LM3909N	1.25
LM320T-5	1.25	NE544N	4.95	MC5558V	.59
LM320T-5.2	1.25	NE550N	1.30	8038B	4.95
LM320T-8	1.25	NE555V	.39	LM75450N	.49
LM320T-12	1.25	NE556N	.99	75451CN	.39
LM320T-15	1.25	NE560B	5.00	75452CN	.39
LM320T-18	1.25	NE562B	5.00	75453CN	.39
LM320T-24	1.25	NE565N/H	1.25	75454CN	.39
LM323K-5	5.95	NE566CN	1.75	75491CN	.79
LM324N	1.49	NE567V/H	.99	75492CN	.89
LM339N	.99	NE570N	4.95	75493N	.89
LM340K-5	1.35	LM703CN/H	.89	75494CN	.89
LM340K-6	1.35	LM709N/H	.29	RC4136	1.25
LM340K-8	1.35			RC4151	3.95
LM340K-12	1.35			RC4194	4.95
LM340K-15	1.35			RC4195	4.49

74LS00TTL

74LS00	.29	74LS47	.89	74LS138	.89
74LS01	.29	74LS51	.29	74LS139	.89
74LS02	.29	74LS54	.29	74LS151	.89
74LS03	.29	74LS55	.29	74LS155	.89
74LS04	.35	74LS73	.45	74LS157	.89
74LS05	.35	74LS74	.45	74LS160	1.15
74LS08	.29	74LS75	.59	74LS161	1.15
74LS09	.35	74LS76	.45	74LS162	1.25
74LS10	.29	74LS78	.49	74LS163	1.15
74LS11	.75	74LS83	.89	74LS164	1.25
74LS13	.59	74LS85	1.25	74LS175	.99
74LS14	1.25	74LS86	.45	74LS181	2.49
74LS15	.35	74LS90	.59	74LS190	1.15
74LS20	.29	74LS92	.75	74LS191	1.15
74LS21	.35	74LS93	.75	74LS192	1.15
74LS22	.35	74LS95	.89	74LS193	1.15
74LS26	.35	74LS96	1.15	74LS194	1.15
74LS27	.35	74LS107	.45	74LS195	1.15
74LS28	.35	74LS109	.45	74LS253	.99
74LS30	.29	74LS112	.45	74LS257	.89
74LS32	.35	74LS123	1.25	74LS258	1.75
74LS37	.45	74LS125	.89	74LS260	.69
74LS40	.35	74LS132	.99	74LS279	.75
74LS42	.89	74LS136	.49	74LS367	.75
				74LS368	.75
				74LS670	2.49

Cromemco
Incorporated



8K Bytesaver II

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.

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, +18V @ 0.4A, −18V @ 0.2A
Operating Environment: 0-55°C.

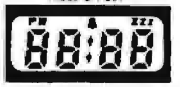
Assembled
8KBS-W.....$245.00

DISCRETE LEDS

.200" dia.			.125" dia.		
XC556R	red	5/$1	XC209R	red	5/$1
XC556G	green	4/$1	XC209G	green	4/$1
XC556Y	yellow	4/$1	XC209Y	yellow	4/$1
XC556C	clear	4/$1			
.200" dia.			.185" dia.		
XC22R	red	5/$1	XC526R	red	5/$1
XC22G	green	4/$1	XC526G	green	4/$1
XC22Y	yellow	4/$1	XC526Y	yellow	4/$1
.170" dia.			XC526C	clear	4/$1
MV108	red	4/$1	.100" dia.		
.085" dia.			XC111R	red	5/$1
MV50	red	6/$1	XC111G	green	4/$1
			XC111Y	yellow	4/$1
			XC111C	clear	4/$1

INFRA-RED LED
1/4"x1/4"x1/16" flat
5/$1

TIMEX T1001
LIQUID CRYSTAL DISPLAY
CLASS II
FIELD EFFECT



4 DIGIT – .5" CHARACTERS
THREE ENUNCIATORS
2.00" × 1.20" PACKAGE
INCLUDES CONNECTOR

T1001-Transmissive $7.95
T1001A-Reflective 8.25

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	4.95	MAN 6740	Common Cathode-red-D.D.	.560	.99
MAN 3	Common Cathode-red	.125	.25	MAN 6750	Common Cathode-red ± 1	.560	.99
MAN 4	Common Cathode-red	.187	1.95	MAN 6760	Common Anode-red	.560	.99
MAN 7G	Common Anode-green	.300	1.25	MAN 6780	Common Cathode-red	.560	.99
MAN 7Y	Common Anode-yellow	.300	.99	DL701	Common Anode-red ± 1	.300	.99
MAN 72	Common Anode-red	.300	.75	DL704	Common Cathode-red	.300	.99
MAN 74	Common Cathode-red	.300	1.25	DL707	Common Anode-red	.300	.99
MAN 82	Common Anode-yellow	.300	.99	DL728	Common Cathode-red	.500	1.49
MAN 84	Common Cathode-yellow	.300	.99	DL741	Common Anode-red	.600	1.25
MAN 3620	Common Anode-orange	.300	.99	DL746	Common Anode-red ± 1	.630	1.49
MAN 3630	Common Anode-orange ± 1	.300	.99	DL747	Common Anode-red	.600	1.49
MAN 3640	Common Cathode-orange	.300	.99	DL749	Common Cathode-red ± 1	.630	1.49
MAN 4610	Common Anode-orange	.400	.99	DL750	Common Cathode-red	.600	1.49
MAN 4640	Common Cathode-orange	.400	.99	DL338	Common Cathode-red	.110	.35
MAN 4710	Common Anode-red	.400	.99	FND70	Common Cathode	.250	.69
MAN 4730	Common Anode-red ± 1	.400	.99	FND358	Common Cathode ± 1	.357	.69
MAN 4740	Common Cathode-red	.400	.99	FND359	Common Cathode	.357	.75
MAN 4810	Common Anode-yellow	.400	.99	FND503	Common Cathode(FND500)	.500	.99
MAN 4840	Common Cathode-yellow	.400	.99	FND507	Common Anode (FND510)	.500	.99
MAN 6610	Common Anode-orange-D.D.	.560	.99	5082-7730	Common Anode-red	.300	.99
MAN 6630	Common Anode-orange ± 1	.560	.99	HDSP-3400	Common Anode-red	.600	1.50
MAN 6640	Common Cathode-orange-D.D.	.560	.99	HDSP-3403	Common Cathode red	.500	1.50
MAN 6650	Common Cathode-orange ± 1	.560	.99	5082-7300	4 x 7 sgl Digit-RHDP	.600	19.95
MAN 6660	Common Anode-orange	.560	.99	5082-7302	4 x 7 Sgl Digit-LHDP	.600	19.95
MAN 6680	Common Cathode-orange	.560	.99	5082-7304	Overrange character (± 1)	.600	15.00
MAN 6710	Common Anode-red-D.D.	.560	.99	5082-7340	4 x 7 Sgl Digit-Hexadecimal	.600	22.50

RCA LINEAR

CA3013T	2.15	CA3082N	2.00
CA3023T	2.56	CA3083N	1.60
CA3035T	2.48	CA3086N	.85
CA3039T	1.35	CA3089N	3.75
CA3046N	1.30	CA3130T	1.39
CA3059N	3.25	CA3140T	1.25
CA3060N	3.25	CA3160T	1.25
CA3080T	.85	CA3401N	.59
CA3081N	2.00	CA3600N	3.50

CALCULATOR CHIPS/DRIVERS

MM5725	$2.95
MM5738	2.95
DM8864	2.00
DM8865	1.00
DM8887	.75
DM8889	.75
9374 7 seg C.A. LED driver	1.50

CLOCK CHIPS

MM5309	$4.95
MM5311	4.95
MM5312	4.95
MM5314	4.95
MM5316	6.95
MM5318	9.95
MM5369	2.95
MM5387/1998A	4.95
CT 7001	6.95

MOTOROLA

MC1408L7	$4.95
MC1408L8	5.75
MC1439L	2.95
MC3022P	2.95
MC3061P	3.50
MC4016(74416)	7.50
MC4024P	3.95
MC4040P	6.95
MC4044P	4.50

IC SOLDERTAIL — LOW PROFILE (TIN) SOCKETS

	1-24	25-49	50-100		1-24	25-49	50-100
8 pin LP	$.17	.16	.15	22 pin LP	$ .37	.36	.35
14 pin LP	.20	.19	.18	24 pin LP	.38	.37	.36
16 pin LP	.22	.21	.20	28 pin LP	.45	.44	.43
18 pin LP	.29	.28	.27	36 pin LP	.60	.59	.58
20 pin LP	.34	.32	.30	40 pin LP	.63	.62	.61

SOLDERTAIL STANDARD (TIN)

	1-24	25-49	50-100		1-24	25-49	50-100
14 pin ST	$.27	.25	.24	28 pin ST	$ .99	.90	.81
16 pin ST	.30	.27	.25	36 pin ST	1.39	1.26	1.15
18 pin ST	.35	.32	.30	40 pin ST	1.59	1.45	1.30
24 pin ST	.49	.45	.42				

SOLDERTAIL STANDARD (GOLD)

	1-24	25-49	50-100		1-24	25-49	50-100
8 pin SG	$.30	.27	.24	24 pin SG	$ .70	.63	.57
14 pin SG	.35	.32	.29	28 pin SG	1.10	1.00	.90
16 pin SG	.38	.35	.32	36 pin SG	1.65	1.40	1.26
18 pin SG	.52	.47	.43	40 pin SG	1.75	1.59	1.45

WIRE WRAP SOCKETS (GOLD) LEVEL #3

	1-24	25-49	50-100		1-24	25-49	50-100
8 pin WW	$.39	.38	.31	22 pin WW	$ .95	.86	.75
10 pin WW	.45	.41	.37	24 pin WW	1.05	.95	.85
14 pin WW	.39	.38	.37	28 pin WW	1.40	1.25	1.10
16 pin WW	.43	.42	.41	36 pin WW	1.59	1.45	1.30
18 pin WW	.75	.68	.62	40 pin WW	1.75	1.55	1.40
20 pin WW	.85	.79	.72				

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ASST. 1	5 ea	10 OHM, 27 OHM	12 OHM, 33 OHM	15 OHM, 39 OHM	18 OHM, 47 OHM	22 OHM, 56 OHM	50 PCS	$1.75
ASST. 2	5 ea	68 OHM, 180 OHM	82 OHM, 220 OHM	100 OHM, 270 OHM	120 OHM, 330 OHM	150 OHM, 390 OHM	50 PCS	1.75
ASST. 3	5 ea	470 OHM, 1.2K	560 OHM, 1.5K	680 OHM, 1.8K	820 OHM, 2.2K	1K, 2.7K	50 PCS	1.75
ASST. 4	5 ea	3.3K, 8.2K	3.9K, 10K	4.7K, 12K	5.6K, 15K	6.8K, 18K	50 PCS	1.75
ASST. 5	5 ea	22K, 56K	27K, 68K	33K, 82K	39K, 100K	47K, 120K	50 PCS	1.75
ASST. 6	5 ea	150K, 390K	180K, 470K	220K, 560K	270K, 680K	330K, 820K	50 PCS	1.75
ASST. 7	5 ea	1M, 2.7M	1.2M, 3.3M	1.5M, 3.9M	1.8M, 4.7M	2.2M, 5.6M	50 PCS	1.75

ASST. 8R Includes Resistor Assortments 1-7 (350 PCS.) **$9.95 ea.**

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TL074CN	Quad Low Noise bi-fet Op Amp	2.49
TL494CN	Switching Regulator	4.49
TL496CP	Single Switching Regulator	1.75
11C90	Divide 10/11 Prescaler	19.95
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DS0026CH	5Mhz 2-phase MOS clock driver	3.75
TIL308	.27" red num. display w/integ. logic chip	10.95
MM5320	TV Camera Sync. Generator	14.95
MM5330	4½ Digit DPM Logic Block (Special)	3.95
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XR205	$8.40			XR2242CP	1.50
XR210	4.40			XR2264	4.25
XR215	4.40			XR2556	3.20
XR320	1.55			XR2567	2.99
XR-L555	1.50	JE2206KB	19.95	XR3403	1.25
XR555	.39	XR1800	3.20	XR4136	1.25
XR556	.99	XR2206	4.40	XR4151	3.95
XR567CP	.99	XR2207	3.85	XR4194	4.95
XR567CT	1.25	XR2208	5.20	XR4202	3.60
XR1310P	1.95	XR2209	1.75	XR4212	2.05
XR1468CN	3.85	XR2211	5.25	XR4558	.75
XR1488	1.95	XR2212	4.35	XR4739	1.15
XR1489	1.95	XR2240	3.45	XR4741	1.47

DIODES

TYPE	VOLTS	W	PRICE	TYPE	VOLTS	W	PRICE
				1N4002	100 PIV	1 AMP	12/1.00
				1N4003	200 PIV	1 AMP	12/1.00
1N746	3.3	400m	4/1.00	1N4004	400 PIV	1 AMP	12/1.00
1N751	5.1	400m	4/1.00	1N4005	600 PIV	1 AMP	10/1.00
1N752	5.6	400m	4/1.00	1N4006	800 PIV	1 AMP	10/1.00
1N753	6.2	400m	4/1.00	1N4007	1000 PIV	1 AMP	10/1.00
1N754	6.8	400m	4/1.00	1N3600	50	200m	6/1.00
1N757	9.0	400m	4/1.00	1N4148	75	10m	15/1.00
1N759	12.0	400m	4/1.00	1N4154	35	10m	12/1.00
1N959	8.2	400m	4/1.00	1N4733	5.1	1w	.28
1N965	15	400m	4/1.00	1N4734	5.6	1w	.28
1N5232	5.6	500m	.28	1N4735	6.2	1w	.28
1N5234	6.2	500m	.28	1N4736	6.8	1w	.28
1N5235	6.8	500m	.28	1N4738	8.2	1w	.28
1N5236	7.5	500m	.28	1N4742	12	1w	.28
1N5242	12	500m	.28	1N4744	15	1w	.28
1N5245	15	500m	.28	1N1183	50 PIV	35 AMP	1.60
1N456	25	40m	6/1.00	1N1184	100 PIV	35 AMP	1.70
1N458	150	7m	6/1.00	1N1185	150 PIV	35 AMP	1.70
1N485A	180	10m	5/1.00	1N1186	200 PIV	35 AMP	1.80
1N4001	50 PIV	1 AMP	12/1.00	1N1188	400 PIV	35 AMP	3.00

SCR AND FW BRIDGE RECTIFIERS

C36D	15A @ 400V	SCR(2N1849)	$1.95
C36M	35A @ 600V	SCR	1.95
2N2328	1.6A @ 300V	SCR	.50
MDA 980-1	12A @ 50V	FW BRIDGE REC	1.95
MDA 980-3	12A @ 200V	FW BRIDGE REC	1.95

TRANSISTORS

C106B1	.50			2N3904	4/1.00
MPSA05	.30	2N3055	.89	2N3905	4/1.00
MPSA06	5/1.00	MJE3055	1.00	2N3906	4/1.00
TIS97	6/1.00	2N3392	5/1.00	2N4013	3/1.00
TIS98	6/1.00	2N3398	5/1.00	2N4123	6/1.00
40409	1.75	PN3567	3/1.00	PN4249	4/1.00
40410	1.75	PN3568	4/1.00	PN4250	4/1.00
40673	1.75	PN3569	4/1.00	2N4400	4/1.00
2N918	4/1.00	MPS3638A	5/1.00	2N4401	4/1.00
2N2219A	2/1.00	MPS3702	5/1.00	2N4402	4/1.00
2N2221A	4/1.00	2N3704	5/1.00	2N4403	4/1.00
2N2222A	5/1.00	MPS3704	5/1.00	2N4409	5/1.00
PN2222 Plastic	7/1.00	2N3705	5/1.00	2N5086	4/1.00
2N2369A	4/1.00	MPS3705	5/1.00	2N5087	4/1.00
MPS2369	5/1.00	2N3706	5/1.00	2N5088	4/1.00
2N2484	4/1.00	MPS3706	5/1.00	2N5089	4/1.00
2N2906	4/1.00	2N3707	5/1.00	2N5129	5/1.00
2N2907	5/1.00	2N3711	5/1.00	PN5134	5/1.00
PN2907 Plastic	7/1.00	2N3724A	.65	PN5138	5/1.00
2N2925	5/1.00	2N3725A	1.00	2N5139	5/1.00
MJE2955	1.25	2N3772	2.25	2N5210	5/1.00
2N3053	2/1.00	2N3823	1.00	2N5449	3/1.00
		2N3903	5/1.00	2N5951	3/1.00

CAPACITOR CORNER

50 VOLT CERAMIC DISC CAPACITORS

	1-9	10-99	100-		1-9	10-99	100-
10 pf	.05	.04	.03	.001µF	.05	.04	.035
22 pf	.05	.04	.03	.0047µF	.05	.04	.035
47 pf	.05	.04	.03	.01µF	.05	.04	.035
100 pf	.05	.04	.03	.022µF	.06	.05	.04
220 pf	.05	.04	.03	.047µF	.06	.05	.04
470 pf	.05	.04	.035	.1µF	.12	.09	.075

100 VOLT MYLAR FILM CAPACITORS

.001mf	.12	.10	.07	.022mf	.13	.11	.08
.0022	.12	.10	.07	.047mf	.21	.17	.13
.0047mf	.12	.10	.07	.1mf	.27	.23	.17
.01mf	.12	.10	.07	.22mf	.33	.27	.22

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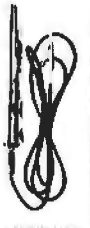
.15/35V	.28	.23	.17	2.2/35V	.35	.31	.27
.22/35V	.28	.23	.17	3.3/25V	.35	.31	.27
.33/35V	.28	.23	.17	4.7/25V	.33	.28	.23
.47/35V	.28	.23	.17	6.8/25V	.49	.45	.35
.68/35V	.28	.23	.17	15/25V	.75	.68	.59
1.0/35V	.28	.23	.17	22/6V	.75	.60	.50

MINIATURE ALUMINUM ELECTROLYTIC CAPACITORS

Axial Lead				Radial Lead			
.47/50V	.15	.13	.10	.47/25V	.15	.13	.10
1.0/50V	.16	.14	.11	.47/50V	.16	.14	.11
3.3/50V	.14	.12	.09	1.0/16V	.15	.13	.10
4.7/25V	.15	.13	.10	1.0/25V	.16	.14	.11
10/25V	.15	.13	.10	1.0/50V	.16	.14	.11
10/50V	.16	.14	.12	4.7/16V	.15	.13	.10
22/25V	.17	.15	.12	4.7/25V	.15	.13	.10
22/50V	.24	.20	.18	4.7/50V	.16	.14	.11
47/25V	.19	.17	.15	10/16V	.14	.12	.09
47/50V	.25	.21	.19	10/25V	.15	.13	.10
100/25V	.24	.20	.18	10/50V	.16	.14	.12
100/50V	.35	.30	.28	47/50V	.24	.21	.19
220/25V	.32	.28	.25	100/16V	.19	.15	.14
220/50V	.45	.41	.38	100/25V	.24	.20	.18
470/25V	.33	.29	.27	100/50V	.35	.30	.28
1000/16V	.55	.50	.45	220/16V	.23	.17	.16
2200/16V	.70	.62	.55	470/25V	.31	.28	.26

Circle 275 on Inquiry card.

Continuity Tester and Flashlight

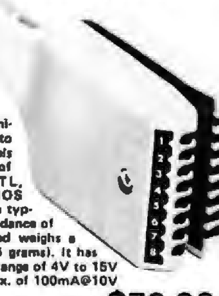


Convenient versatile tool for quickly checking continuity of dead circuits, switches, appliances, cords, fuses, motors, control equipment, coils and panel boards. Also tests circuits for low-resistance shorts and helps identify wires in multi-wire cables. Dozens of other uses. Plus the added convenience of a handy, durable flashlight. Uses two AA size penlight batteries (not furnished). Insulated clip prevents accidental shorting to case. Alligator clip has 48" lead with plug.

RT300 .... **$7.95**

CSC CONTINENTAL SPECIALTIES

Logic Monitor



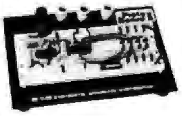
The Logic Monitor allows you to check logic levels on all 16 pins of any DTL, HTL, TTL, or CMOS device. It has a typical input impedance of 100K ohms and weighs a mere 3 oz. (85 grams). It has an input volt. range of 4V to 15V and draws a max. of 100mA@10V

LM-1............$70.00

Proto Clips

14-PIN CLIP	PC-14	.... $ 4.50
16-PIN CLIP	PC-16	.... $ 4.75
24-PIN CLIP	PC-24	.... $10.00
40-PIN CLIP	PC-40	.... $16.00

Proto Boards



PB-6	.... $17.95
PB-100	.... 19.95
PB-101	.... 22.95
PB-102	.... 26.95
PB-103	.... 44.95
PB-104	.... 55.95
PB-203	.... 99.95
PB-203A	.... 155.00
PB-203A-Kit	... 131.00

Jumbo 6-Digit Clock Kit

- Four .630"ht. and two .300"ht. common anode displays
- Uses MM5314 clock chip
- Switches for hours, minutes and hold functions
- Hours easily viewable to 30 feet
- Simulated walnut case
- 115VAC operation
- 12 or 24 hour operation
- Includes all components, case and wall transformer
- Size: 6¾ x 3⅛ x 1¾

JE747..............$29.95

- Bright .300 ht. comm. cathode display
- Uses MM5314 clock chip
- Switches for hours, minutes and hold modes
- Hrs. easily viewable to 20 ft.
- Simulated walnut case
- 115 VAC operation
- 12 or 24 hr. operation
- Incl. all components, case & wall transformer
- Size: 6¾" x 3-1/8" x 1¾"

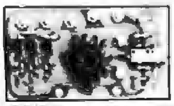
JE701

6-Digit Clock Kit $19.95

Regulated Power Supply

Uses LM309K. Heat sink provided. PC board construction. Provides a solid 1 amp @ 5 volts. Can supply up to ±5V, ±9V and ±12V with JE205 Adapter. Includes components, hardware and instructions. Size: 3½" x 5" x 2"H

JE200.......$14.95



ADAPTER BOARD —Adapts to JE200— ±5V, ±9V and ±12V

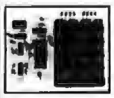
DC/DC converter with +5V input. Toriodal hi-speed switching XMFR. Short circuit protection. PC board construction. Piggy-back to JE 200 board. Size: 3½" x 2" x 9/16"H

JE205 ....$12.95

MICROPROCESSOR COMPONENTS

8080A/8080A SUPPORT DEVICES			
8080A	CPU		$ 7.95
8212	8-Bit Input/Output		3.25
8214	Priority Interrupt Control		5.95
8216	Bi-Directional Bus Driver		3.49
8224	Clock Generator/Driver		3.95
8226	Bus Driver		3.49
8228	System Controller/Bus Driver		4.95
8238	System Controller		5.95
8251	Prog. Comm. I/O (USART)		7.95
8253	Prog. Interval Timer		14.95
8255	Prog. Periph. I/O (PPI)		9.95
8257	Prog. DMA Control		19.95
8259	Prog. Interrupt Control		19.95
6800/6800 SUPPORT DEVICES			
MC6800	MPU		$14.95
MC6802CP	MPU with Clock and Ram		24.95
MC6810API	128X8 Static Ram		5.95
MC6821	Periph. Inter. Adapt (MC6820)		7.49
MC6828	Priority Interrupt Controller		12.95
MC6830L8	1024X8 Bit ROM (MC68A30-8)		14.95
MC6850	Asynchronous Comm. Adapter		7.95
MC6852	Synchronous Serial Data Adapt		9.95
MC6860	0-600 bps Digital MODEM		12.95
MC6862	2400 bps Modulator		14.95
MC6880A	Quad 3-State Bus. Trans. (MC8T26)		2.25
MICROPROCESSOR CHIPS—MISCELLANEOUS			
Z80(780C)	CPU		$14.95
Z80A(780-1)	CPU		15.95
CDP1802	CPU		19.95
2650	MPU		19.95
6502	CPU		11.95
8035	8-Bit MPU w/clock, RAM, I/O lines		19.95
P8085	CPU		19.95
TMS9900JL	16-Bit MPU w/hardware, multiply & divide		49.95
SHIFT REGISTERS			
MM500H	Dual 25 Bit Dynamic		$.50
MM503H	Dual 50 Bit Dynamic		.50
MM504H	Dual 16 Bit Static		.50
MM506H	Dual 100 Bit Static		.50
MM510H	Dual 64 Bit Accumulator		.50
MM5016H	500/512 Bit Dynamic		.89
2504T	1024 Dynamic		3.95
2518	Hex 32 Bit Static		4.95
2522	Dual 132 Bit Static		2.95
2524	512 Static		.99
2525	1024 Dynamic		2.85
2527	Dual 256 Bit Static		2.95
2528	Dual 250 Static		4.00
2529	Dual 240 Bit Static		4.00
2532	Quad 80 Bit Static		2.95
3341	Fifo		6.95
74LS670	4X4 Register File (TriState)		2.49
UART'S			
A-Y-5-1013	30K BAUD		5.95
MICROPROCESSOR MANUALS			
M-Z80	User Manual		$7.50
M-CDP1802	User Manual		7.50
M-2650	User Manual		5.00
ROM'S			
2513(2140)	Character Generator(upper case)		$9.95
2513(3021)	Character Generator(lower case)		9.95
2516	Character Generator		10.95
MM5230N	2048-Bit Read Only Memory		1.95
RAM'S			
1101	256X1	Static	$1.49
1103	1024X1	Dynamic	.99
2101(8101)	256X4	Static	3.95
2102	1024X1	Static	1.75
21L02	1024X1	Static	1.95
2111(8111)	256X4	Static	3.95
2112	256X4	Static MOS	4.95
2114	1024X4	Static 450ns	7.95
2114L	1024X4	Static 450ns low power	10.95
2114-3	1024X4	Static 300ns	10.95
2114L-3	1024X4	Static 300ns low power	11.95
5101	256X4	Static	7.95
5280/2107	4096X1	Dynamic	4.95
7489	16X4	Static	1.75
74S200	256X1	Static Tristate	4.95
93421	256X1	Static	2.95
UPD414 (MK4027)	4K	Dynamic 16 pin	4.95
UPD416 (MK4116)	16K	Dynamic 16 pin 250ns	9.95
TMS4044-45NL	4K	Static	14.95
TMS4045	1024X4	Static	14.95
2117	16,384X1	Dynamic 350ns (house marked)	9.95
MM5262	2KX1	Dynamic	4/1.00
PROM'S			
1702A	2048	FAMOS	$5.95
2716INTEL	16K*	EPROM	59.95
TMS2516 (2716)	16K*	EPROM	49.95
	*Requires single +5V power supply		
TMS2532	4KX8	EPROM	89.95
2708	8K	EPROM	10.95
2716 T.I.	16K**	EPROM	29.95
	**Requires 3 voltages, −5V, +5V, +12V		
5203	2048	FAMOS	14.95
6301-1(7611)	1024	Tristate Bipolar	3.49
6330-1(7602)	256	Open C Bipolar	2.95
82S23	32X8	Open Collector	3.95
82S115	4096	Bipolar	19.95
82S123	32X8	Tristate	3.95
74186	512	TTL Open Collector	9.95
74188	256	TTL Open Collector	3.95
74S287	1024	Static	2.95

JE600 HEXADECIMAL ENCODER KIT



FEATURES:

- Full 8 bit latched output for microprocessor use
- 3 User Define keys each one being bi-stable operation
- Debounce circuit provided for all 19 keys
- LED readout to verify entries
- Easy interfacing with standard 16 pin IC connector
- Only +5VDC required for operations

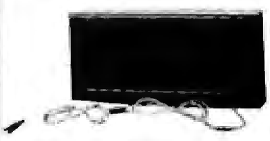
FULL 8 BIT LATCHED OUTPUT—19 KEYBOARD

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 LED readouts. Also included is a key entry strobe.

JE600 ....$59.95

Hexadecimal Keypad only $14.95

DIGITAL THERMOMETER KIT



- Dual sensors—switching control for in-door/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 reading
- Sim. walnut case - AC wall adapter incl.
- Size: 3-1/4"H x 6-5/8"W x 1-3/8"D

JE300 ....$39.95

62-Key ASCII Encoded Keyboard Kit

The JE610 62-Key ASCII Encoded 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.

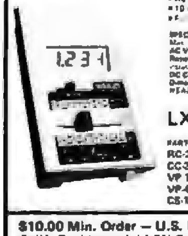
FEATURES:

- 60 Keys generate the full 128 characters, upper and lower case ASCII set
- Fully buffered
- 2 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

62-Key Keyboard only..$34.95

HICKOK LX303 Portable LCD Digital Multimeter



[illegible]

SPECIFICATIONS: [illegible]

LX303 Digital Multimeter $74.95

PART NO	DESCRIPTION	PRICE
RC-3	115V AC ADAPTER	7.50
CC-3	PADDED CARRYING CASE	7.50
VP 10	X10 DC PROBE ADAPTER (Up to 10K)	14.95
VP-40	40kV DC PROBE	35.00
CS-1	10 Amp DC Current Shunt	14.95

$10.00 Min. Order — U.S. Funds Only
Calif. Residents Add 6% Sales Tax
Postage—Add 5% plus $1 Insurance (if desired)

Spec Sheets — 25¢
1980 Catalog Available — Send 41¢ stamp

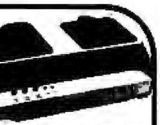
FREE 1980 CATALOG

Jameco ELECTRONICS

PHONE ORDERS WELCOME (415) 592-8097

MAIL ORDER ELECTRONICS — WORLDWIDE
1355 SHOREWAY ROAD, BELMONT, CA 94002
ADVERTISED PRICES GOOD THRU MARCH

The Incredible "Pennywhistle 103"



$139.95 Kit Only

The Pennywhistle 103 is capable of recording data to and from audio tape without critical speed requirements for the recorder and it is able to communicate directly with another modem and terminal for telephone "hamming" and communications. In addition, it is free of critical adjustments and is built with non-precision, readily available parts.

Data Transmission Method	Frequency-Shift Keying, full-duplex (half-duplex selectable)
Maximum Data Rate	300 Baud
Data Format	Asynchronous Serial (return to mark level required between each character)
Receive Channel Frequencies ...	2025 Hz for space; 2225 Hz for mark.
Transmit Channel Frequencies ..	Switch selectable: Low (normal) = 1070 space, 1270 mark; High = 025 space, 2225 mark.
Receive Sensitivity	46 dbm accoustically coupled
Transmit Level	15 dbm nominal. Adjustable from −6 dbm to −20 dbm
Receive Frequency Tolerance ..	Frequency reference automatically adjusts to allow for operation between 1800 Hz and 2400 Hz
Digital Data Interface	EIA RS-232C or 20 mA current loop (receiver is optoisolated and non-polar)
Power Requirements	120 VAC, single phase, 10 Watts
Physical	All components mount on a single 5" by 8" printed circuit board. All components included.
Requires a VOM, Audio Oscillator,	Frequency Counter and/or Oscilloscope to align

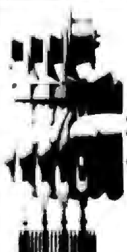
TRS-80 16K Conversion Kit

Expand your 4K TRS-80 System to 16K.
Kit comes complete with:

- 8 each UPD416-1 (16K Dynamic Rams) 250NS
- Documentation for conversion

TRS-16K $75.00

JUST WRAP



- 30 AWG wire
- Daisy chain or point-to-point
- No stripping or slitting required—just wrap
- .025" square posts
- Built-in cut off
- Includes 50 ft. wire

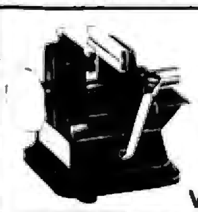
Part No.	Wire Color	Price
JW-1-B	Blue	$14.95
JW-1-W	White	14.95
JW-1-Y	Yellow	14.95
JW-1-R	Red	14.95

JUST WRAP Replacement Wire

Part No.	Color		Price
R-JW-B	Blue	50 ft. roll	$2.98
R-JW-W	White	50 ft. roll	2.98
R-JW-Y	Yellow	50 ft. roll	2.98
R-JW-R	Red	50 ft. roll	2.98

JUST WRAP Unwrap Tool $3.49

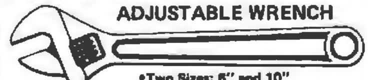
Vacuum Vise



Vacuum-based light-duty vise for small components and assemblies. ABS construction. 1½" jaws, 1¼" travel. Can be permanently installed.

VV-1.......$3.49

ADJUSTABLE WRENCH



- Two Sizes: 6" and 10"
- Professional Quality
- Chrome Vanadium Steel

6"— AW-6 . . $4.95   10"— AW-10 . . $6.95

JOYSTICK VIDEO CONTROLLER

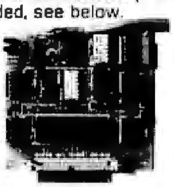
- IDEAL FOR ALL VIDEO GAMES OR REMOTE CONTROL PROJECTS
- SMALL CASE SIZE: 1-1/2"H x 2-3/8"W x 4-5/16"L
- 2 MINIATURE POTENTIOMETERS—40K OHM EACH
- SPST PUSH BUTTON CONTROL
- 5-WIRE CONNECTION CABLE — 5 FEET LONG
- RUGGED PLASTIC CASE

JVC-40 ......$4.95 each

Circle 275 on inquiry card.

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. 8010 C. No connectors provided, see below.

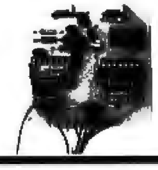


EIA/RS-232 connector Part No DB25P $6.00, with 9', 8 conductor cable $10.95 Part No. DB25P8.

3' ribbon cable with attached connectors to fit TRS-80 and our serial board $19.95 Part No 3CAB40

MODEM

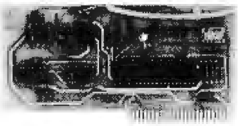
• Type 103 • Full or half duplex • Works up to 300 baud • Originate or Answer • No coils, only low cost components • TTL input and output-serial • Connect 8 Ω speaker and crystal mic. directly to board • Uses XR FSK demodulator • Requires +5 volts • Board only $7.60 Part No. 109, with parts $29.95 Part No. 109A



DISKETTES

Box of 10, 5" $29.95, 8" $39.95.
Plastic box, holds 10 diskettes, 5" - $4.50, 8" - $6.50.

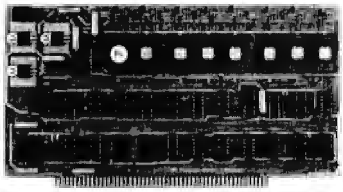
APPLE II SERIAL I/O INTERFACE



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 selectrics. • Also watches DTR • Board only $15.00 Part No. 2, with parts $42.00 Part No. 2A, assembled $62.00 Part No. 2C

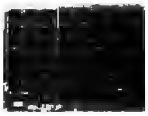
8K EPROM PIICEON

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.



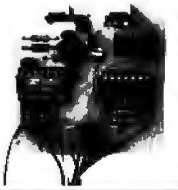
T.V. TYPEWRITER

• 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 curser • Auto scroll • Non-destructive curser • Curser 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



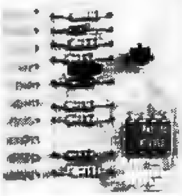
TAPE INTERFACE

• 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



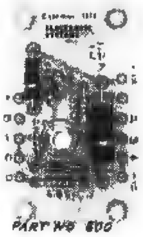
RS-232/ TTL INTERFACE

• 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.



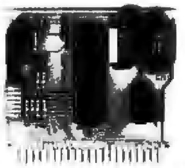
RS-232/TTY INTERFACE

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.



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.

WAMECO PRODUCTS WITH ELECTRONIC SYSTEMS PARTS

FDC-1 FLOPPY CONTROLLER BOARD will drive shugart, pertek, remex 5" & 8" drives up to 8 drives, on board PROM with power boot up, will operate with CPM (not included). PCBD $42.95
FPB-1 Front Panel. (Finally) IMSAI size hex displays. Byte or instruction single step. PCBD $42.95
MEM-1A 8Kx8 fully buffered, S-100, uses 2102 type RAMS. PCBD .... $24.95, $168 Kit
QMB-12 MOTHER BOARD, 13 slot, terminated, S-100 board only .... $34.95 / $69.95 Kit
CPU-1 8080A Processor board S-100 with 8 level vector interrupt PCBD .. $25.95 / $89.95 Kit
RTC-1 Realtime clock board. Two independent interrupts. Software programmable. PCBD .... $25.95, $60.95 Kit
EPM-1 1702A 4K EPROM card PCBD .... $25.95 / $49.95 with parts less EPROMS
EPM-2 2708/2716 16K/32K EPROM card PCBD .... $24.95 / $49.95 with parts less EPROMS
QMB-9 MOTHER BOARD. Short Version of QMB-12. 9 Slots PCBD .... $30.95 / $67.95 Kit
MEM-2 16Kx8 Fully Buffered 2114 Board PCBD .... $25.95, $269.95 Kit

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

To Order: Mention part no. description, and price. In USA shipping paid by us for orders accompanied by check or money order. We accept C.O.D. orders in the U.S. only, or a VISA or Master Charge no., expiration date, signature, phone no., shipping charges will be added. CA residents add 6.5% for tax. Outside USA add 10% for air mail postage and handling. Payment must be in U. S. dollars. Dealer inquiries invited. 24 hour order line (408) 448-0800

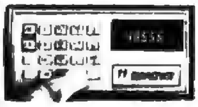
Send for FREE Catalog . . . a big self-addressed envelope with 41¢ postage gets it fastest!

ELECTRONIC SYSTEMS Dept. B P. O. Box 21638, San Jose, CA USA 95151

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.



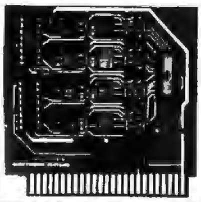
FLOPPY DISK STORAGE BINDER

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

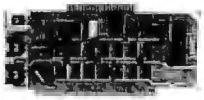
There are 8 inputs that can be driven from TTL logic or any 5 volt source. The circuit board can be plugged into any of the 8 sockets of your Apple II. It has a 16 pin socket for standard dip ribbon cable connection.

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

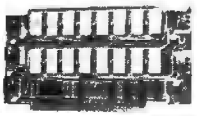


SYSTEM MONITOR

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. $1:19.95.

ASCII KEYBOARD

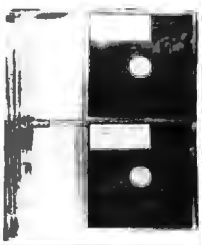
53 Keys popular ASR-33 format • Rugged G-10 P.C. Board • Tri-mode MOS encoding • Two-Key Rollover • MOS/DTL/TTL Compatible • Upper Case lockout • Data and Strobe inversion option • Three User Definable Keys • Low contact bounce • Selectable Parity • Custom Keycaps • George Risk Model 753. Requires +5, -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 minidiskette 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 multitudes of ten. $9.95/10 Pack.

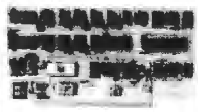


ATARI 800

Computer with 8K $995.00, disk drive $549.00, printer $599.99

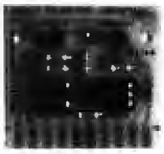
VIDEO TERMINAL

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

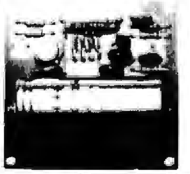
For the Apple, TRS-80 or Pet $8 each Part No. 4116/ 2117.

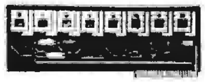
APPLE II HOBBY/ PROTOTYPING CARD

$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

This board has 8 triacs capable of switching 110 volt 6 amp loads (660 watts per channel) or a total of 5280 watts. Board only $15.00 Part No. 210, with parts $119.95 Part No. 210A.

To Order: Mention part no. description, and price. In USA shipping paid by us for orders accompanied by check or money order. We accept C.O.D. orders in the U.S. only, or a VISA or Master Charge no., expiration date, signature, phone no., shipping charges will be added. CA residents add 6.5% for tax. Outside USA add 10% for air mail postage and handling. Payment must be in U.S. dollars. Dealer inquiries invited. 24 hour order line (408) 448-0800

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Circle 276 on inquiry card.

Circle 299 on inquiry card.

Unclassified Ads

FOR SALE: RCA Cosmac VIP CDP1802. Fully assembled and working beautifully. Pixe-Verter for television and cassette recorder included. Also, two manuals and one issue of *Viper* magazine. Asking $200 or best offer. I pay shipping. Jeff Roberts, 1800 Huntington Tpke, Trumbull CT 06611, (203) 375-9430.

FOR SALE: Three 6800 systems at my cost less 50 to 70%. AMI PROTO processor, Davis 16 K random-access-memory boards, MSI/GSI disks, IDS printers. Buy system or components. Send SASE for complete list of components and prices. Phil Reagan, 1557 Jackson St #106, Oakland CA 94612, (415) 839-3409.

FOR SALE: Radio Shack TRS-80, Level II, 16 K. Complete system (processor/keyboard, video monitor, cassette recorder). Plus some programs, assorted books, and many cassettes. One-year-old, used three months. Sacrifice at $650. Stan Birnbaum, 1610 Hudson St Apt 4, Helena MT 59601, (406) 443-7320.

WANTED: Sanders 708 video display terminal, or equivalent, for X-Y vector displays. Send details, including price and condition. George B Konizer, 2008 N Brailsford Rd, Camden SC 29020.

WANTED: A ZE, ZB, ZC, or ZD erasable read-only memory for Digital Group Z80 board. A Z80 operating system cassette for 1024 TVC, also by Digital, or a good copy of same. You name the price. Fred A Bufanio, 96 Overlook Ter, Bloomfield NJ 07003.

FOR SALE: PerSci dual 8-inch disk drive, double-density rated with cable for direct input/output (I/O), Model #2142; also, controller card for S-100 bus. Both one-year-old and working. Original cost over $2700; sell for $2300. Richard Turner, 1420 Balboa Av Apt J-75, Panama City FL 32401, (904) 769-8025 Wednesday and Friday evenings and weekends.

FOR SALE: TRS-80 computer system 16 K Level II, expansion interface, RS-232 interface, and disk drive with disk operating system disk (all cables included). Excellent condition. Buying larger system. My cost $1900, will sell for $1600 or best offer. S Phail, 4900 Bristow Dr, Annandale VA 22003, (703) 941-4075.

WANTED: MITS 88-2SIO input/output (I/O) board. All integrated circuits must be socketed and board must be in working order. R Tsubota, Rt 2 POB 442, Ontario OR 97914.

FOR SALE: Heathkit H8 computer system with 16 K, H8-5 input/output (I/O) cassette interface, H9 video terminal, and HC8-14 cassette software system. All factory tested and running. Includes all manuals, documentation, and software. $1000 or best offer. (Canadian funds) Will ship. Reason selling: I have two computer systems. Robert Tremblay, 1316 Teillet, Ste-Foy Quebec, CANADA G1W 3C2.

WANTED: Apple II or Apple II Plus. No Apple is too small. If you want to trade up, give a hand to a beginner. Send a description and price. Please include your phone number. Everyone will receive a reply if at all possible. David Hayes, 537 Hall St, Ripon WI 54971.

WANTED: Information about fixes or patches for bugs in TDL-Xitan FORTRAN and/or Disk BASIC. Will pay with money or similar information known to me. Have written FORTRAN program for communication and file transfer between Micro and WYLBUR on 370. Will be happy to share. M Frankel, Dept of Statistics, Baruch College CUNY, 46 E 26 St, NYC NY 10010.

WANTED: Diablo 1650 print mechanism with or without interface. Or Selectric print mechanism wth ASCII interface. Dennis Toeppen, 409 S Hi Lusi, Mount Prospect IL 60056, (312) 255-2255 after 6 PM weekdays.

FOR SALE: Expandor Black Box printer. See 11/77 *Kilobaud* for detailed article or 5/79 *Jade* ad for brief description of this compact eighty-column impact printer. Case, parallel interface, cable, connectors, documentation, and shipping included. Cost new is $470. First $300 bank check or money order gets mine. Used nine months. Fred Lepow, 1700 Circo del Cielo Dr, El Cajon CA 92020, (714) 440-9310 (nights) or (714) 276-3414 (days).

FOR SALE: Two Friden Flexowriter units. Each has paper-tape read/write on keyboard, a desk/console, and an auxiliary scanning/reader. $265 each. Also, Tektronix 513 oscilloscope DC to 18 MHz; $195. Gerald Ortman, 7619 Forrest Av, Munster IN 46321, (219) 836-1514 evenings.

FOR SALE: IBM 1050 Data Communication System (RS-232). Consists of control unit, Selectric-based printer-typewriter, paper-tape punch, paper-tape reader. Full documentation. Excellent condition. $800. SASE would be appreciated. Arkady G Makhlin, 39 Hammersmith, Danbury CT 06810, (203) 743-9509.

FOR SALE: Two 2315 2.4 M bytes disk cartridges, Hewlett-Packard Model #12869A, in Wright Line Model #5835-20 disk pack carrying case; $100 or reasonable offer. Fourteen Hewlett-Packard 9162-0050 digital cassettes; $28 or reasonable offer. James R Schueler, 317 Chilean Av Rear, Palm Beach FL 33480.

FOR SALE: Altos/8000 (Model ACS 8000-1) with two 8-inch drives (½ Mb), 64 K main memory, CP/M operating system, Xitan Extended Disk BASIC, Texas Instruments' (Model 810) 150 characters per second (cps) printer with forms length control, Volker Craig video display with numeric pad, detachable keyboard, and addressable cursor. John Whiffen, (416) 279-1496 (CANADA).

FOR SALE: Intel single-board, computer-based system. Includes: SBC-80/10 (8080A processor card), SBC-104 (4 K random access memory, input/output (I/O), etc), SBC-116 (16 K random access memory, read-only memory, I/O), SBC-310 (high-speed math processor), SBC-534 (four-channel serial I/O), SBC-604 (card cage), SBC-635 (14 A power supply). Also, SBC-80/04 (8085 processor), ultraviolet programmable read-only memory eraser, National Multiplex digital cassette recorder, and DEC LA-36 terminal. Will negotiate price or trade. Jim Mortons, POB 65, Fond du Lac WI 54935.

FOR SALE: PDP-11 boards. Removed from working PDP-11/15. Complete processor. Very powerful. Too many boards to list. One Hex (front panel), four Quad, six Dual, three Single, seven Single small. Twenty-one boards in all. $60. Take advantage of the low value of the Canadian dollar and buy. Write for complete information. David Lai, 13250 Racine St, Pierrefonds Quebec, CANADA H8Z 1Y7.

FOR SALE: Three IMSAI 4 K random-access-memory boards for S-100 bus with individual 1 K write-protect. $85 each. One Polymorphics video board with 16 by 64 characters, 48 by 128 graphics, 1 K of on board random access memory, and an 8-bit parallel port for keyboard. Also for S-100 bus. $160. Everything assembled. Peter Hack, 579 Diamond St, San Francisco CA 94114, (415) 824-4225.

FOR SALE: Commodore PET 2001/8 with full documentation. Assorted software games included. Excellent condition, burned in, and running. $525. Michael DiMario, 4300 N 92 St Apt 1, Milwaukee WI 53222, (414) 476-8300 ext 720 days, (414) 463-0836 evenings.

FOR SALE OR TRADE: I will design and print a single- or double-sided printed-circuit board from your specifications on my Tektronix graphics computer. Will trade for surplus computer gear. Send SASE for sample of my work. Rex Taylor, 2367 NW Kearney, Portland OR 97210.

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Readers who are soliciting or giving advice, or who have equipment to buy, sell or swap should send in a clearly typed notice to that effect. To be considered for publication, an advertisement must be clearly noncommercial, typed double spaced on plain white paper, contain 75 words or less, and include complete name and address information.

These notices are free of charge and will be printed one time only on a space available basis. Notices can be accepted from individuals or bona fide computer users clubs only. We can engage in no correspondence on these and your confirmation of placement is appearance in an issue of BYTE.

Please note that it may take three or four months for an ad to appear in the magazine.

FOR SALE: VIM single-board microcomputer in original box with all documentation; $195. Also, Radio Shack Editor-Assembler for TRS-80 unused; $25. V M Faulkner, RR 2 POB 294A, Yorktown IN 47396, (317) 289-4138.

FOR SALE: IMSAI 8080, 22-slot mother board, 2P + S, Tarbell cassette, 16/32 K erasable-programmable read-only memory, Godbout active terminator, 8 K Seals + 24 K Godbout random access memory, H9 terminal, Mullen extender. $2000. Larry, 516 E St, Galt CA 95632, (209) 745-1843.

FOR SALE: Two Processor Technology 16 K dynamic programmable memory boards #16KRA for SOL or S-100 system. See January 1977 BYTE, page 10. With manual. 32 K for $200. Not sold separately. First check or money order takes it. Bob Duke, 13526 Pyramid Dr, Dallas TX 75234, (214) 241-2888.

OLD COMPUTING DEVICES: Do you have or know about planimeters, integraphs, integrators, mechanical computers, pre-1900 calculators, or other unusual early computing machines? Do you have books, manuals, or other documentation about them? I am buying, studying, and exchanging stories about these things. What's the weirdest computing machine you know of? I'd particularly like to hear about unusual projects, both historical and recent. Dick Rubinstein, 15 Maugus Av, Wellesley MA 02181.

FOR SALE: Digital Group standard mother board, Z80 processor board, input/output (I/O) board, TVC/cassette interface, George Risk keyboard in oak cabinet, TV monitor conversion kit, dual Phi-Deck and controller board, nonstandard power supply and cabinet. All documentation and system programs included. Boards assembled by professional digital technician. System never calibrated or run. $800 complete or trade for TRS-80 disks or printer. Jim Lewis, POB 22045, Knoxville TN 37922.

WANTED: I need a few odd integrated circuits for repairs to circuit boards made by Intel Corp. Type numbers are: P3404, MC3002, 8267, 8263, NE550, MC3003. Damaged boards with salvageable usable circuits would be satisfactory. Merle Vogt, POB 145, Von Ormy TX 78073.

WANTED: Hewlett-Packard 9830 in excellent working condition, preferably under H-P maintenance. With plasma display, tape cartridge drive, thermal printer, BASIC, and manual. R Kesell, 345 W 88th St, NYC NY 10024, (212) 873-5556.

FOR SALE: Upgrading all TRS-80 Model I equipment to Model II. Must sell like-new expansion interface with 32 K random access memory. Only $470. Two Shugart disk drives with cable, and four MPI disk drives with cable. Your choice only $385 per drive. Buy two or more drives and get the cable free. One Centronics printer (call or write for price). Bruce Taylor, 118 S Mill St, Pryor OK 74361, (918) 825-4844, after 6:00 PM (918) 434-5242.

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BOMB - BYTE's Ongoing Monitor Box

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December BOMB Numerical Analysis

"Add Nonvolatile Memory to Your Computer" by Steve Ciarcia (page 36) proved to be the most popular among those readers who voted. Second place in the BOMB voting went to James L Peterson for "Text Compression" (page 106). These two authors receive the $100 first-place and $50 second-place prizes. Third place was shared by F R Ruckdeschel ("Frequency Analysis of Data Using a Microcomputer," page 10) and Christopher O Kern ("A User's Look at Tiny-C," page 196).■