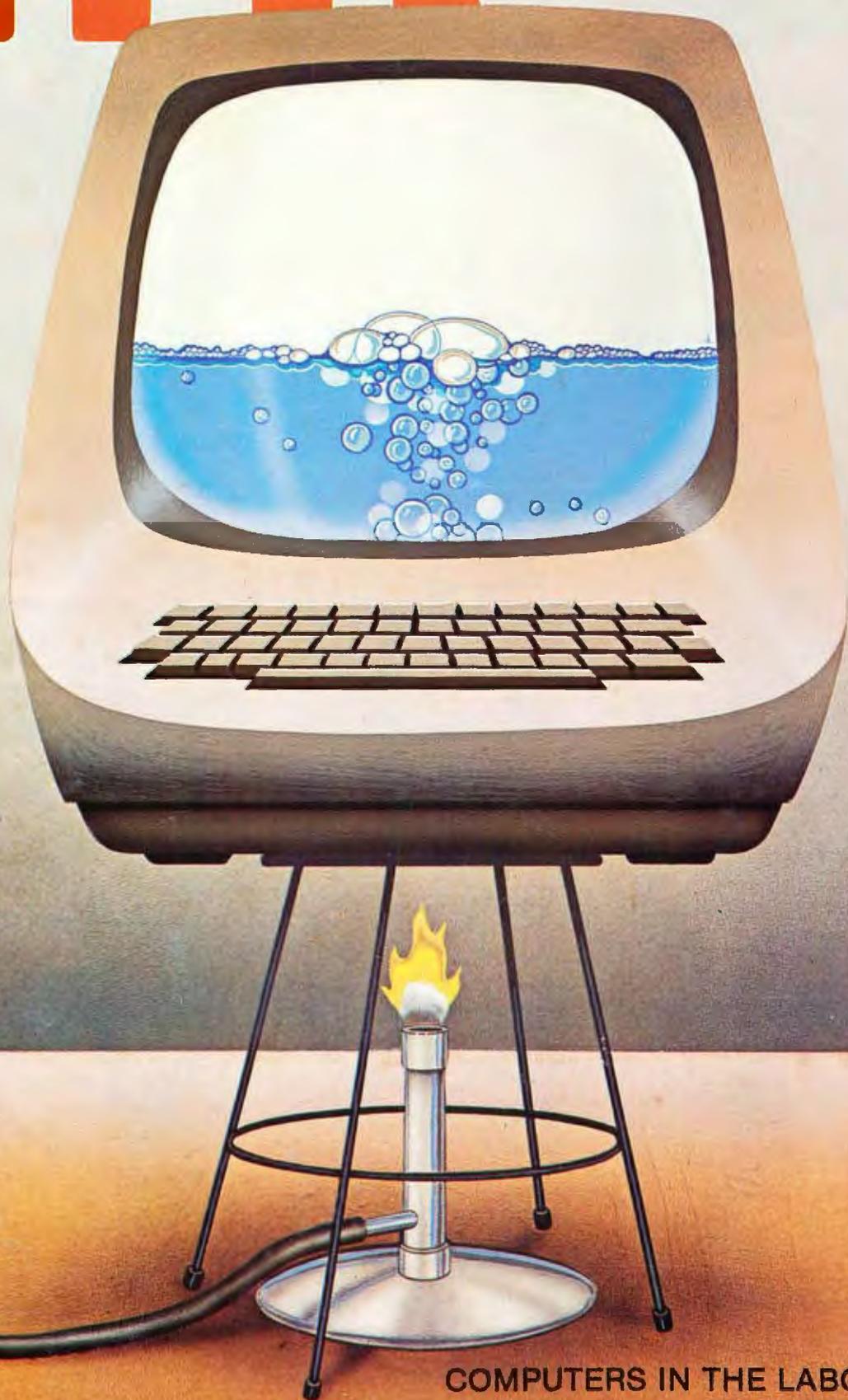


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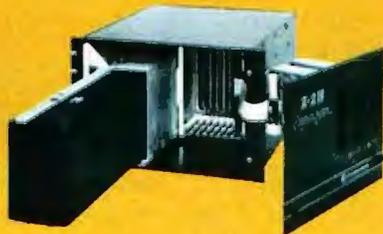
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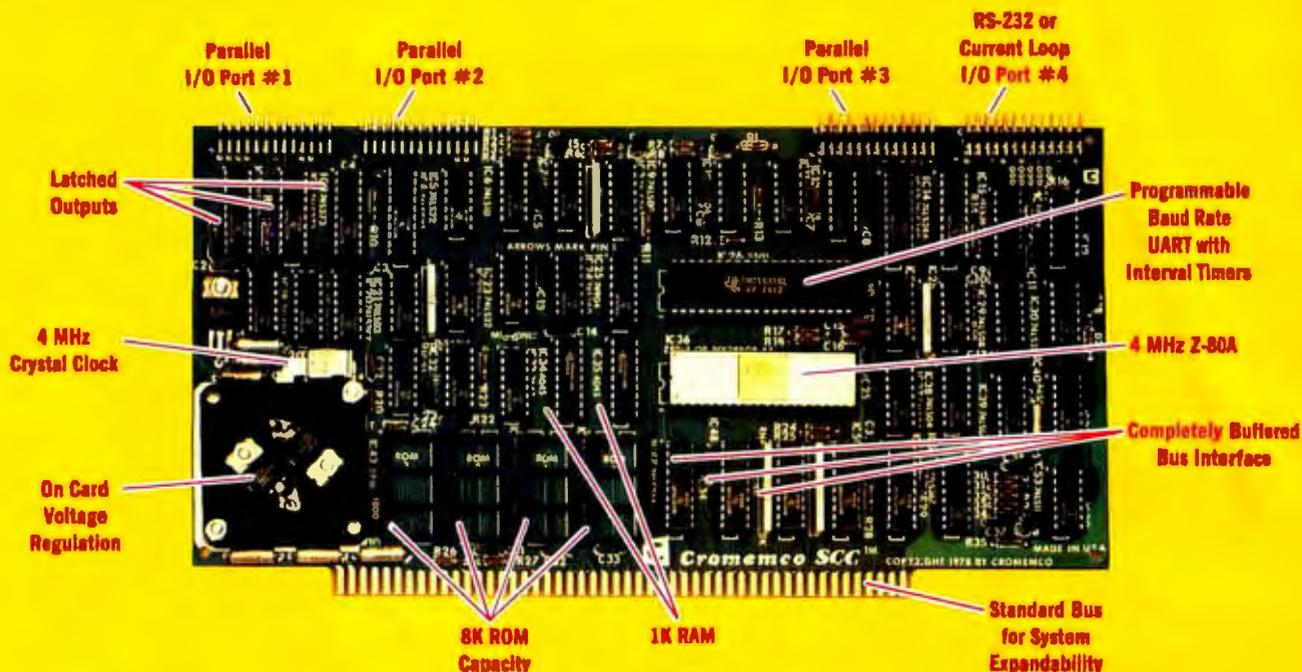
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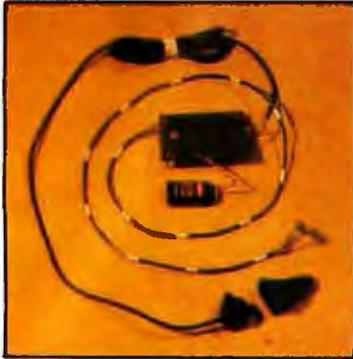
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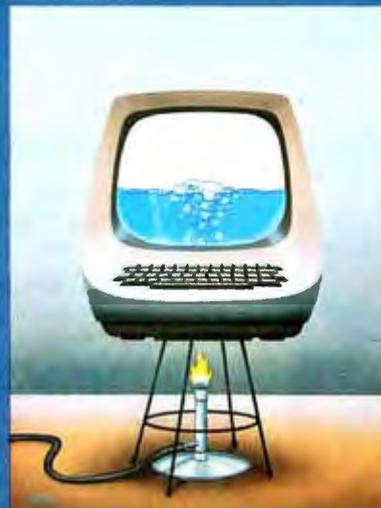
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ON THE COVER

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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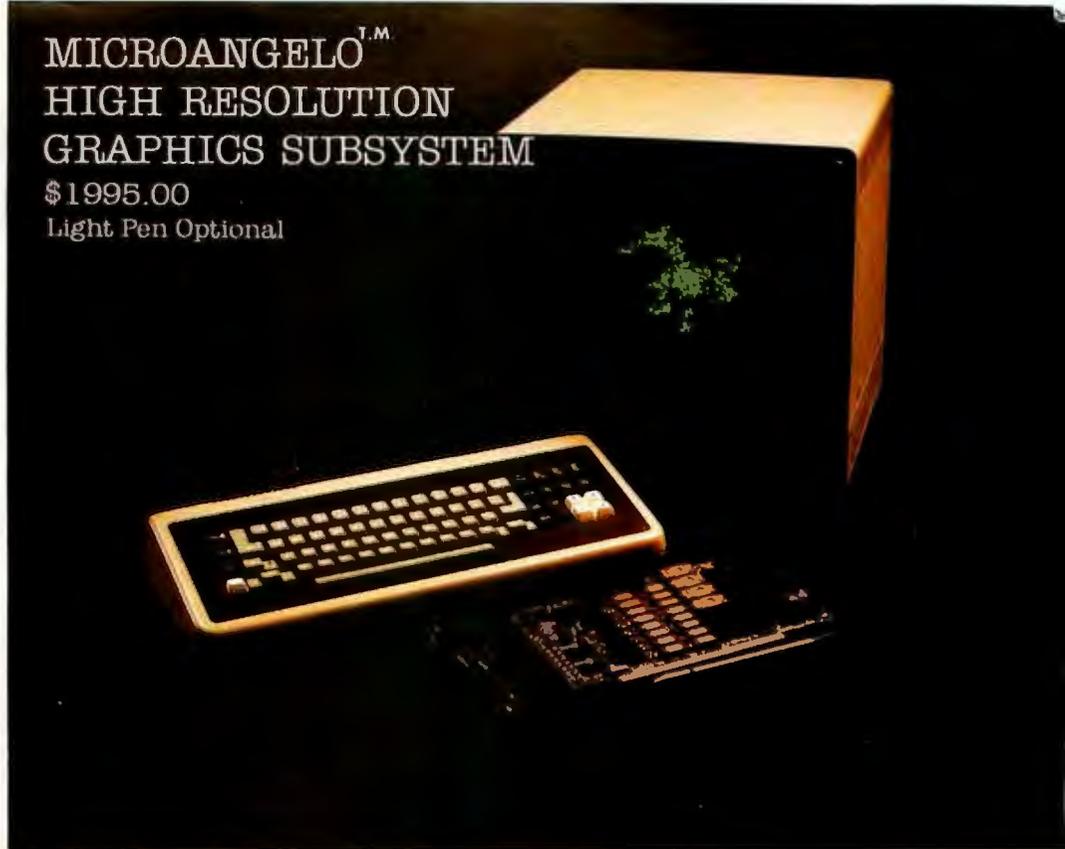
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Editorial

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.

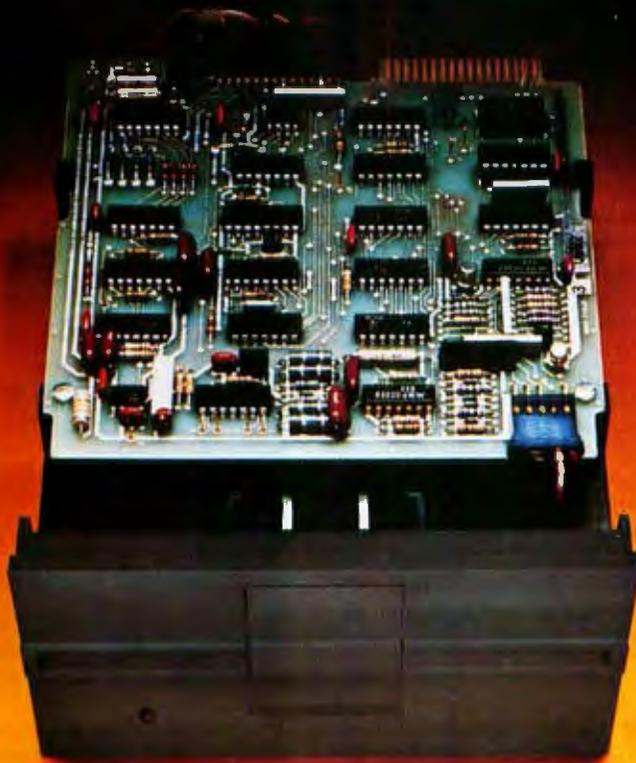
With the decision to go made, the next decision was how to implement the system. The number one step, of course, was to order a motor drive and a magazine back for the Nikon camera. I quickly came to the conclusion that if I were going to travel all the way to Kenya to watch 4 minutes of celestial follies, 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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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.

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 editorial'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



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.)

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

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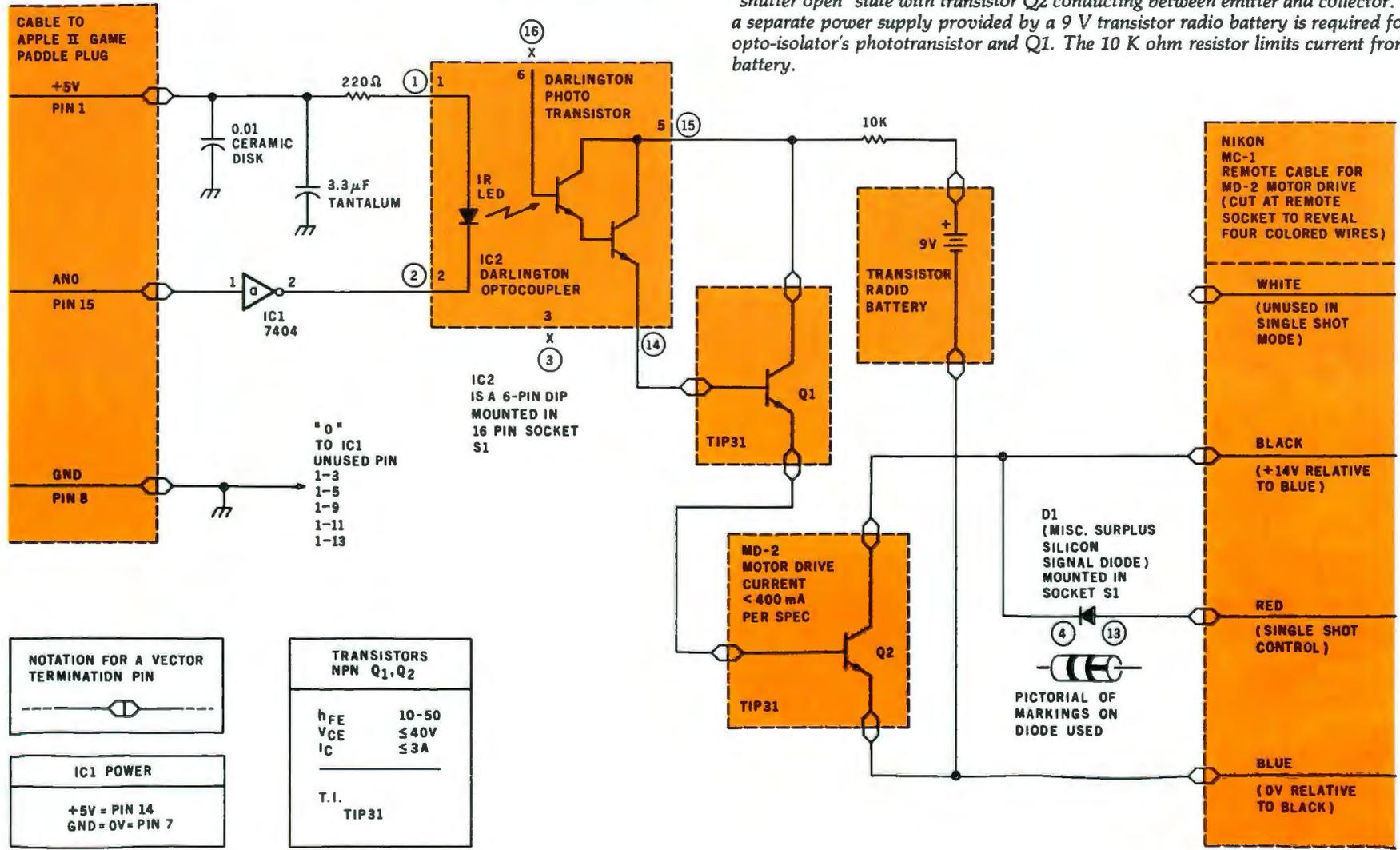
Figure 1: The schematic of the Apple II/Nikon interface. The two transistors (Q1 and Q2) and diode D1 simulate a switch and a diode found inside the original Nikon MD-2 motor drive shutter-control head. The colors noted at the right in this figure correspond to the colors found in the four-wire cable 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.



NOTATION FOR A VECTOR TERMINATION PIN

IC1 POWER

+5V = PIN 14
GND = 0V = PIN 7

TRANSISTORS NPN Q1, Q2	
h _{FE}	10-50
V _{CE}	≤ 40V
I _C	≤ 3A
T.I. TIP31	

"0" TO IC1 UNUSED PIN

1-3
1-5
1-9
1-11
1-13

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80 Character Video

With 80 characters per line our VB3 is the perfect video interface for word processing. It produces a standard 80x24 display of upper and lower case characters or as much as 80x51 for a full page of text. The matrix for graphic display goes up to 160x204. And with optional EPROM, as many as 256 user programmed characters or symbols can be produced.

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We spent over a year designing the CB2 to assure that it will be the most fully S-100 compatible Z-80 CPU on the market.

It operates at 2MHZ or 4MHZ by DIP switch selection and includes two sockets for 2716/2732 EPROMs or TMS 4016 2K RAMs. Memory sockets can be disabled. Separate run/stop and single step switches allow system evaluation without the benefit of a front panel.

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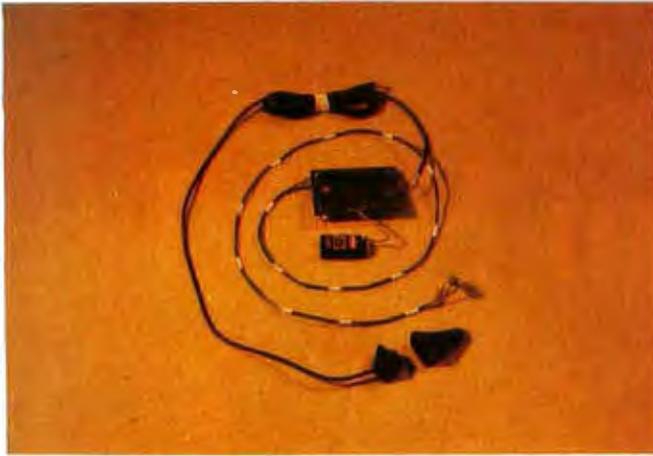


Photo 3: The Apple II/Nikon interface. The interface of figure 1 was wired on a framework of "P" pattern Vector perforated board. Vector terminal pins were used to provide anchorage for the Apple II cable (left edge), the cable from the Nikon MC-1 shutter extension (right edge), the connector for a 9 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.

```
(
  ( NOTES ABOUT THE DESIGN PROCESS )
  ( Step 1: High Level Description - begun November 22, 1979 )
  ( This is a first cut at a program to simulate the eclipse )
  ( photographs 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 )
  ( a = number of diamond rings exposures )
  ( t = totality time )
  ( s = slack in allocated totality time )
  ( Then let us seek the followings... )
  ( 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 )
  ( N = 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 12/14/79 )
  (
  ( 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... )
  ( mail_cue )
  ( diamond_ring_burst )
  ( totality )
  (
  ( Step 4: Adapt to real time control - )
  ( Put in assemblations of the software to actually demon- )
  ( strate operation with the Nikon F2A camera via a relay )
  ( plugged into the Apple II Case Paddle Socket )
  ( THIS IS THE FINAL FORM OF THE PROGRAM TO BE USED IN THE )
  ( FIELD CONTROLLING THE EXPERIMENT... )
  ( Necessary step: determines 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_printer = ^STRING;

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

Listing 1 continued on page 96

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

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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 possibly 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

A growing line of tools to expand the Apple.

Time events in time operating modes — continuous, single shot, frequency comparison, and pulse width comparison. Includes three 16-bit interval timers, plus flexible patch area for external interface. Programmable interrupts, on-board ROM, and much more.

7720A Parallel Interface. Two bi-directional 8-bit I/O ports will connect your Apple to a variety of parallel devices, including printers, paper tape equipment, current relays, external on/off devices. Full featured, programmable interrupts, supports DMA daisy chaining.

7811B Arithmetic Processor. Interfaces with Applesoft, so you just plug in and run. Based on the AM 9511 device, provides full 16/32-bit arithmetic, floating point, trigonometric, logarithmic, exponential functions. Programmed I/O data transfer, much, much more. (Not currently compatible with Apple II Plus — check with your dealer.)

7710A Asynchronous Serial Interface. Conforming to RS-232-C A thru E 1978 standard, this card will drive a variety of serial devices such as CRT terminals, printers, paper tape devices, or communicate with any standard RS-232 device, including other computers. Full hand-shaking, and fully compatible with Apple PASCAL!

7470A 3% BCD A/D Converter. Converts a DC voltage to a BCD number for computerized monitoring and analysis. Typical inputs include DC inputs from temperature or pressure transducers. Single channel A/D, 400 ms per conversion.

7490A GPIB IEEE 488 Interface. A true implementation of the IEEE 488 standard — the standard protocol for instrumentation and test devices. Control and monitor test instruments such as digital voltmeters, plotters, function generators, or any other device using the IEEE 488.

7114A PROM Module. Permits the addition to or replacement of Apple II firmware without removing the Apple II ROMs. Available with on-board enable/disable toggle switch.

7500 A Wire Wrap Board. For prototyping your own designs.

7510A Solder Board.

7590A Extender Board.

7018A 16K Dynamic Memory Add-On.

Watch this space for new CCS products for the Apple. We've got some real surprises in the works. To find out more about the CCS product line, visit your local computer retailer. The CCS product line is available at over 250 locations nationally, including most that carry the Apple. Or circle the reader service number on this ad.

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We see it as a good way to get things done.

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We make components for the S-100 bus, the PET, and the TRS-80, too. We built our products to deliver hard-nosed value to the OEM, and to the inventor who knows the best, at prices that are unbeaten.

To find out how much computer your Apple II can be, see things our way. Because for serious users with serious uses for the Apple, we've got the tools.



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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 subconscious minds are. I feel my subconscious 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 non-recursive 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
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high level, general-purpose language has to offer, you'll see why that's very good news indeed.



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If you'd like to let the world know who speaks Pascal, here's how:

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.

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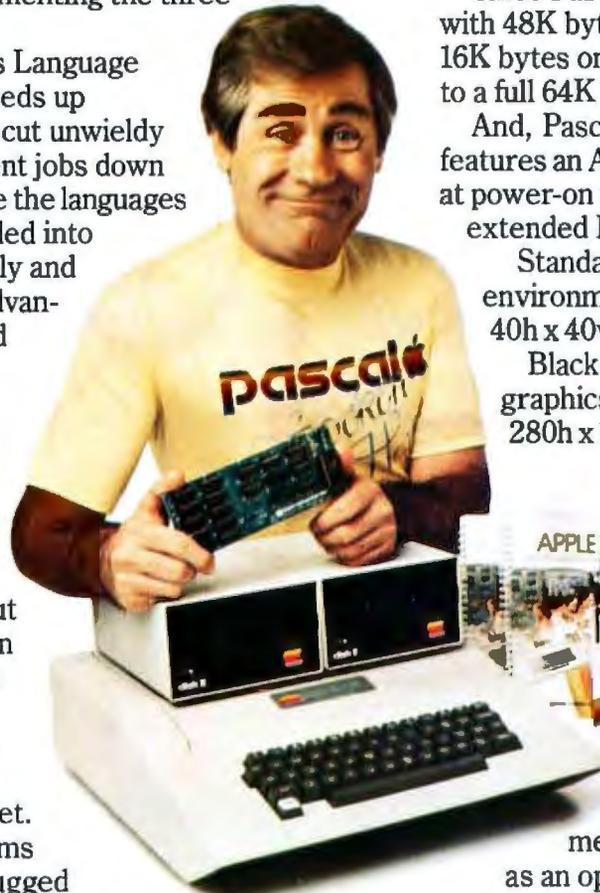
Apple's Pascal language takes full advantage of Apple high resolution and color graphics, analog input and sound generation capabilities. It turns the Apple into the lowest priced, highest powered Pascal system on the market. With Pascal, programs can be written, debugged and executed in just one-third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

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Because Apple uses UCSD Pascal,TM 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).

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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.



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 micro-processor 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 micro-processors. 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.

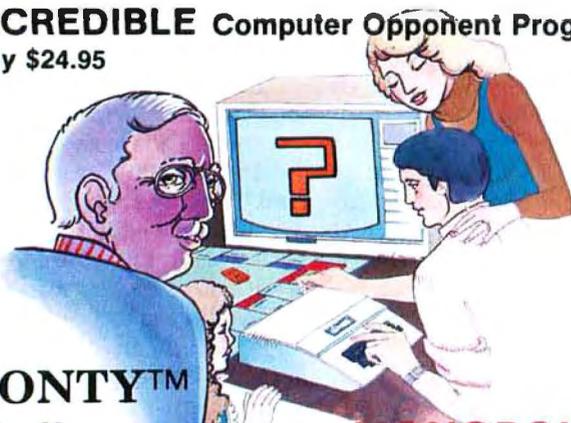
A Gradual Approach to 16-Bit Computing

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

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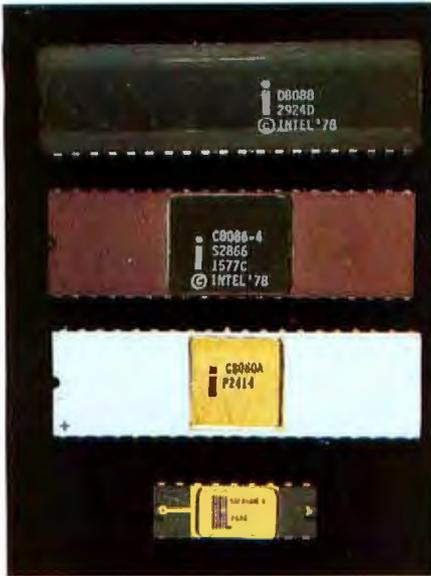


Photo 1: An exhibit of advancing microprocessor technology. Here are four integrated circuits produced by Intel Corporation. From bottom to top, we have the 8008, the first 8-bit general-purpose microprocessor; the 8080A, one of the breed of 8-bit devices that helped ignite the microcomputing boom; the 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.

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



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).

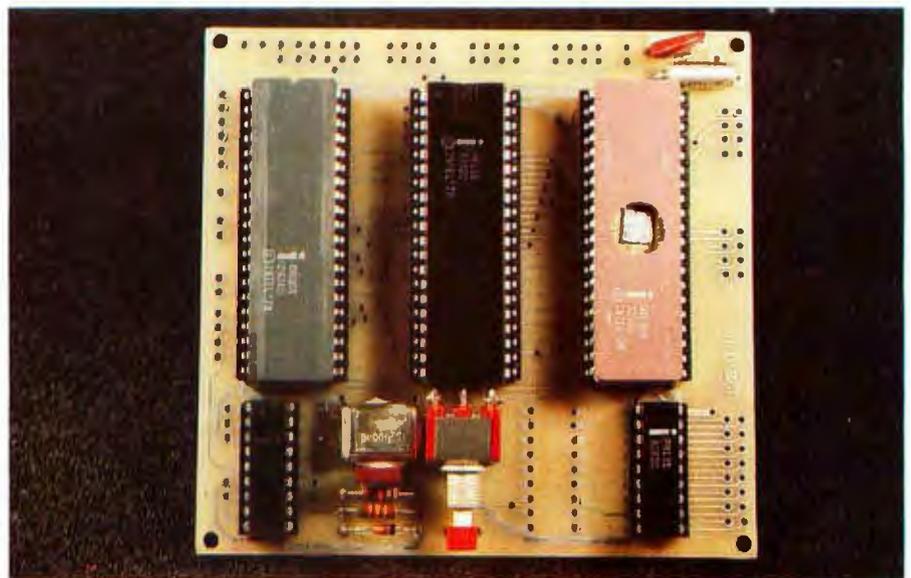


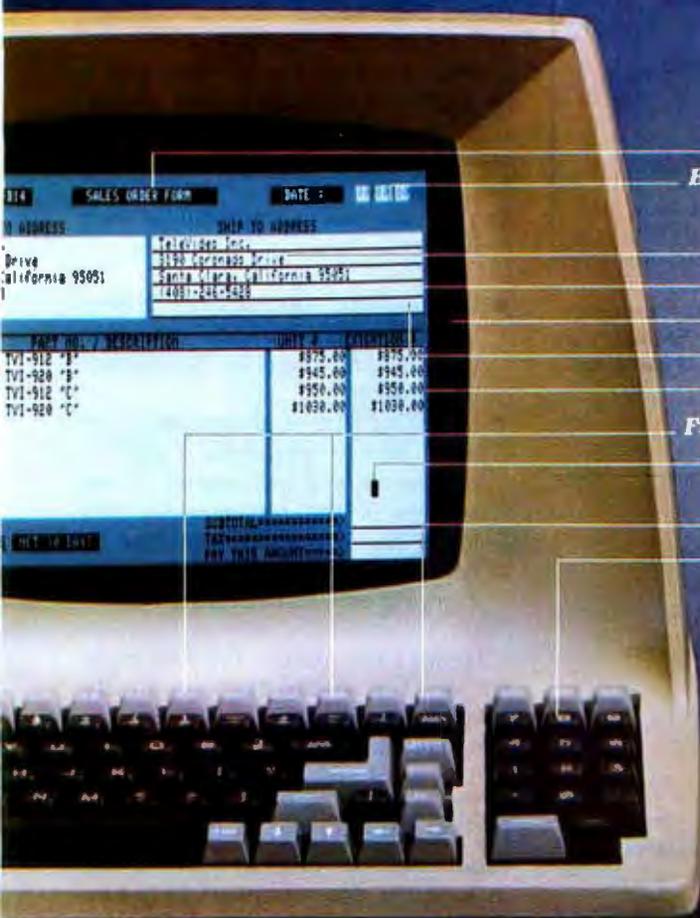
Photo 3: Using the 8088 and other components of kindred technology, it is possible to build a functional microcomputer system with only five integrated circuits. Part 2 of this article (in the April 1980 BYTE) will present more detailed information about this system.

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.

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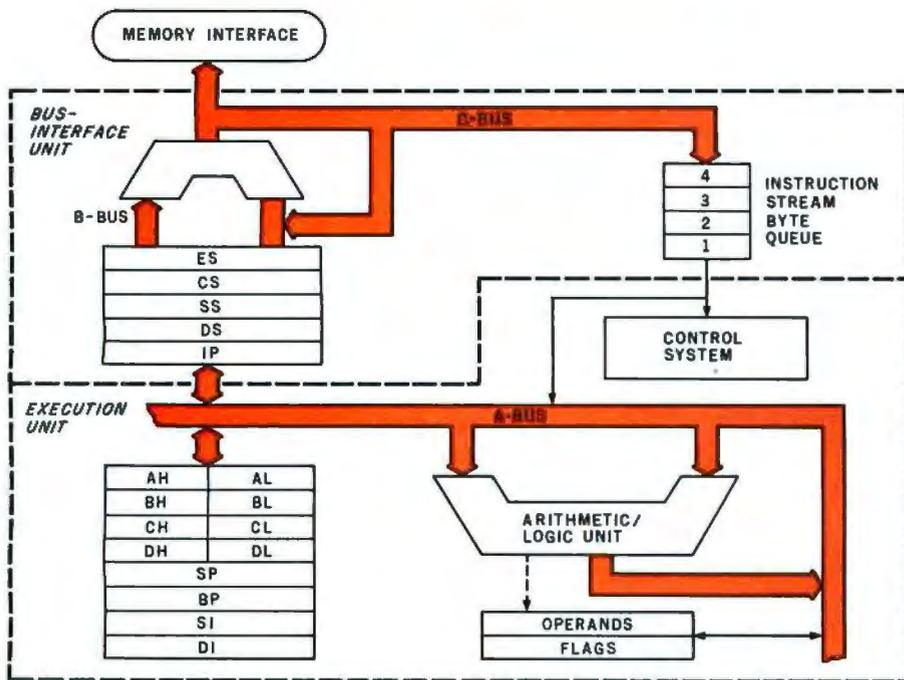


Figure 1: Diagram showing internal operational principles of the 8088 microprocessor. The 8088 (and the 8086) use a pipelined architecture that increases performance by overlapping instruction execution with memory-fetch operations. The 8088 can directly execute any 8086 software.

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.)

8088 REGISTER MODEL: (8080 REGISTERS SHADED)

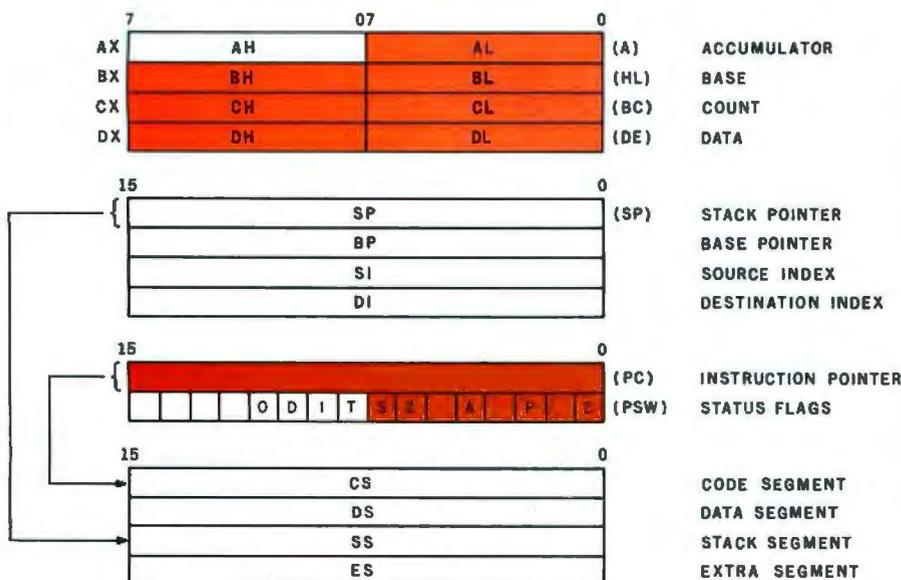


Figure 2: The 8088 contains fourteen 16-bit registers. The shaded registers are those common to the 8088 and the 8080.

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 *High* and *Low* 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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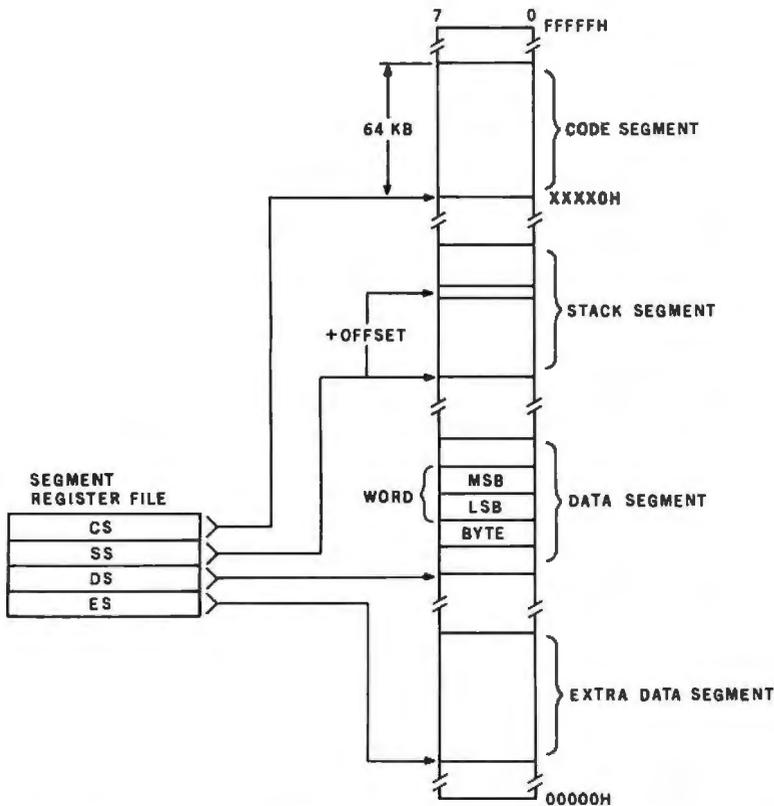


Figure 3: Memory organization. The 8088 uses a memory-segmentation technique to address up to 1,048,576 bytes (1 M byte) of memory. The user can use attributes of the memory-addressing system to dynamically relocate a program anywhere within the entire address space.

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.

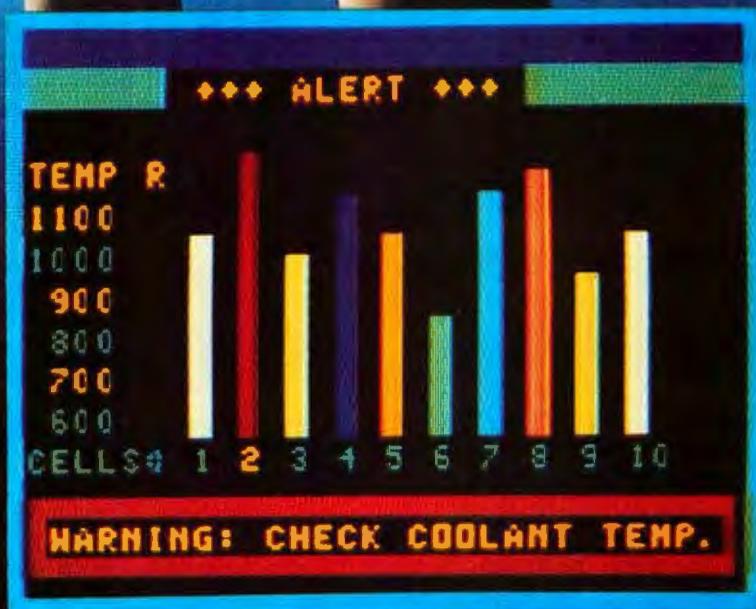
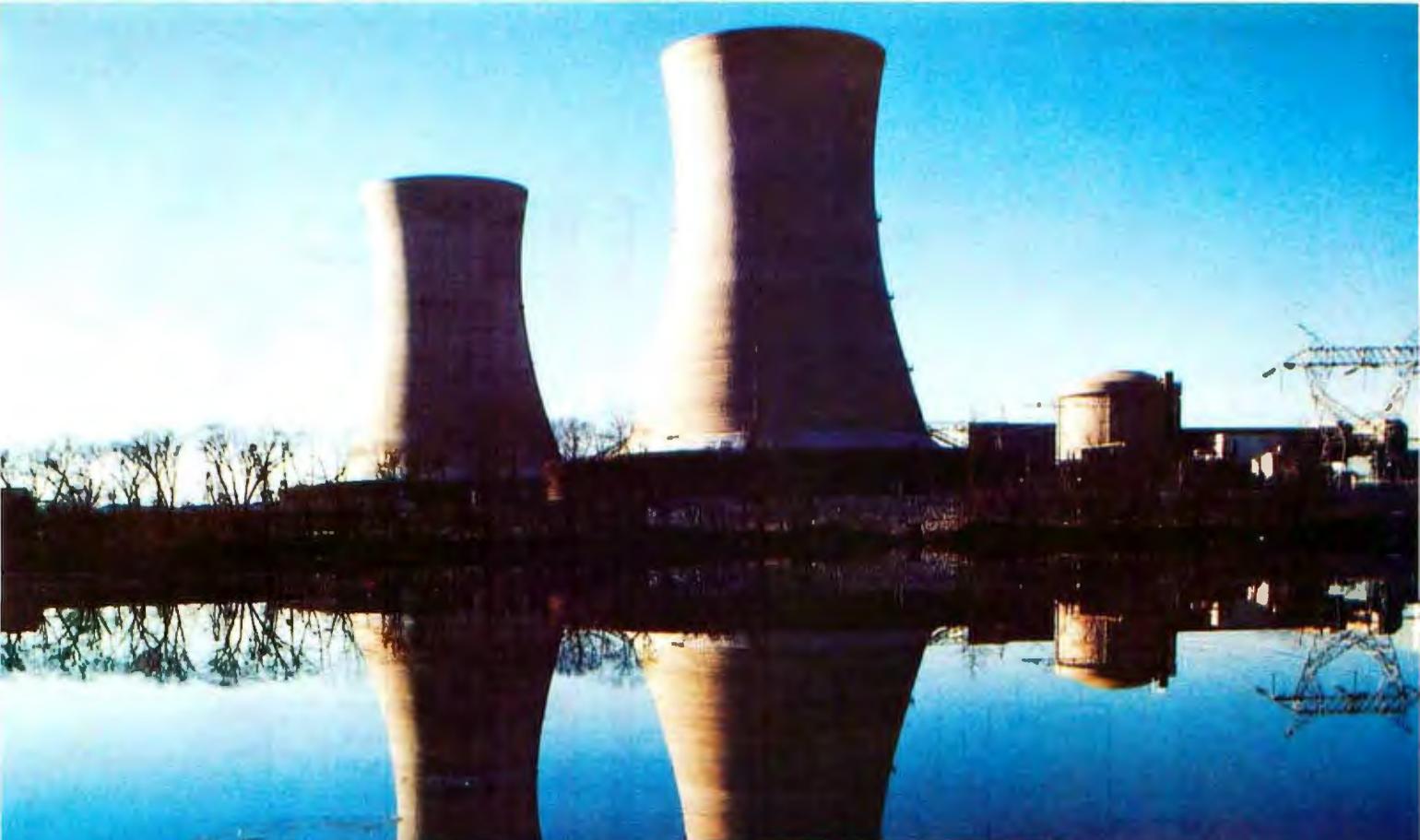
The 8088 has both relative and absolute branch instructions. When all branch instructions within a given segment of memory are specified in relation to the instruction pointer and the program segment does not modify the value of the code-segment register, the program segment can be relocated dynamically 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



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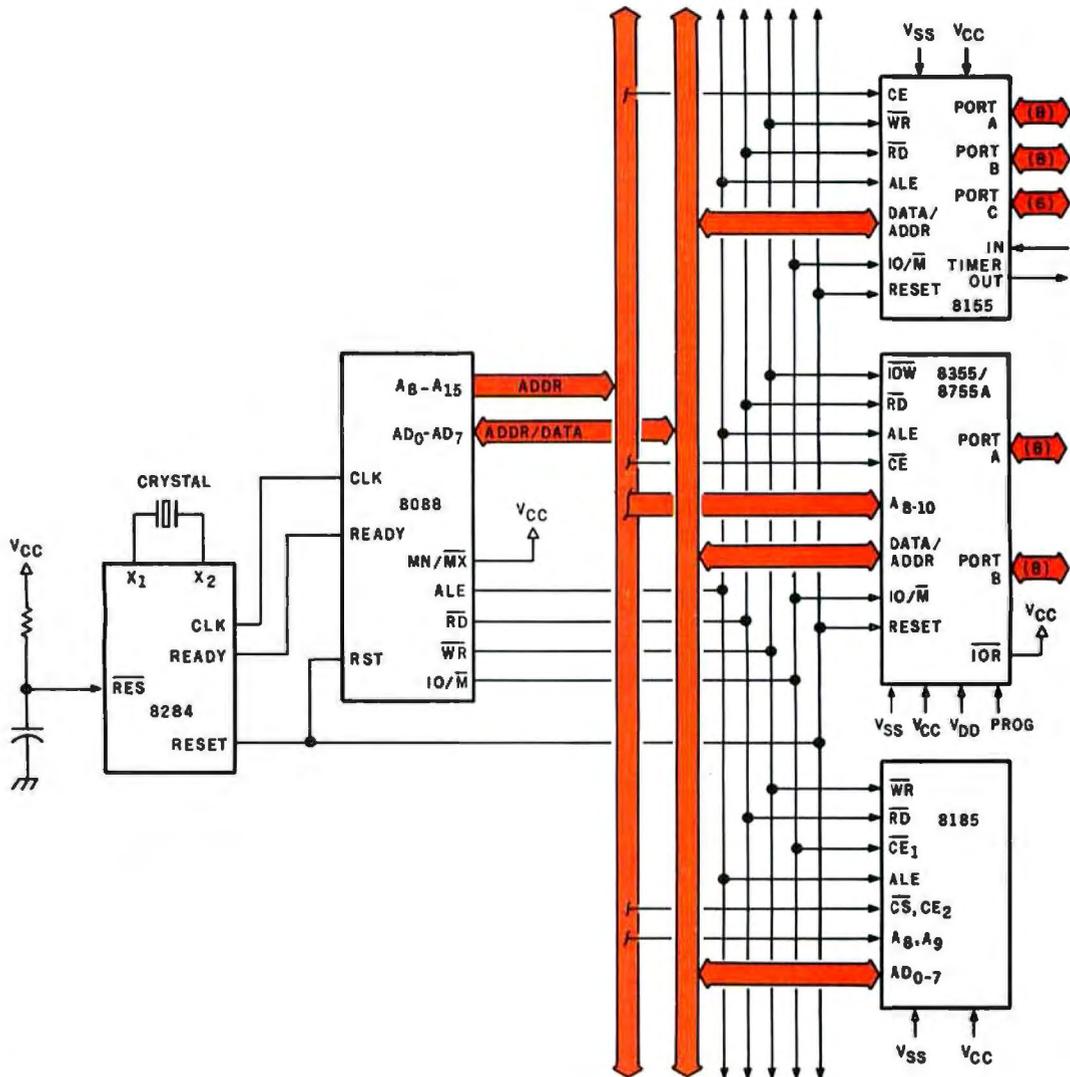


Figure 4: When used in the minimum mode (MN/\overline{MX} line held high), the 8088 interfaces directly with the multiplexed address and data components in the 8085A-support family to form a functional microcomputer system using only five integrated circuits. Detailed information concerning this circuit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

        CMP  E           ;Compare data
        JC  Next        ;counter (divisor) with
                           ;dividend; if divisor is larger,
                           ;bypass subtract.
                           ;Divisor is smaller; subtract.

        SUB  E           ;Divisor is smaller; subtract.
        MOV  B, A
        MOV  A, D
        OR  L
        MOV  L, A

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

        MOV  A, L
        OUT  Output #   ;Outport running average

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

        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

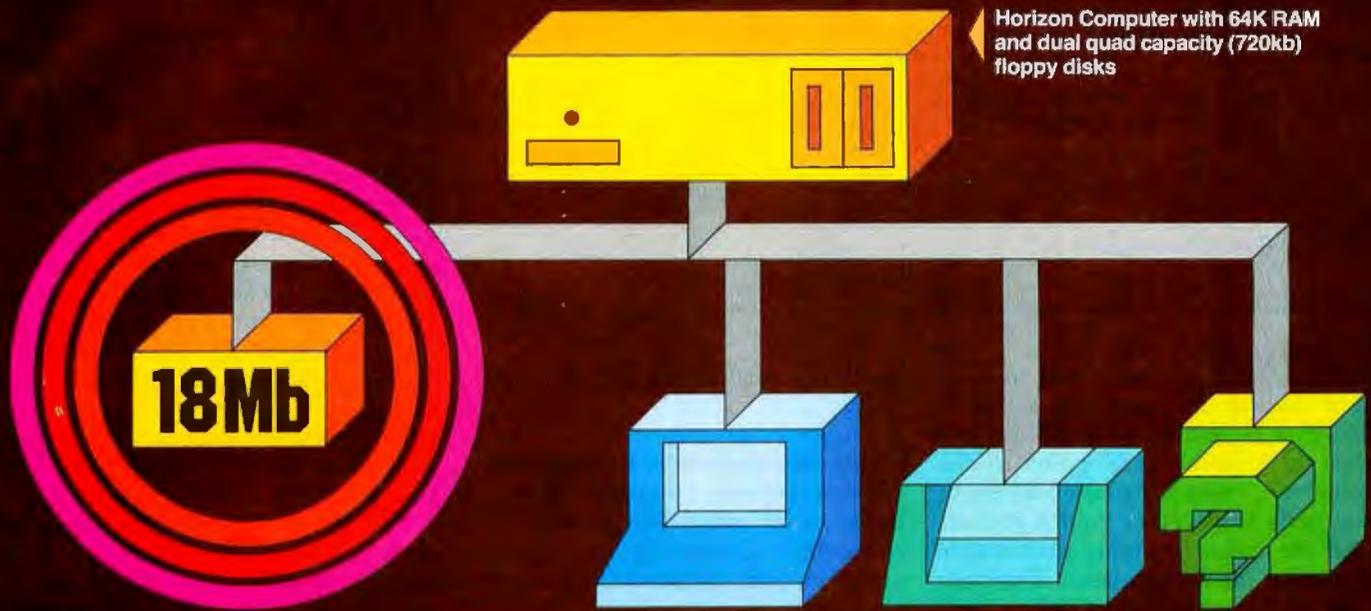
The direct use of unpacked binary-coded decimal (BCD) or ASCII-encoded data in a microcomputer has a number of obvious advantages. Since many I/O devices present data to the processor in American Standard Code for Information Interchange (ASCII) format and expect responses in the same format, microcomputer-system 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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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:

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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
Elkhorn NB 68022

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 sub-microscopic 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.

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

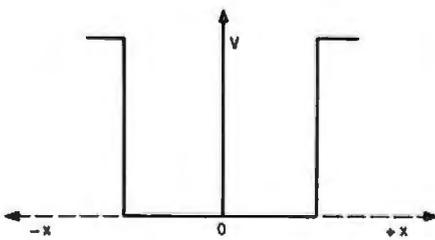


Figure 1: Rectangular potential well model that approximates the relation of an electron to the nucleus of an atom. The depth of the well indicates the extent to which the electron is confined to the region about the nucleus.

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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

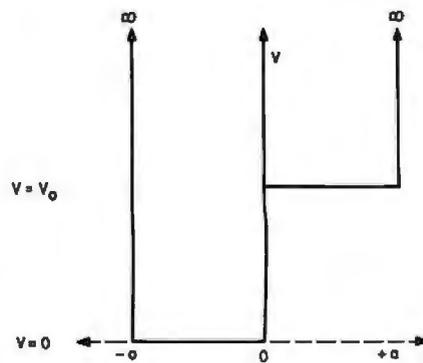


Figure 2: When a diatomic molecule is formed, the relationship between the two atoms may be considered as a combination of two potential wells.

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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^{-16} 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, ψ_R , 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 V0
40 REM PROGRAM LINES 10-1000
50 PRINT : PRINT : PRINT
60 DIM S$(10),R(10),IP(10),EA(10)
70 PRINT TAB(20);"-PROFILE OF A CHEMICAL BOND--"
80 PRINT
90 PRINT"    THE ELECTRON DENSITY IN THE CHEMICAL BOND OF A DIATOMIC MOLECULE"
100 PRINT"DEPENDS UPON THE POTENTIAL DIFFERENCE (V0) BETWEEN THE TWO ELEMENTS"
110 PRINT"WHICH ARE BOUND TOGETHER AND UPON THE LENGTH OF THE BOND (A).  THE"
120 PRINT"AVERAGE OF THE IONIZATION ENERGY AND THE ELECTRON AFFINITY OF AN"
130 PRINT"ELEMENT OFFERS A MEASURE OF THE POTENTIAL OF THE ELEMENT."
140 PRINT
150 PRINT"    THIS PROGRAM CALCULATES A PROFILE OF A CHEMICAL BOND BASED"
160 PRINT"UPON THIS INFORMATION.  FROM THE LIST OF ELEMENTS BELOW, SELECT TWO"
170 PRINT"WHICH WILL MAKE UP THE MOLECULE.  ENTER THE SYMBOLS FOR THESE"
180 PRINT"ELEMENTS AT THE REQUEST OF THE PROGRAM."
190 PRINT : PRINT
195 F=0
200 PRINT TAB(10)"HYDROGEN    -  H"
210 PRINT TAB(10)"LITHIUM     -  Li";TAB(40)"FLUORINE    -  F"
220 PRINT TAB(10)"SODIUM      -  Na";TAB(40)"CHLORINE   -  Cl"
230 PRINT TAB(10)"POTASSIUM   -  K";TAB(40)"BROMINE     -  Br"
240 PRINT TAB(10)"RUBIDIUM    -  Rb";TAB(40)"IODINE      -  I"
250 PRINT TAB(10)"CESIUM     -  Cs"
260 PRINT
270 PRINT
280 INPUT"ENTER ELEMENT NUMBER ONE - ";A$
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

```

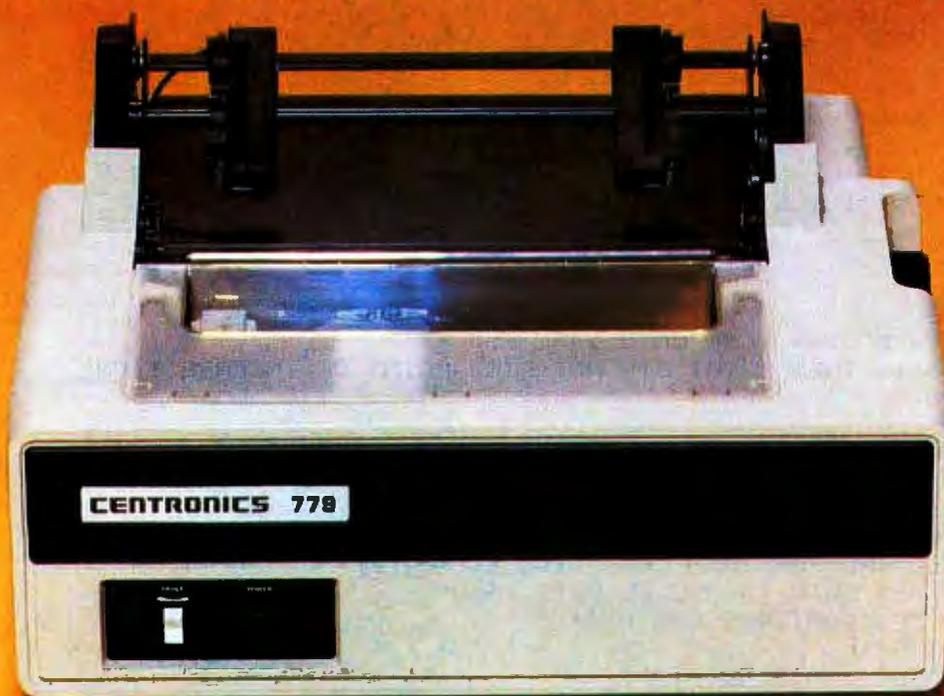
Listing 1 continued on page 38

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 V0=V2-V1
520 IF V0<0 THEN V0=-V0
530 N=SQR(2*M*V0/Q9)*A/H
540 N2=N^2
550 PRINT"V0 = ";
560 PRINT USING"##.###";V0
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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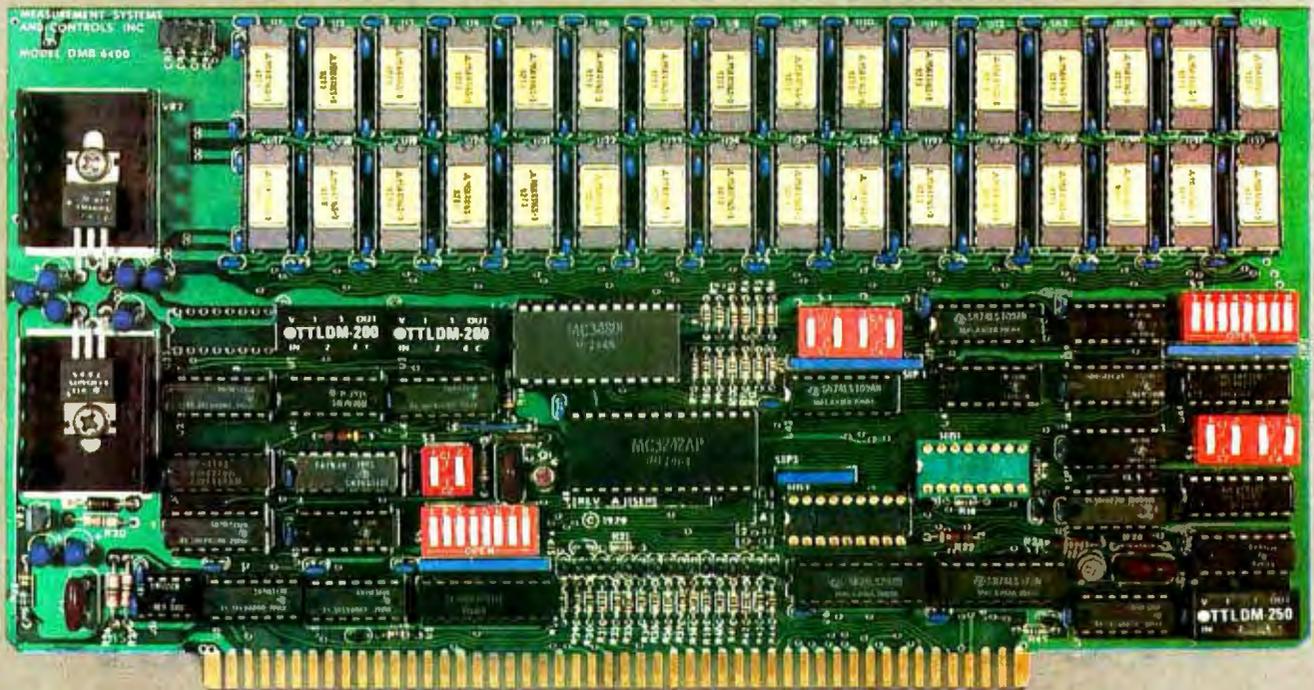
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Listing 1 continued:

```
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 GOTU 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 "1";
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 $\psi_{R,u}$. 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 $\psi_{R,u}$
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.

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

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

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.

$$D \text{ i) } \beta^2a^2 = \alpha^2a^2 - n^2 \text{ for } E > V_0$$

$$\text{ii) } \gamma^2a^2 = n^2 - \alpha^2a^2 \text{ for } E < V_0$$

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

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

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

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 .

$$F \text{ i) } B = A \sin(\alpha a) / \sin(\beta a) \text{ for } E > V_0$$

$$\text{ii) } C = -D / \tanh(\gamma a) \text{ for } E < V_0$$

$$D = A \sin(\alpha a)$$

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.]

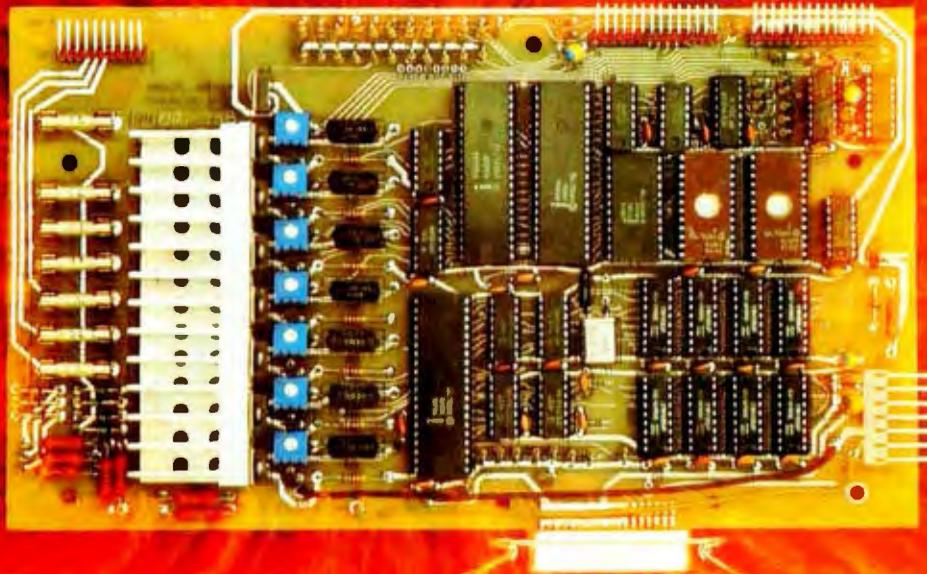
The program lists the elements by

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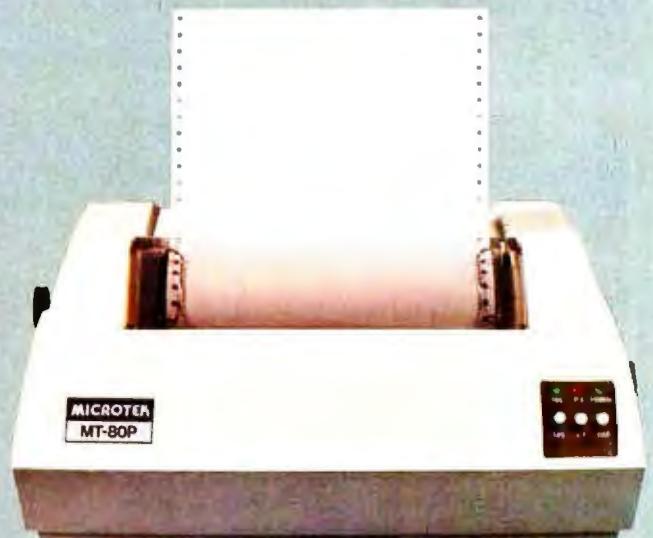
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the difference between the two sides of the transcendental equation (squared so that negative numbers are inconsequential) is a minimum, the program prints out the value of αa . Depending upon the relative size of αa and n , the program then evaluates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

RUM CHMBND

-PROFILE OF A CHEMICAL BOND-

THE ELECTRON DENSITY IN THE CHEMICAL BOND OF A DIATOMIC MOLECULE DEPENDS UPON THE POTENTIAL DIFFERENCE (V_0) 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	FLOURINE	--	F
LITHIUM	-	Li	CHLORINE	-	Cl
SODIUM	-	Na	BROMINE	-	Br
POTASSIUM	-	K	IODINE	-	I
RUBIDIUM	-	Rb			
CESIUM	-	Cs			

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

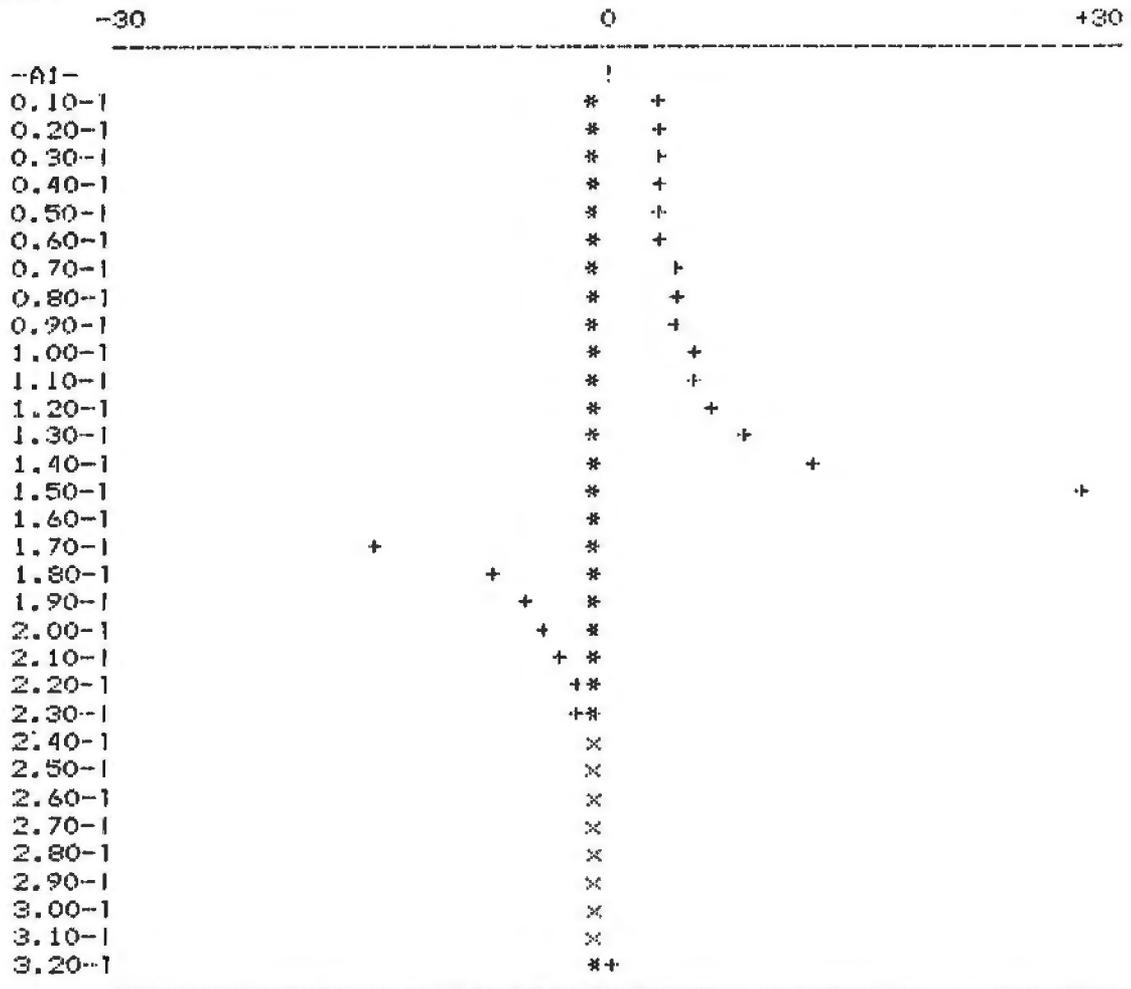
$V_0 = 5.743$
 $N = 3.414$

WHEN READY TO CONTINUE TYPE A CARRIAGE RETURN.

GRAPHICAL SOLUTION OF
TRANSCENDENTAL EQUATION

Listing 2 continued on page 50

Listing 2 continued:



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

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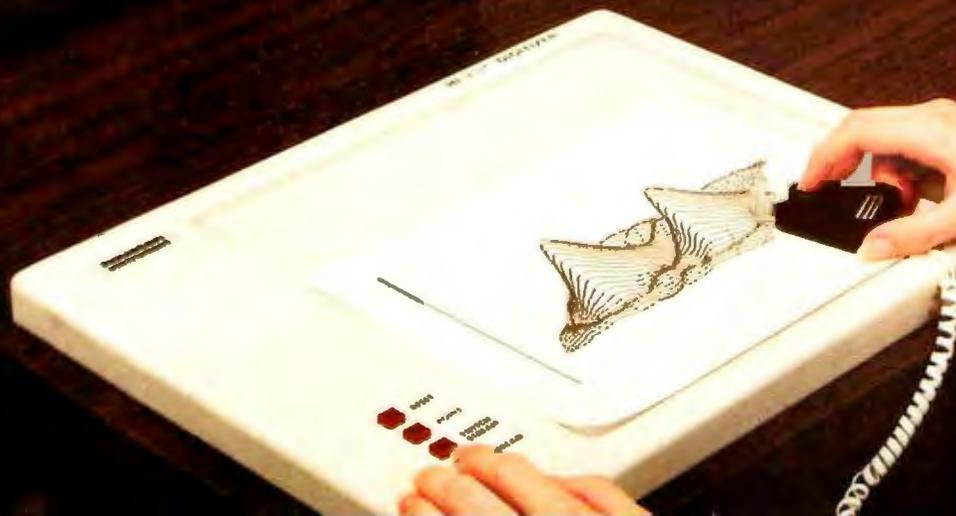
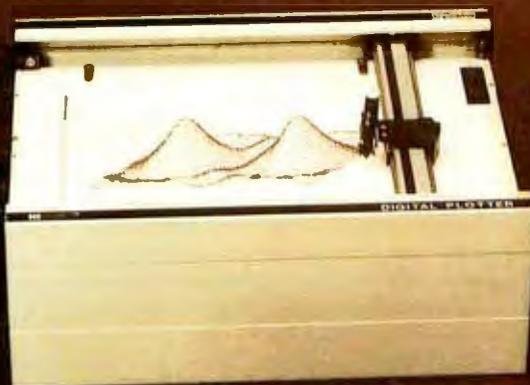
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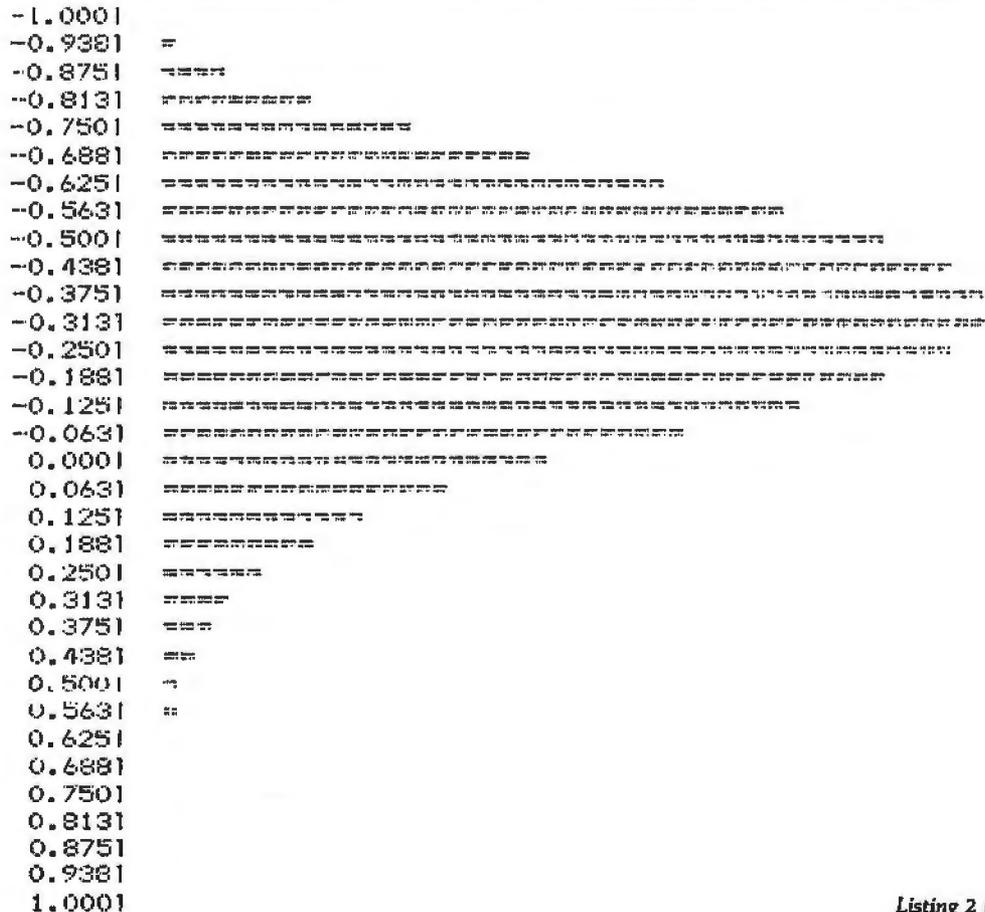
Listing 2 continued:

-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



Listing 2 continued on page 54

Chief Relief

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Listing 2 continued:

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

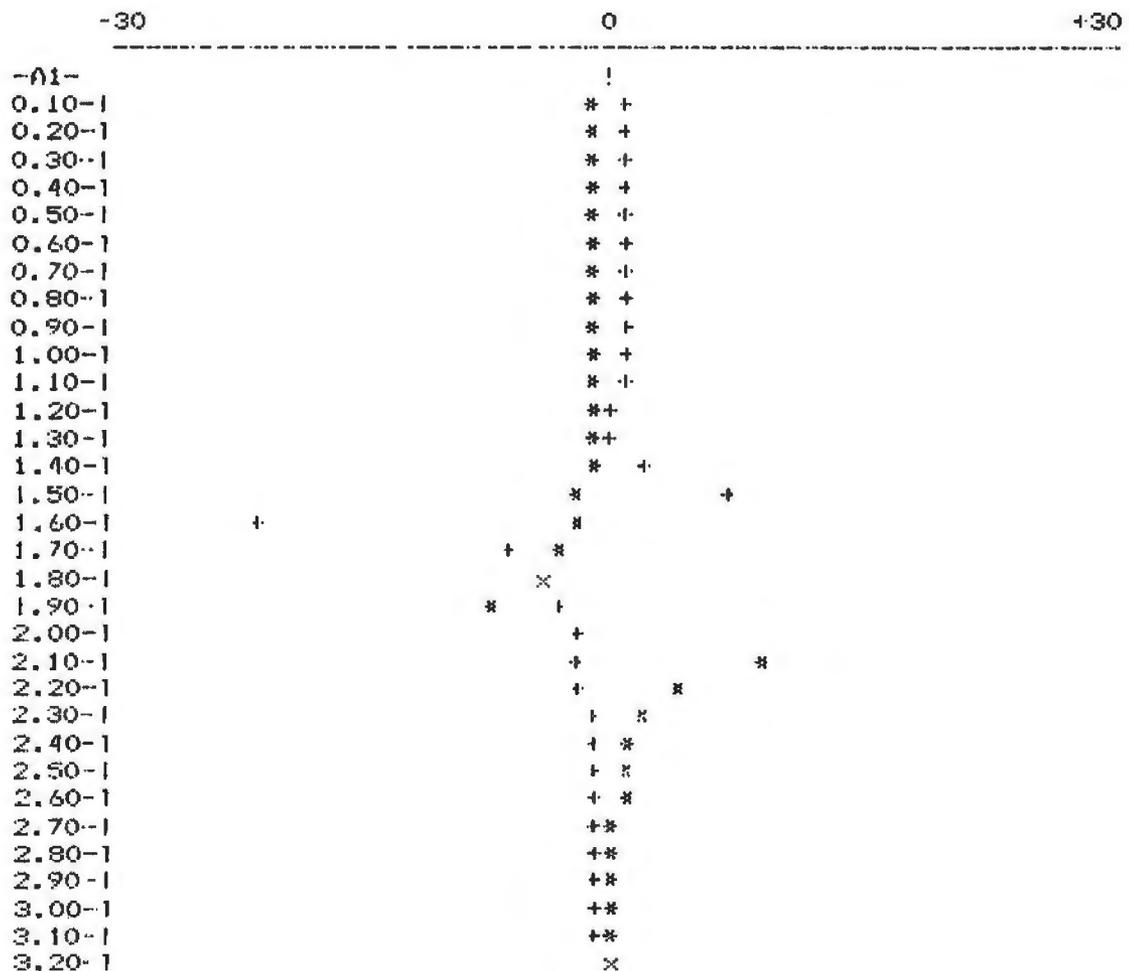
HYDROGEN	-	H			
LITHIUM	-	Li			
SODIUM	-	Na			
POTASSIUM	-	K			
RUBIDIUM	-	Rb			
CESIUM	-	Cs			
			FLOURINE	-	F
			CHLORINE	-	Cl
			BROMINE	-	Br
			IODINE	-	I

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

$V_0 = 0.439$
 $N = 1.270$

WHEN READY TO CONTINUE TYPE A CARRIAGE RETURN.

GRAPHICAL SOLUTION OF
TRANSCENDENTAL EQUATION



Listing 2 continued on page 56

26 MEGABYTES

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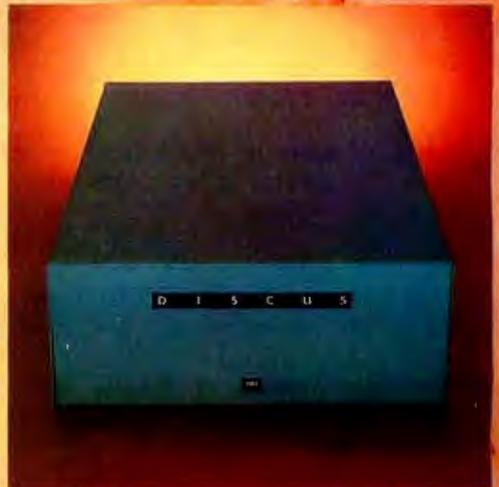
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Listing 2 continued:

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

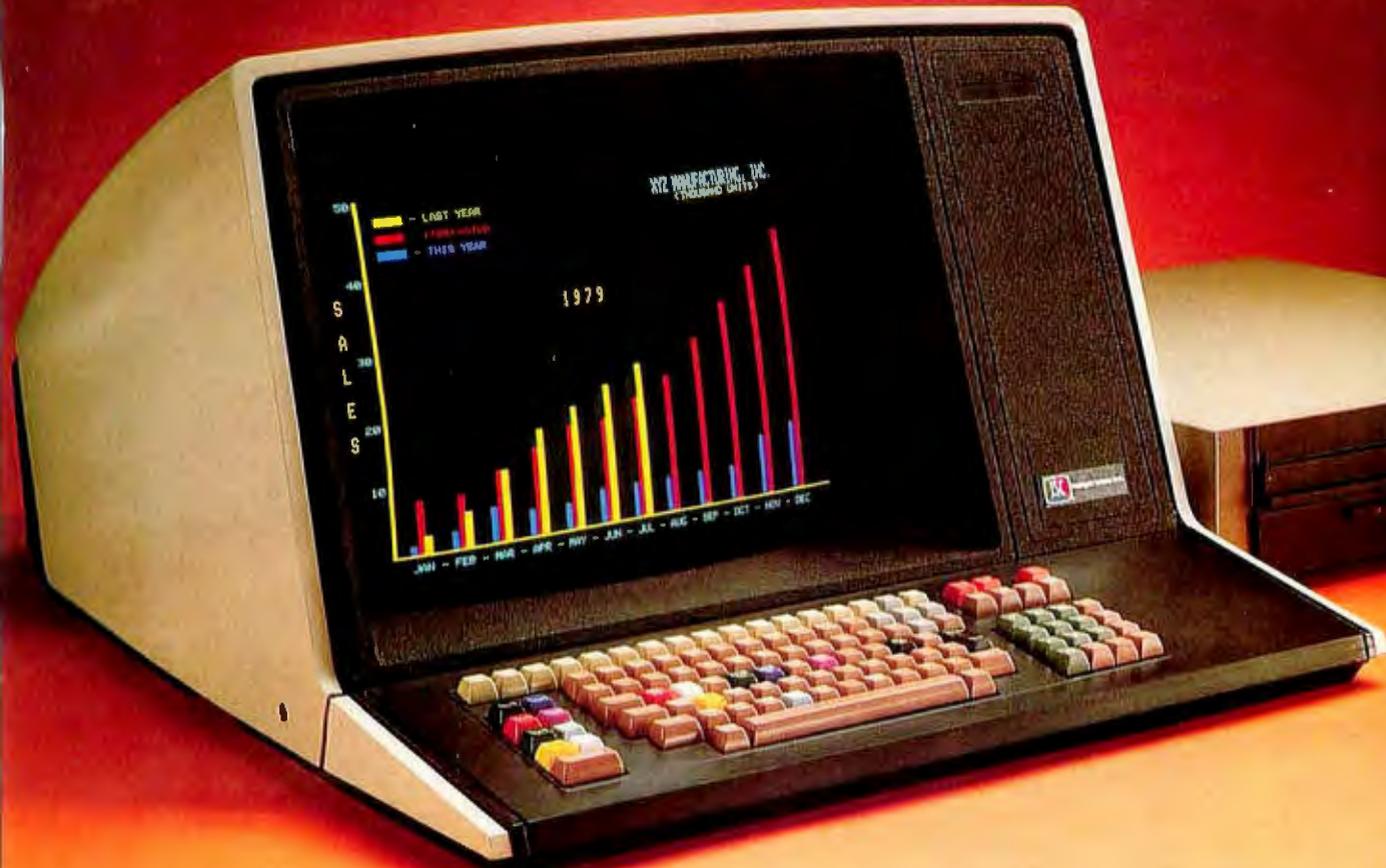
Text continued from page 48:

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).

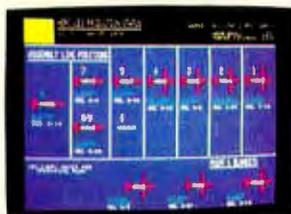
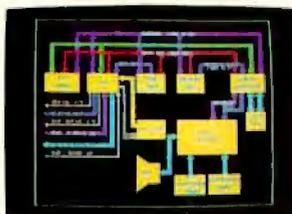
Uses of the Program

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



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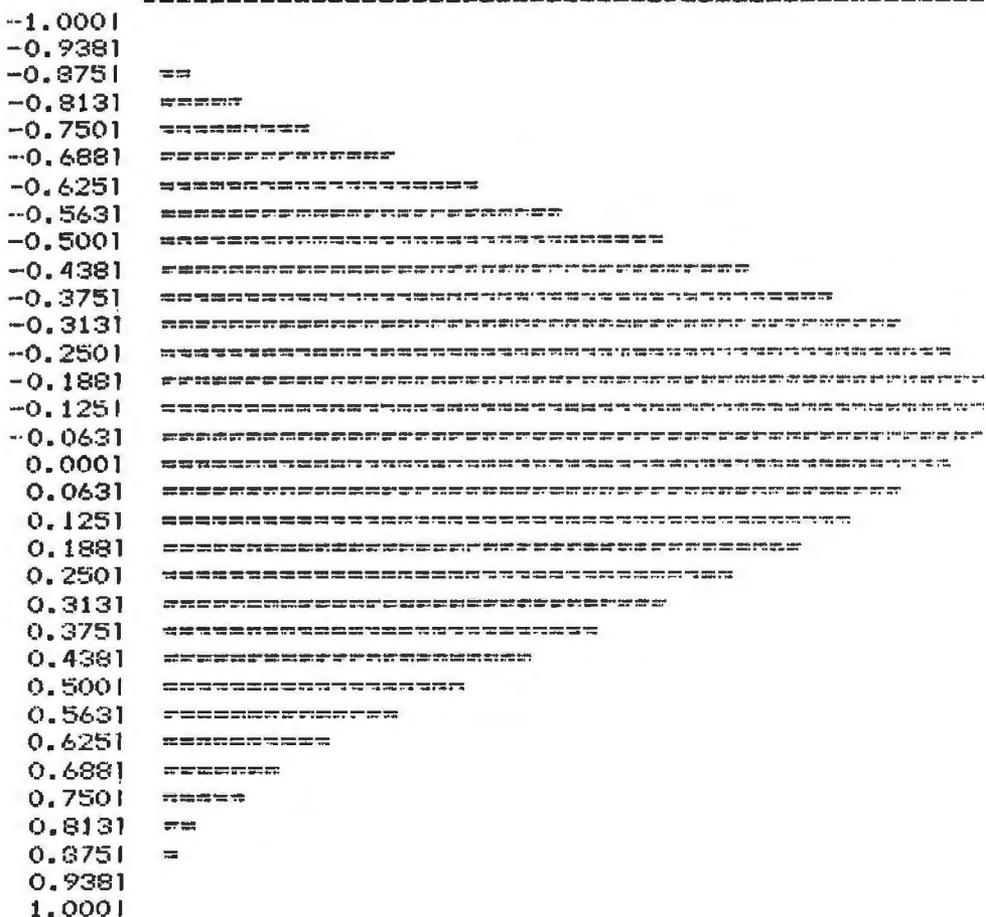
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(PS1)^2



WOULD YOU LIKE TO STUDY ANOTHER PAIR OF ELEMENTS?
 ENTER A YES OR NO
 ? 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 micro-computer 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.

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sembler 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.

Your operators will praise the SuperBrain's good looks. A full ASCII keyboard with a numeric keypad and function keys. A non-glare, dynamically focused, twelve inch screen. All in an attractive desktop unit weighing less than a standard

office typewriter. Sophisticated users will acclaim SuperBrain's twin Z-80 processors which transfer data to the screen at 38 kilobaud! Interfacing a printer or modem is no problem using SuperBrain's RS-232C communications port. But best of all, you won't need a PhD in computer repair to maintain the SuperBrain. Its single board design makes servicing a snap!

So don't be fooled by all the freshman students in the small systems business. Insist on this year's honor graduate . . . the SuperBrain.



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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.

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service in most major cities (see below) and a reduced phone charge in over a hundred others.

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



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

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 B PLOT 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

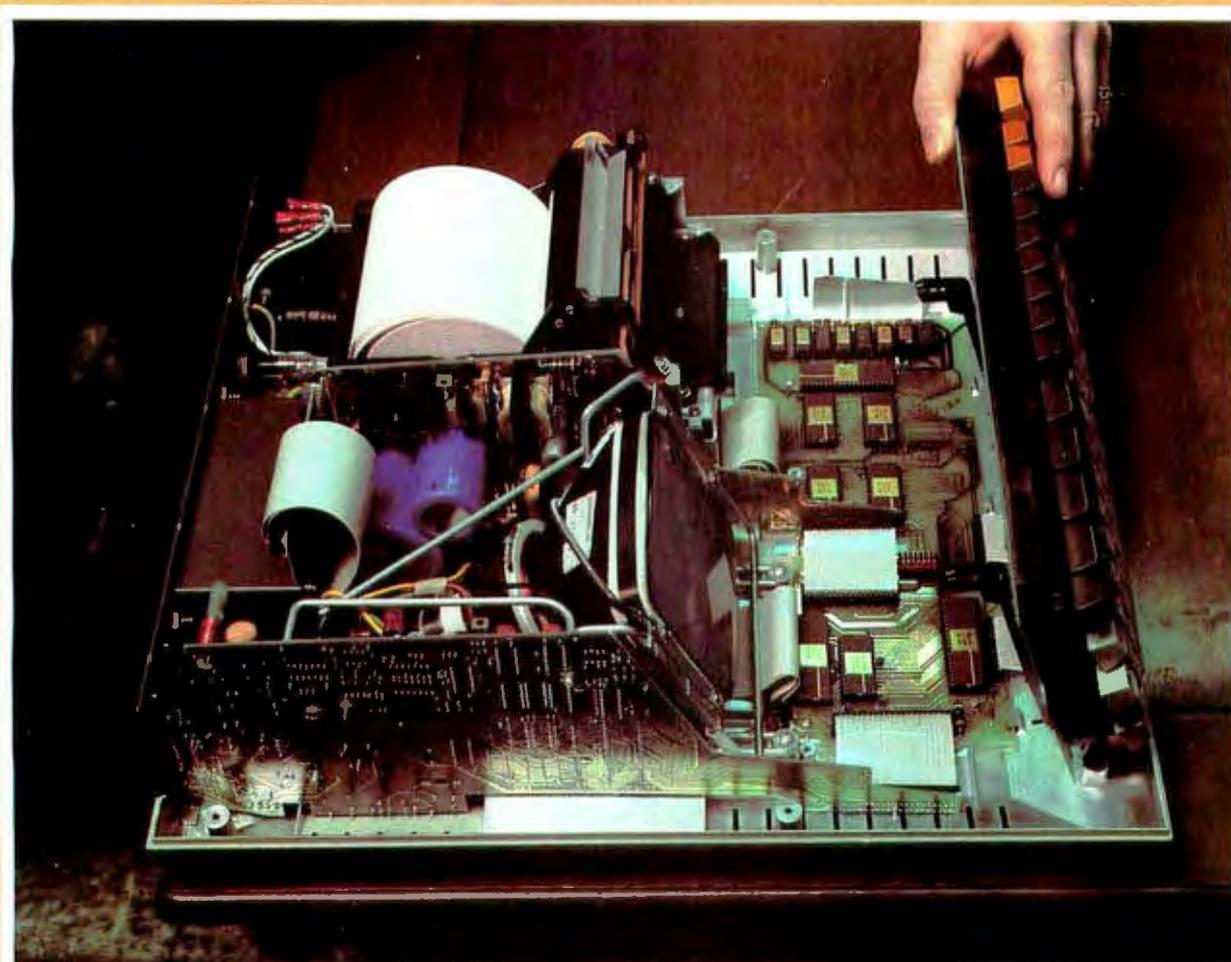


Photo 3: Internal view of the HP-85, showing the processor board under the hinged keyboard. The 8-bit processor is a custom Hewlett-Packard design, as are most of the integrated circuits in the computer.

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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

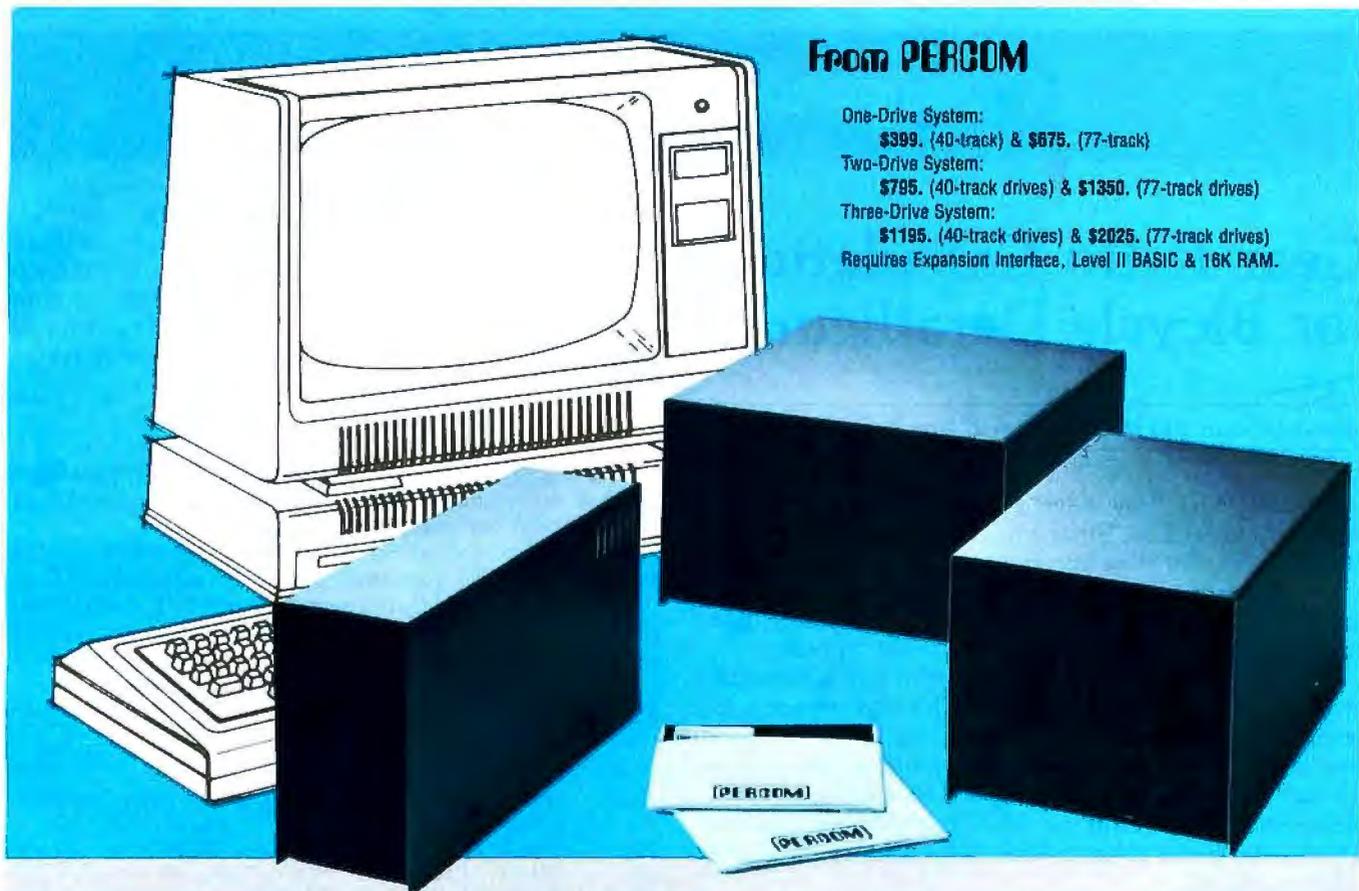
We were impressed with the performance of the HP-85 computer. The graphics alone make this an attractive, albeit not inexpensive, alternate to existing small systems on the market. And many of its features are unique. Although Hewlett-Packard is pinning its hopes on heavy sales to the professional marketplace,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

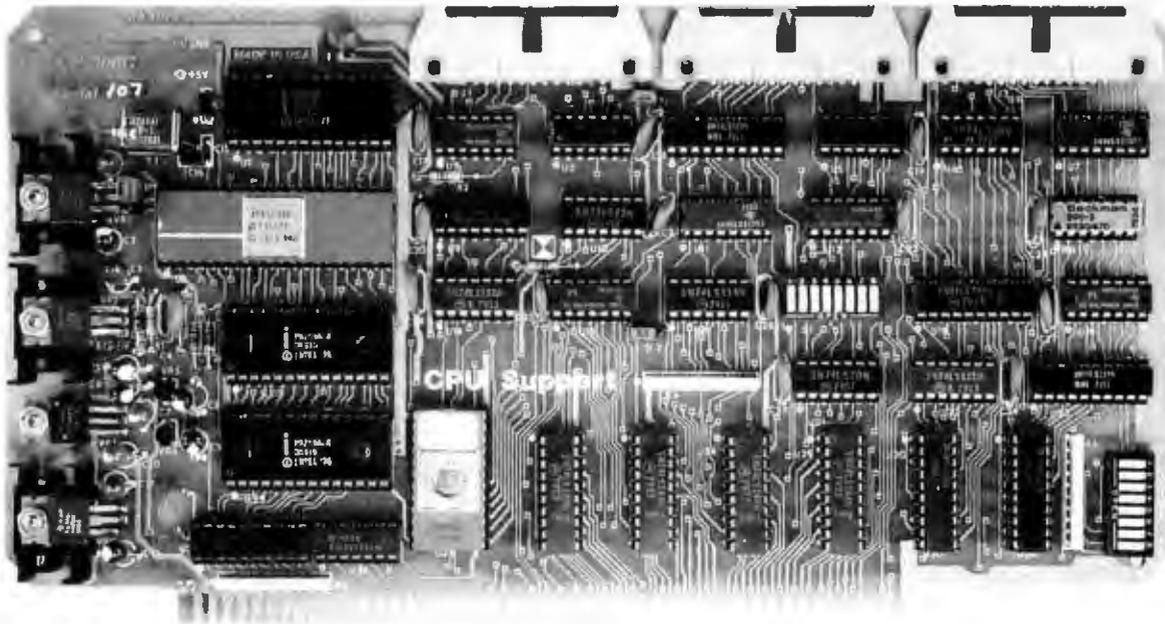
ratio on one of the old high-wheel (ie: penny-farthing) bikes of the nineteenth century. The program is written in TDL 12 K BASIC, but should run unaltered on any computer that uses Microsoft or a similar BASIC system such as the TRS-80, PET, Apple II, or Ohio Scientific. Happy cycling, and wear a helmet!

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:

```
TI=P(J+1,I) : P(J+1,I)=P(J,I) : P(J,I)=TI
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
```



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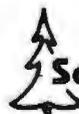
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Notes on Gear Ratios

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:

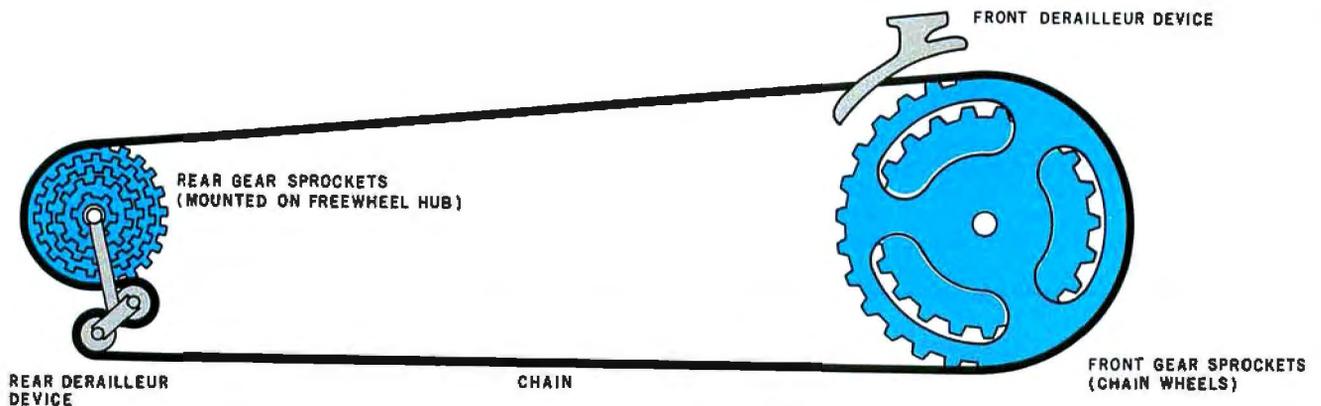
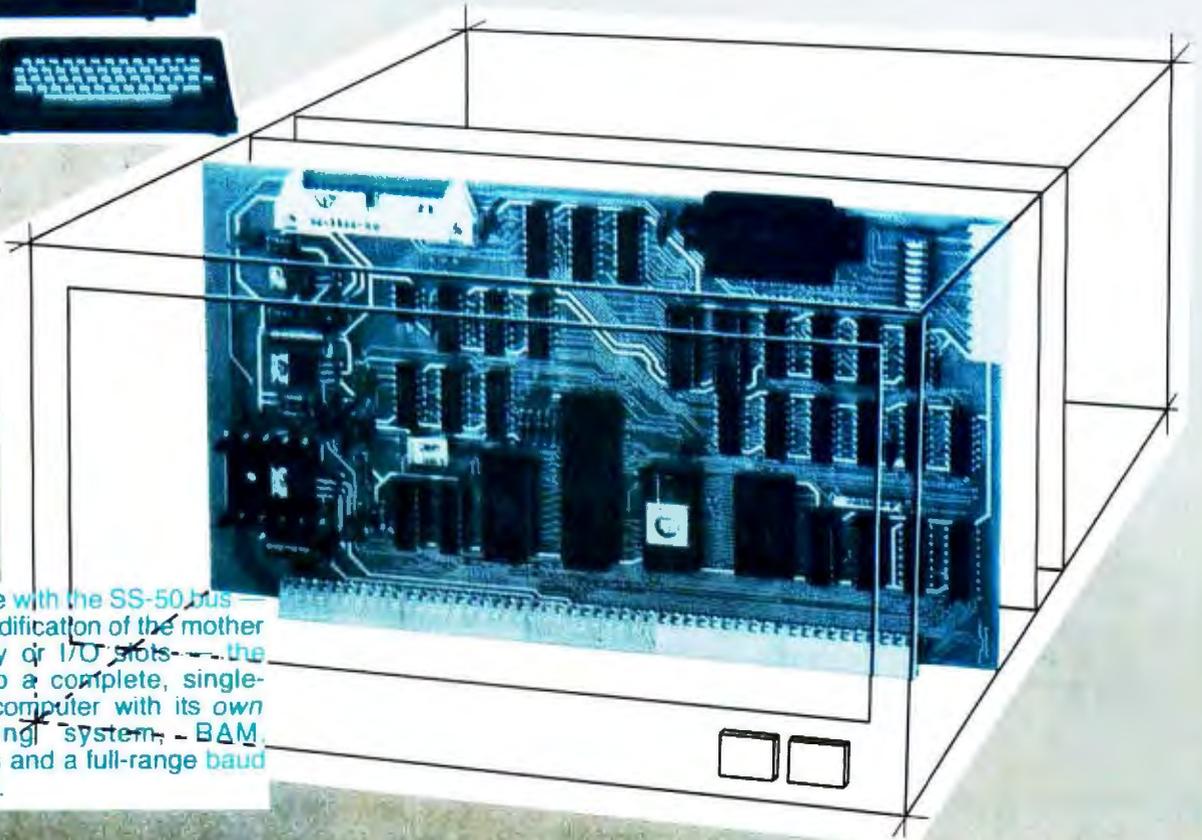


Figure 1: Diagram of the drive mechanism of a ten-speed, derailleur-equipped bicycle. The pedal cranks (not shown) are attached to the front gear sprockets (ie: chain wheels) through the crank axle. The front derailleur device can shift the chain between the large front sprocket and the small front sprocket.

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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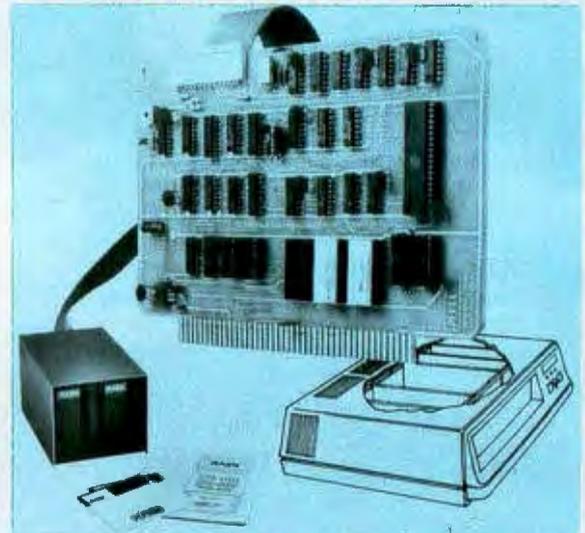
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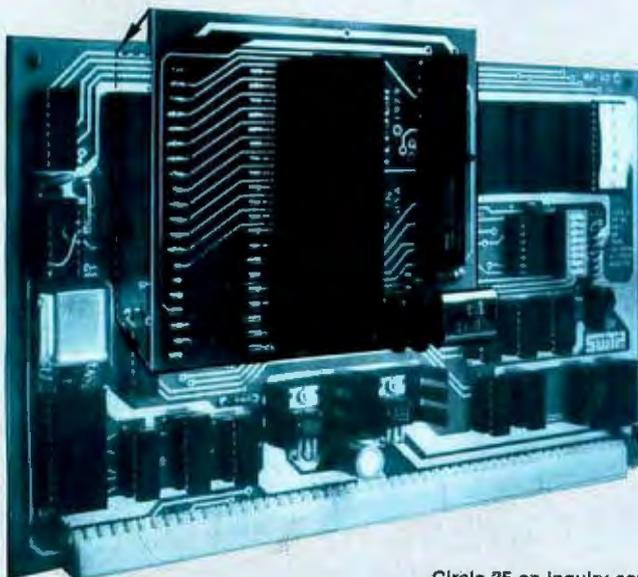
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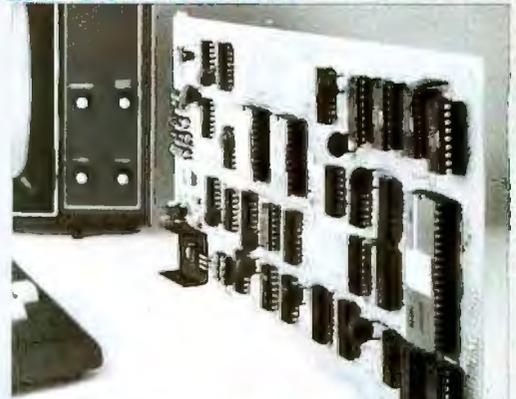
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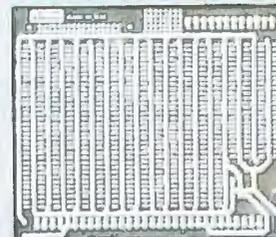
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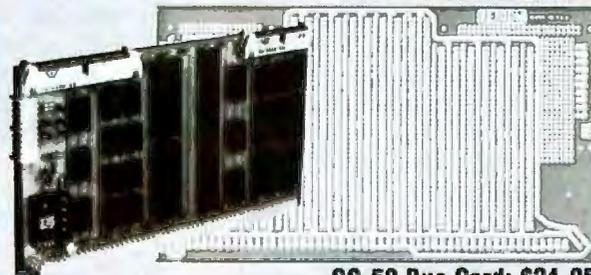
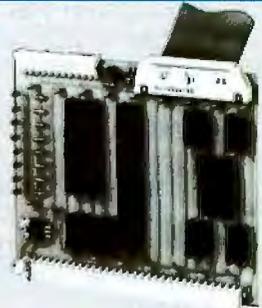
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Solving Problems Involving Variable Terrain

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 am-

biguous, 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.

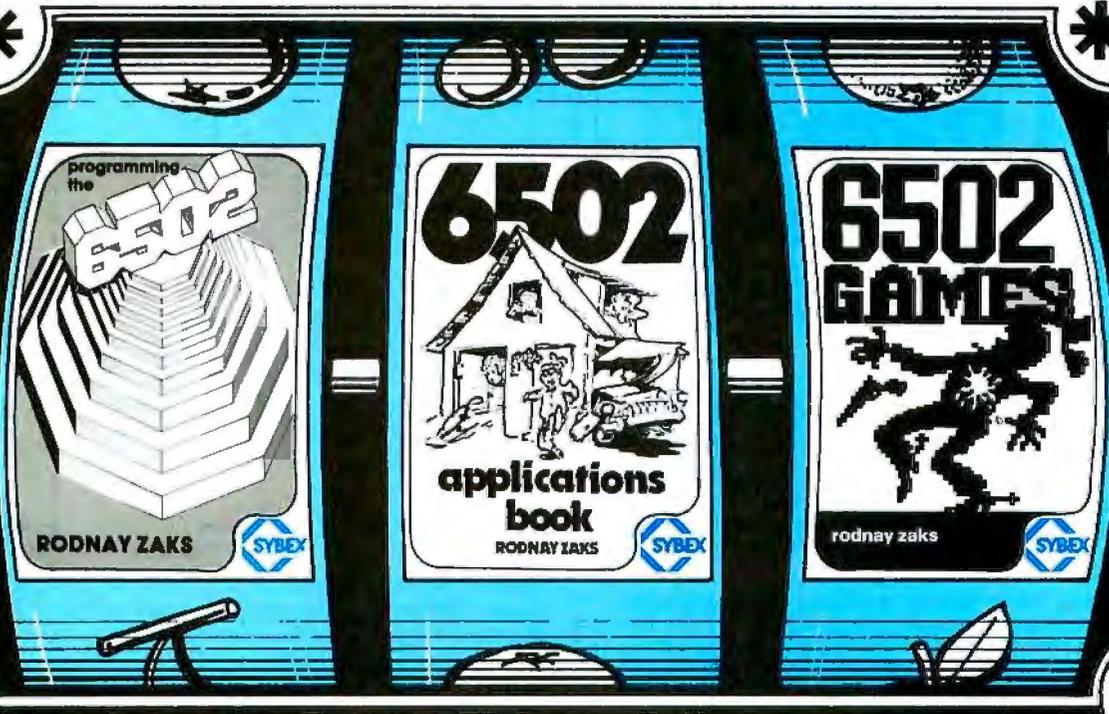
By defining a third, dependent coordinate Z to be $X - Y + C$, where C is any integer constant, our slant metric (ie: distance function) is simply the maximum of the absolute values of the differences of the three coordinates. That is, for (a,b,c) and (d,e,f), the distance is defined as:

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

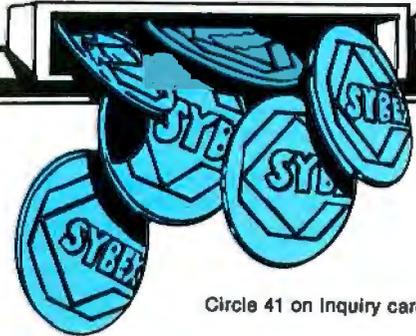
The Z coordinate is constant along the other slanting line from upper left to lower right. It will be left for the reader to prove both of these statements by working examples with figure 10.

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

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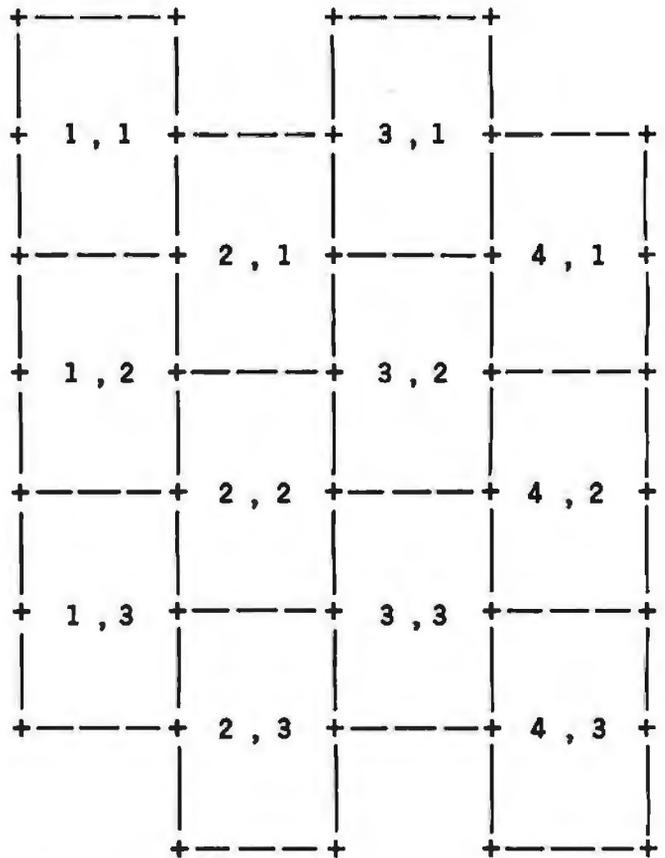


Figure 9: When working with a hexagonal grid, a set of coordinates different from those used for a square grid must be developed. One such coordinate system, shown here, is the offset coordinate system. This system produces difficulties when the distance between two coordinates must be determined. (Numbering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

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

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.

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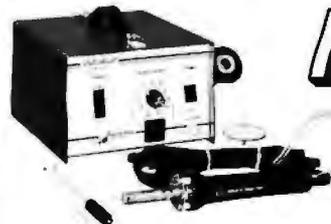
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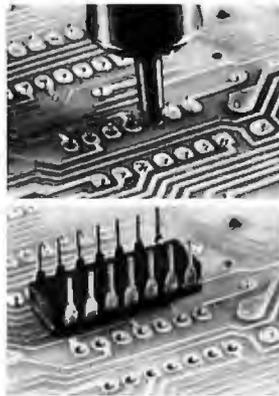


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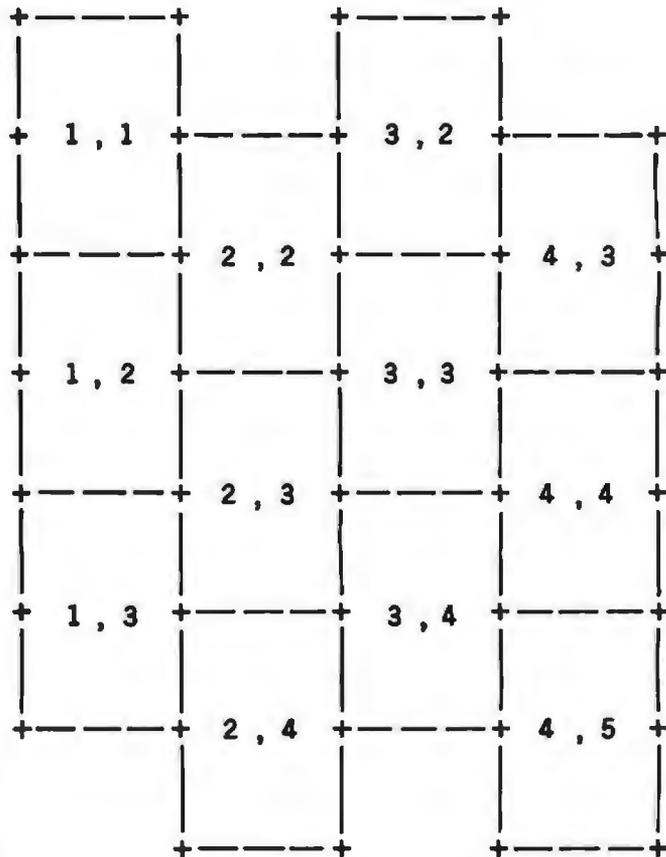


Figure 10: A coordinate system that solves the distance problems found in the offset coordinate system is the slant coordinate system. In this system, one of the coordinates is constant along a diagonal (ie: slanted) axis.

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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:

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

$$\text{OR } (T_2 \text{ AND } XSC(Z \text{ AND } M_{n-2}))$$

.

.

.

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

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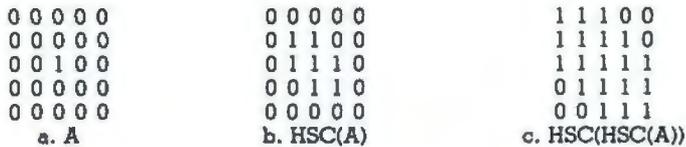


Figure 11: An example of the hexagonal scatter-function mappings that develop from a central starting point, assuming that the movement cost of all terrain is equal.

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 ter-

rain, 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.

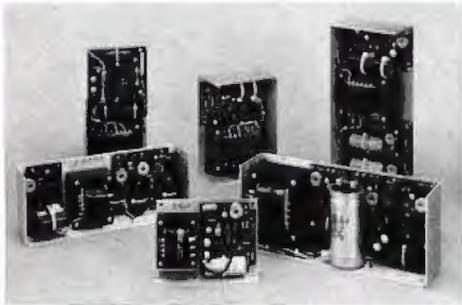
With a fixed scale, however, our algorithm must be modified. For example, when we have roads that lower the movement cost for units following the road, we must first adjust our cost scale so that this cheaper, road-movement cost is our unit cost.

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

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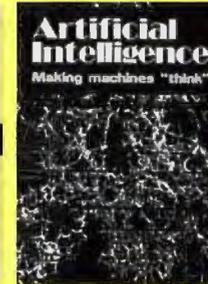
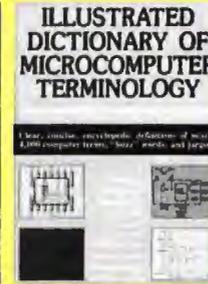
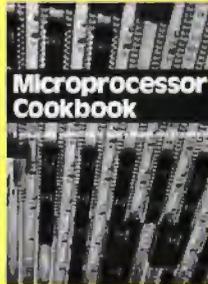
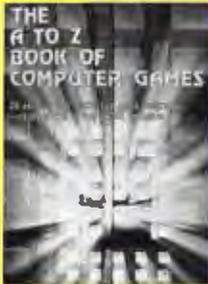
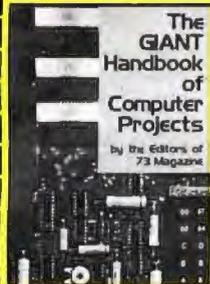


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multiplied by the number of different movement costs of directional terrain. For example, if trails reduce the movement cost to one-half, and roads reduce the movement cost to one-third, on a map using the city metric scatter function, eight directional 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 pre-masks 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 pre-masks 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 $I_d(I,J)=I_d(I,J)$ AND $P_d(I,J)$ for all I and J .

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

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

Similarly:

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

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

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

Summary

We have seen that many problems involving variable terrain may be solved through the use of scatter mappings, scatter sums, pre-masking, and post-masking. 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. ■



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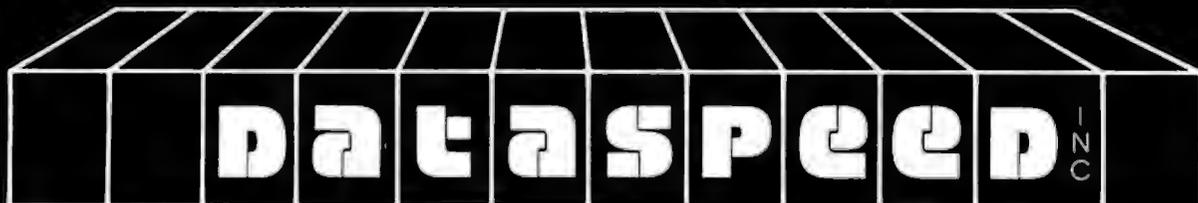
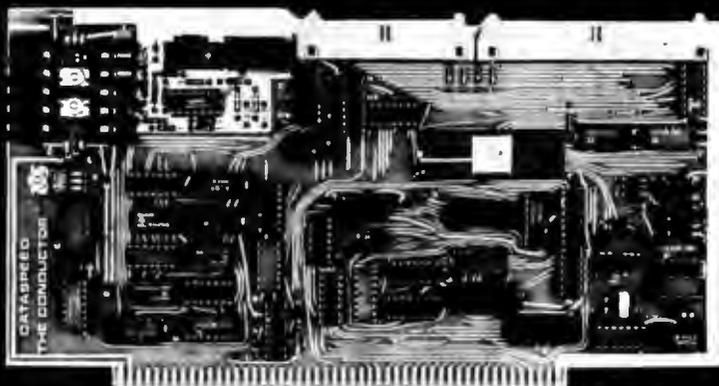
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TRS-80 Performance Evaluation by Program Timing

James R Lewis
4051 Mountain Dr
San Bernardino CA 92407

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,

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
```

"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.

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 Problem and the TRSDOS Disk Operating System

I relocated my assembly-language program to hexadecimal location

Test	Listing	Run Time			Description
		hours	minutes	seconds	
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.

Text continued on page 92

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```

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  X = 0

Enter:
? TAN (X) * COS (X) + 1/COS (X):
Responds:
  2 * SIN(X)
Symbolic Integration:
? INT (X*COS(A*X+2), X):
  SIN (X+2*A) / (2*A)
Symbolic Matrix Inversion:
? |1, X|
  |0, A| + -1;
  |1, -X/A|,
  |0, 1/A|,
Exact Arithmetic:
? 991 * 9+(1/2) / 40+35;
  296438922463401814427834899493
  2562055695871443300411356128843
  2003804089287504517225987785830307
  497936652596433351 / 1250000000000
    
```

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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.

```

START  ORG 7000H
        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 DIVISIBLE
        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 WORK
        DEFM 'TOTAL ='
        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

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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

;
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
DIV161 SLA     C             ;16 BIT DIVISION
        RL      B             ;MOVE C REG
        ADC    HL,HL         ;NOW B WITH CARRY
        SBC    HL,DE         ;BUMP REMAINDER
        JR      NC,DIV162    ;16 BIT SUBTRACT WITH CARRY
        ADD    HL,DE         ;UNDERFLOW
        JR      DIV163
        INC    C             ;ADJUST
        DEC    A             ;SKIP SETTING QUOTIENT BIT
        JR      NZ,DIV161    ;BUMP QUOTIENT
        RET                  ;DECREMENT LOOP COUNTER
;                                ;LOOP TIL DONE
        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);
        END;
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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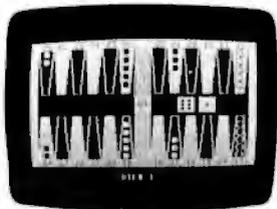
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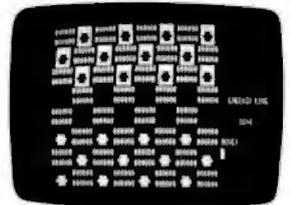
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Listing 6: Test program coded in assembler language for the IBM 370. Writing in the native language of this very fast machine, we obtain the shortest time for finding prime numbers from 5 to 10,000.

	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	OUTPUT 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 μ s for the Z80 division subroutine versus 30.7 μ s 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 μ s, and the 370 load halfword takes 1.958 μ s. 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 personal IBM 370-148. ■

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```

n:n          : INTEGER;
s:sa        : INTEGER;
which_rins  : (second,third);

a:b:c       : absolute_time;
rins_time  : absolute_time;
second_contact_rins : absolute_time;
third_contact_rins : absolute_time;
tot_time   : absolute_time;
time_totality : absolute_time;
earrin_time : absolute_time;
current_line : absolute_time;
half_time  : absolute_time;
quarter_line : absolute_time;
slack_in_totality : absolute_time;
dumax     : absolute_time;
total_duration : absolute_time;

maxinum    : exposures;
total_eclipse : exposures;
rins_frames : exposures;
current_shot : exposures;

ten_shot_groupins : 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(' ');
END (new_page);

PROCEDURE set_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 (set_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
END (set_parameter);

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

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

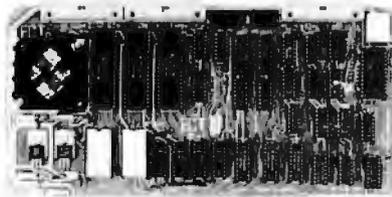
```

Listing 1 continued on page 98

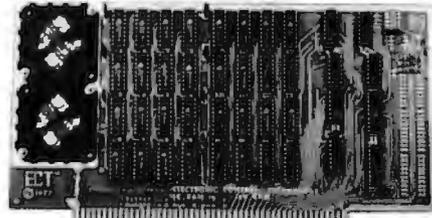
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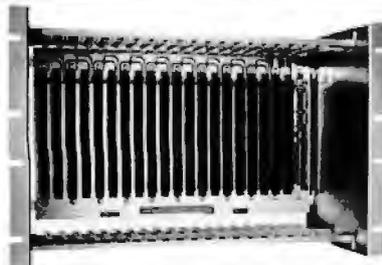
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Listing 1 continued:

```
transient_shots[1].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';
set_parameter(dummy);
maximum := dummy.units;
s := 'Enter number of exposures during totality';
REPEAT
  BEGIN
    set_parameter(dummy);
    total_eclipse := dummy.units;
  END
UNTIL
  (total_eclipse > 0)
  AND
  (total_eclipse < maximum);
s := 'Enter time of totality in "seconds.thousandths"';
set_parameter(time_totality);
s := 'Enter slack time margin (in seconds)';
set_parameter(slack_in_totality);
crash_ahead := TRUE
END (initialize);

PROCEDURE error_abort;
BEGIN
  maximum := 250;
  total_eclipse := 200;
  rns_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;
  s := 0;
  IF c.thousandths < 0 THEN
    BEGIN
      c.thousandths := c.thousandths + 1000;
      s := -1;
    END;
  c.units := a.units - b.units + s;
END;

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

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

PROCEDURE print_time(a : absolute_time);
VAR
  z1000,z100 : STRING(13);
BEGIN
  IF a.thousandths < 100 THEN z1000 := '0' ELSE z1000 := '';
  IF a.thousandths < 10 THEN z100 := '0' ELSE z100 := '';
  WRITELN(s.s.units,'.',z1000,z100,a.thousandths);
END;

PROCEDURE normalize_times;
VAR
  i : INTEGER;

PROCEDURE sum_up_rins(rins : INTEGER; VAR rns_total : absolute_time);
VAR
  index,j : INTEGER;
  this_rins : absolute_time;
BEGIN
  rns_total.units := 0;
  rns_total.thousandths := 0;
  FOR i := 1 TO rns_frames DO
    BEGIN
      this_rins.units := 0;
      this_rins.thousandths := transient_shots[rins].wait_after;
      add_time(this_rins,rns_total,rns_total);
      this_rins.thousandths := transient_shots[rins].duration;
      add_time(this_rins,rns_total,rns_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



THE DATA BASE SPECIALIST

HDBS - HIERARCHICAL DATA BASE MANAGEMENT SYSTEM
MDBS - OUR FULL NETWORK DATA BASE MANAGEMENT SYSTEM

HDBS FEATURES	ADDITIONAL FEATURES IN MDBS	
<ul style="list-style-type: none"> • HIERARCHICAL DATA STRUCTURES • FIXED LENGTH RECORDS • READ/WRITE PROTECTION AT FILE LEVEL • ONE-TO-MANY SET RELATIONSHIPS ALLOWED 	<ul style="list-style-type: none"> • HIERARCHICAL AND FULL NETWORK DATA STRUCTURES (CODASYL ORIENTED) • FIXED AND VARIABLE LENGTH RECORDS • MULTIPLE LEVELS OF READ/WRITE PROTECTION AT ITEM, RECORD, SET AND FILE LEVELS 	<ul style="list-style-type: none"> • EXPLICIT REPRESENTATION OF ONE-TO-ONE, ONE-TO-MANY, MANY-TO-ONE AND MANY-TO-MANY SETS • RECORD TYPES MAY OWN OTHER OCCURRENCES OF THE SAME RECORD TYPE • A SINGLE SET MAY HAVE MULTIPLE OWNER AND MEMBER RECORD TYPES

FEATURES COMMON TO HDBS and MDBS

STRAIGHT FORWARD USE OF ISAM-LIKE STRUCTURES
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 COMMANDS TO ADD, DELETE, UPDATE, SEARCH AND TRAVERSE THE DATA BASE
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Also

UP TO 254 RECORD-TYPES MAY BE DEFINED IN THE DATA BASE
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 EACH ITEM-TYPE MAY BE UP TO 9,999 BYTES IN LENGTH

REQUIREMENTS

- Z-80 APPROXIMATELY 18K MEMORY -
- 8080 APPROXIMATELY 20K MEMORY -
- IN ADDITION TO THE OPERATING SYSTEM, HOST LANGUAGE, USER'S PROGRAM AND SOME BUFFER AREA
- 6502 APPROXIMATELY 28K MEMORY

NEW DYNAMIC RESTRUCTURING SYSTEM

MDBS-DRS FEATURES

ALLOWS ITEM, RECORD AND/OR SET TYPES TO BE ADDED TO OR DELETED FROM AN EXISTING MDBS DATA BASE. THIS ALLOWS THE USER TO RE-DESIGN A DATA BASE AFTER IT IS ALREADY ON-LINE.

THIS FEATURE CAN ONLY BE ADDED TO THE MDBS SYSTEM.

HDBS and MDBS PACKAGES INCLUDE

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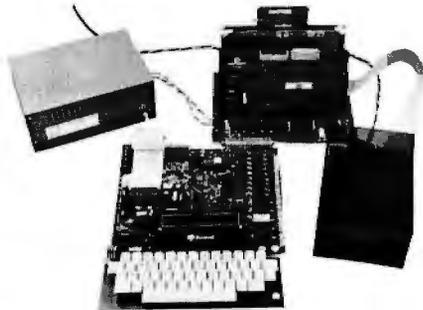
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Listing 1 continued:

```

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

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

  WRITELN('-----');
  which_rins := second;
  sum_up_rins(ORD(which_rins),second_contact_rins);

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

  which_rins := third;
  sum_up_rins(ORD(which_rins),third_contact_rins);

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

  add_time(second_contact_rins,third_contact_rins,rins_time);
  s := 'Total time devoted to diamond rins sequences = ' +
    print_time(rins_time);
  divide_time(quarter_time,second_contact_rins,2);
  s := 'Anticipation time for first diamond rins = ' +
    print_time(quarter_time);

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

  divide_time(half_time,rins_time,2);
  s := 'Extra slack due to diamond rins overlaps = ' +
    print_time(half_time);

  add_time(tol_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_groupings[i].wait_after :=
      ten_shot_groupings[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(tol_time);
  s := 'Adjusted time devoted to total phase = ' +
    print_time(tol_time);

  add_time(tol_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
  rins_frames :=
    (maximum - total_eclipse) DIV 2;
  IF rins_frames < 2 THEN error_abort;
  s := maximum - (total_eclipse + (2 * rins_frames));
  total_eclipse := total_eclipse + s;
  WRITELN('');
  WRITELN('Exposures map:');
  WRITELN('  First diamond rins = ',rins_frames);
  WRITELN('  Totality = ',total_eclipse);
  WRITELN('  Second diamond rins = ',rins_frames);
  WRITELN('-----');
  WRITELN('          TOTAL = ',maximum);
  WRITELN('');
  WRITELN('');
  WRITELN('Press return to continue');
  READLN(s);
END (alloc_exposures);

BEGIN (normalize_times)
  alloc_exposures;
  preliminary_allocation;

```

Listing 1 continued on page 102

DIGITAL RESEARCH

- CP/M FLOPPY DISKETTE OPERATING SYSTEM - Packages supplied on diskette complete with 8080 assembler, text editor, 8080 debugger and various utilities plus full documentation. CP/M available configured for most popular computer/disk systems including North Star Single, Double or Quad density, Altair 8/8, Helios II, Exidy Sorcerer, Vector MZ, Heath H17 or H89, TRS-80, ICOM 3712 and ICOM Micro Disk plus many other configurations available. \$145/\$25 CP/M version 2 (not all formats available immediately) \$170/\$25

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- MAC - 8080 Macro Assembler. Full Intel macro definitions. Pseudo Ops include RPL, RPT, REPT, TITLE, PAGE, and MACLIB. Z80 library included. Produces Intel absolute hex output plus symbols file for use by SID (see below). \$85/\$15
- SID - 8080 symbolic debugger. Full trace, pass count and break-point program testing system with back trace and histogram utilities. When used with MAC, provides full symbolic display of memory labels and equated values. \$70/\$15
- Z80 - As above. Z80 utilities Z80 CPU \$95/\$25
- TEX - Text formatter to create paginated, page-numbered and justified copy from source text files. Direct access to disk or printer. \$70/\$15
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MDBS - Micro Data Base System. Full network data base with all features of HDBS plus multi-level Read/Write protection for FILE, SET, RECORD and ITEM. Explicit representation of one to one, one to many, many to many, and many to SET relationships. Supports multiple owner and multiple record types within SETS. HDBS files are fully compatible.
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HDBS-Z80 version \$250/\$35
MDBS-D80 version \$370/\$35
8080 Version available at \$75. extra.
Z80 version requires 20K RAM. 8080 version requires 24K RAM (Memory requirements are additional to CP/M and application program.)

- When ordering HDBS or MDBS please specify if the version required is for Micro, Z80, TRS-80, COBOL-80, BASIC COMPILER, 2) MBASIC 4 XX, 3) BASIC-80.0.
Prices and specifications subject to change without notice.

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KBASIC - Microsoft Disk Extended BASIC with all KISS facilities, integrated by implementation of nine additional commands in language. Package includes KISS, REL as described above, and a sample mail list program. \$585/\$45
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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

```

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

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 = 262.960
Slack time margin at end of totality = 6.000
Extra slack due to diamond ring overlaps = 5.450
Total time committed 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 = 228.388
Adjusted total time committed = 239.838
-----
Margin time after allocation to totality = 0.170
Press return to end program

```

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.

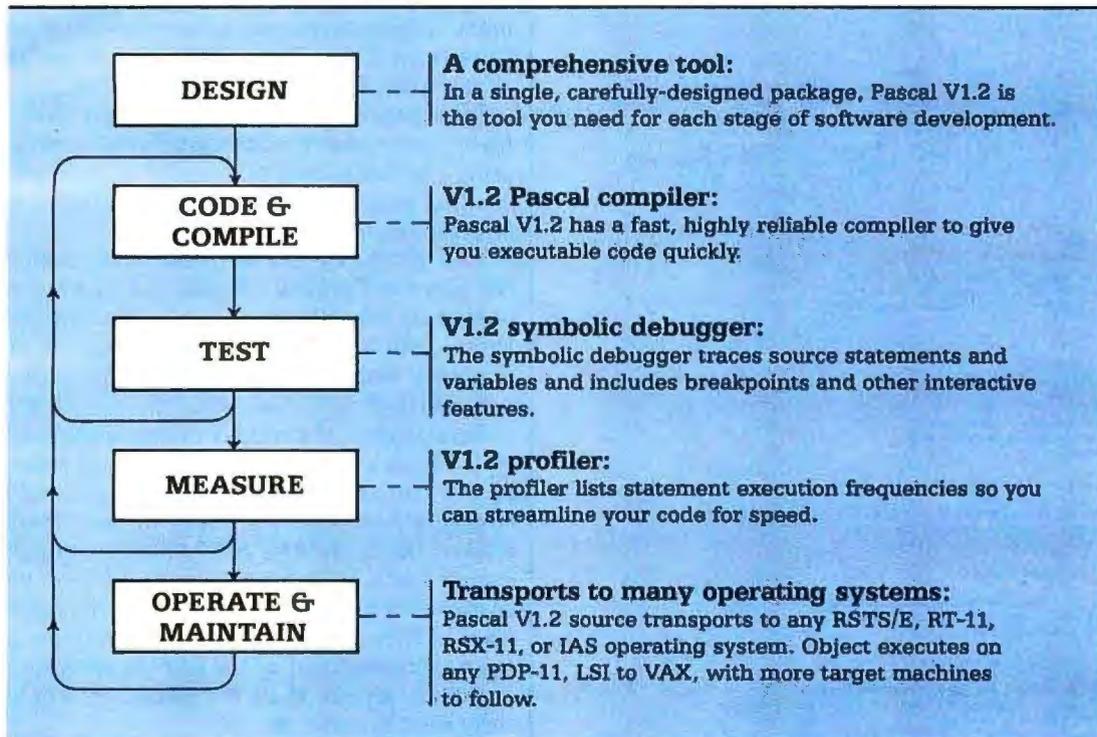
The most important concept here is the very real machine-independent viability of a high-level language, such as Pascal, in designing and then communicating the idea of a program. The functional simulation stage of my eclipse control program is now complete in concept and awaits some final details to 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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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 ANO.

```

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 D2 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 ANO output to "1");
  close_shutter_address = -16296 (resets ANO output to "0");

VAR
  reiterations : INTEGER;
  J,K,I : INTEGER;
  c : 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, i.e. 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;
  END;

VAR
  ansbyte : memory;
  anschar : CHAR;

BEGIN
  ansbyte.a_number := address;
  anschar := ansbyte.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(c);
        IF c = ' ' THEN
          ELSE IF c = 'N' THEN change_reiterations;
          ELSE IF c = 'E' THEN I := 1000;
        start_exposure;
        FOR J := 1 TO reiterations DO
          WRITELN('***** Shutter is now open *****');
          READLN(c);
          IF c = ' ' THEN
            ELSE IF c = 'N' THEN change_reiterations;
            ELSE IF c = 'E' THEN I := 1000;
          end_exposure;
        END;
      END;
    END;
  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. ■

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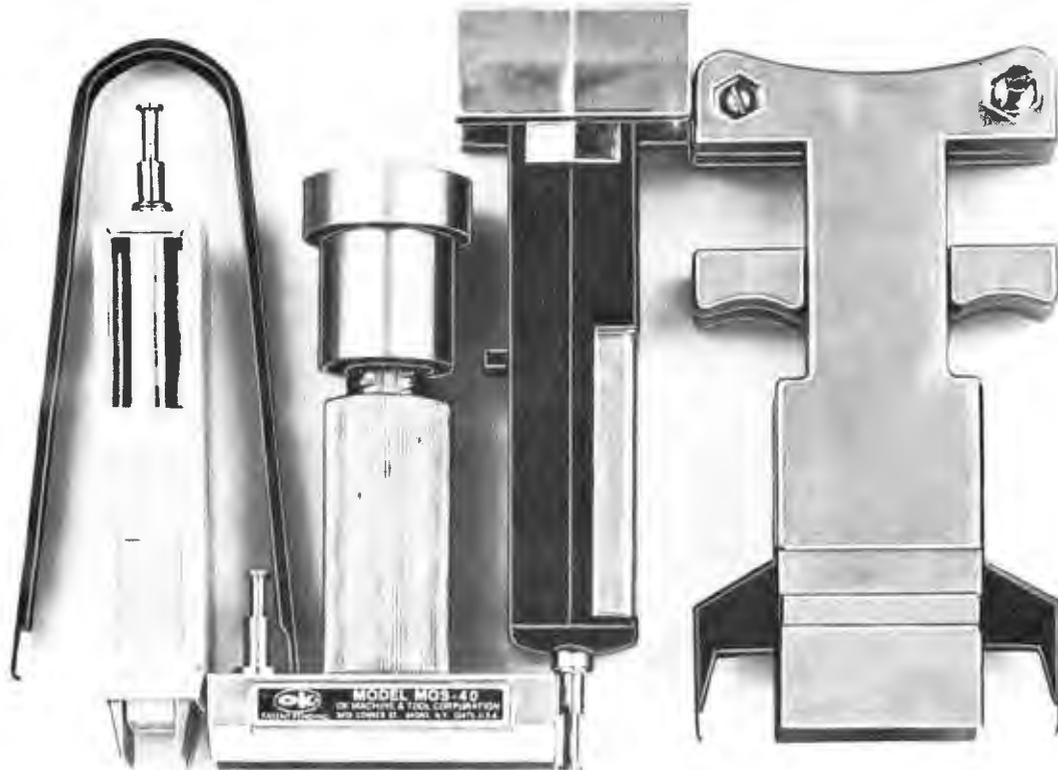


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This revolutionary new microcomputer system features an Altos-developed Multi-User Executive (AMEX) software program that's unique in two ways. It includes a multi-user CP/M capability and the ability to handle Winchester-type hard disks. This advanced 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.

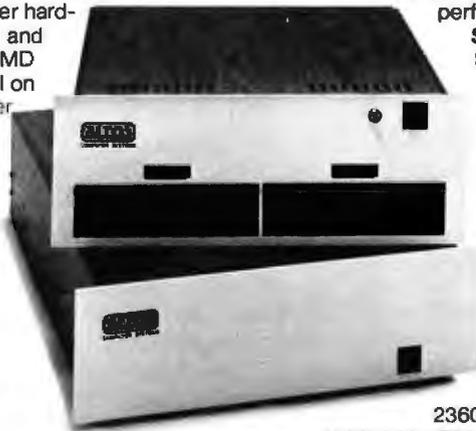
With AMEX at the helm, your Altos ACS8000-6 system can support up to four simultaneous users with 48K bytes of RAM each plus 58 megabytes of Winchester storage and 4 megabytes of floppy back up. And that adds up to the first microcomputer to give you the power and

performance of a minicomputer.

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

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ALTOS
COMPUTER SYSTEMS

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.

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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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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.

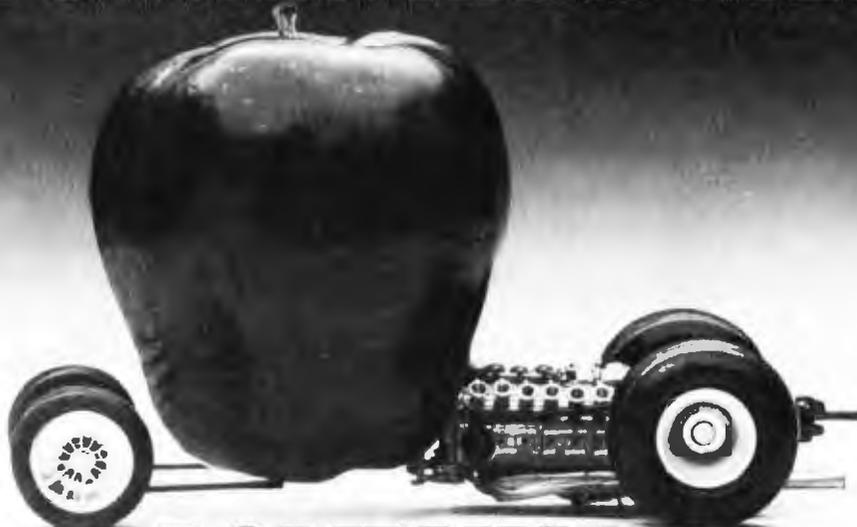
The new small Winchester disk drives, or micro-Winchesters, will have storage capacities starting at 1 megabytes and removable disk modules about the size of an 8-track audio tape cartridge. The back-end processors will be available by the mid-1980s. They will combine Winchester-disk-controller and data-base-management 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 its 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.

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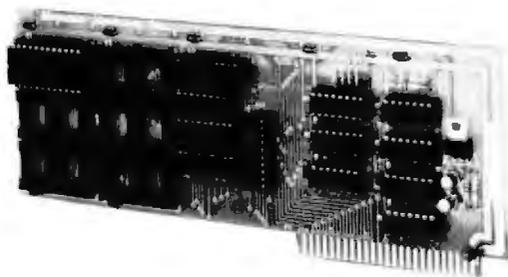
In addition to the Keyboard Filter ROM, ROMPLUS+ offers five sockets for ROM or EPROM, plus "scratch-pad" RAM. And, sophisticated firmware on ROMPLUS+ allows one, two, or more of its chips to be used simultaneously for programs longer than 2K.

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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 literature 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 beginning 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.

Sol Libes
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(ACG - NJ)
1776 Raritan Rd
Scotch Plains NJ 07076

SCIENTIFIC AMERICAN



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March 1980

Do divers and gymnasts violate the law?

physics is the same for the astronauts in space who need to control their body orientation in a weightless environment.

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each other as cholera, diabetes and manic-depressive psychosis. In each there occurs a form of failure of fit between signal-bearing molecules from one cell and the receptor molecules in the outer or internal membranes of the target cell.

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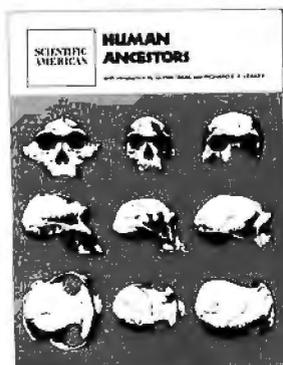
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We are accustomed to seeing divers and gymnasts begin to twist and somersault long after they have left the springboard or the floor. Indeed, in order to win gold medals divers need to perform such complex feats in midair as the forward two-and-a-half somersault with two twists. But, you may ask, doesn't this violate the law of conservation of angular momentum? It postulates: *In the absence of torques, or rotational forces, the angular momentum of a body is conserved.* In the March SCIENTIFIC AMERICAN you will see how this paradox is resolved. You may be relieved to learn that divers and gymnasts (and free-falling cats, too) perform their midair rotations without violating any laws of physics. Moreover, the underlying

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Electronic Planimetry

Peter A Santi
John Fryhofer
Gregory Hansen
Medical Research East
University of Minnesota
2630 University Ave SE
Minneapolis MN 55414

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 Summagraphics 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 Corporation (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 magnetostrictive 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

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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
Media	35 milliseconds track-to-track
Disk Rotation	5 1/4 inch mini-disk
Internal Memory	300 RPM
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 7/8" (H) x 21 1/2" (W) x 23 1/4" (D)
Environment	Operating: 0° to 50° C Storage: 0° to 85° C, 10 to 95% rel. humidity - non condensing.
Power Requirements	115 VAC, 60 HZ, 1 AMP (optional 230VAC/50HZ model available).

*Specifications subject to change without notice.

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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

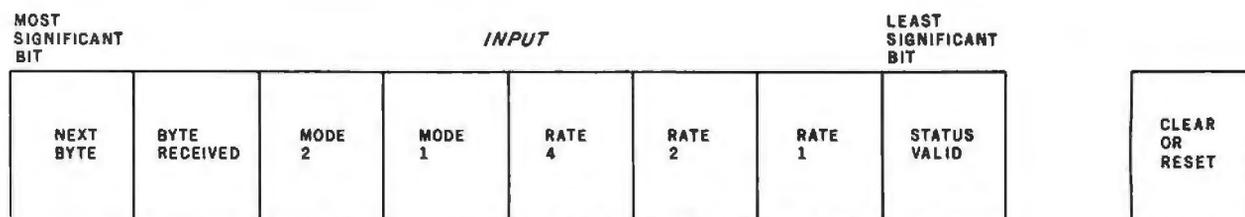


Figure 1: The bit format of the input or command byte for the Bit Pad. In addition, a single line is used by the host computer to reset or clear the Bit Pad's electronic circuitry.

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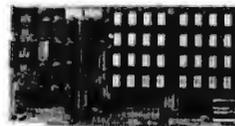
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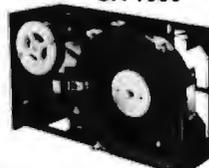
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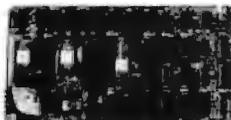
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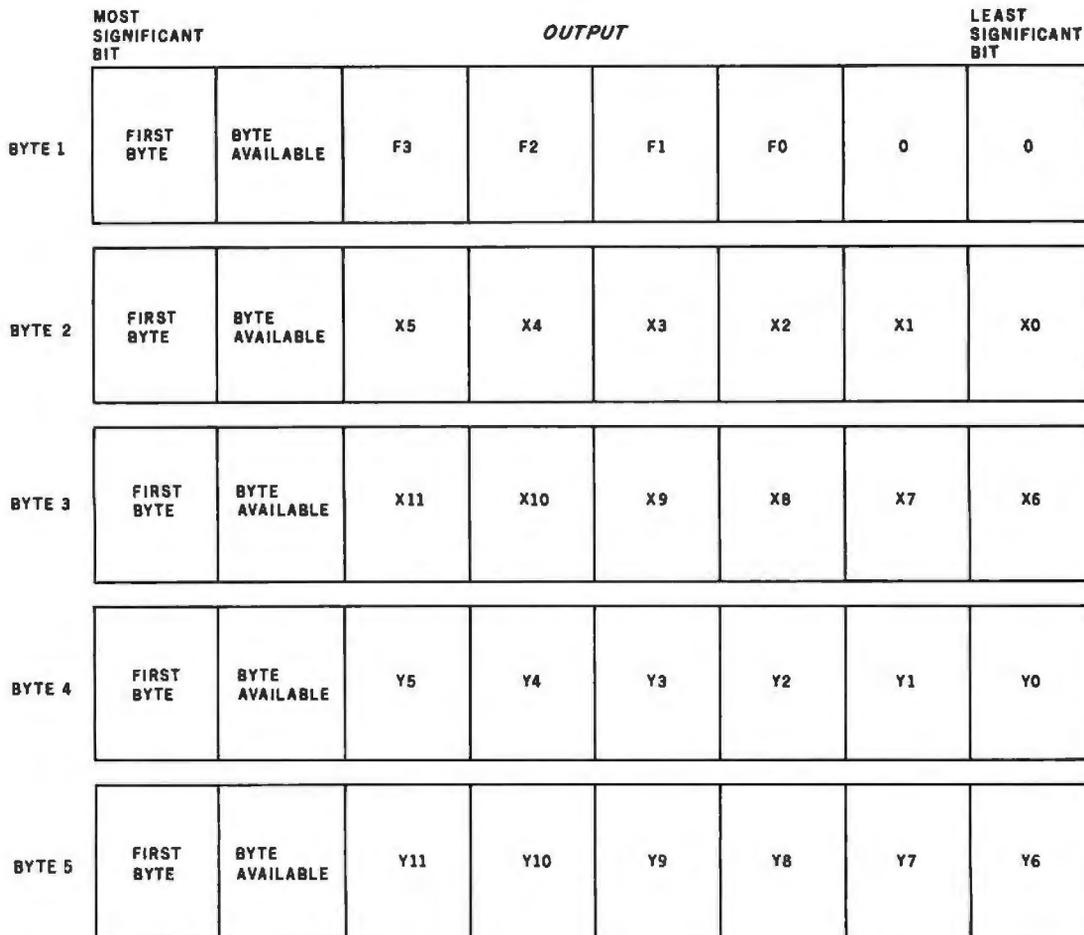


Figure 2: Five bytes of data are transmitted from the Bit Pad's output port for each coordinate pair of points generated. The first byte contains information concerning depression of the Z-axis switch. The next four bytes contain a 12-bit representation of the X and Y coordinates. Each byte also contains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

plies 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 data-

type 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.P1 contains the Terak I/O buffers for the parallel port.

Each input byte is read as LOOKB := BITPAD.P1.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

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```

PROGRAM PLANIMETER;
(* Written by: John Fruhofer

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;
  RESPON: CHAR;
  START, (* Start new figure *)
  DIDPRINT: (* Already printed for button up *)
    BOOLEAN;
  FIRSTX, FIRSTY, LASTX, LASTY, X, Y,
  AREA, LEN, CUMAREA, CUMLEN, MAGR: REAL;
  N: PACKED ARRAY [0..1] OF CHAR; (* Dummy array; KC03 holds command *)
  PTR : INTERACTIVE;

PROCEDURE NEXTBYTE;
VAR W: LOWBYTE;
BEGIN
  (* Reads next byte from BIT PAD *)
  REPEAT
    IF NOT UNITBUSY(2) THEN UNITREAD (2,KC03,1,1); (* Look for command *)
    LOOKB := BITPAD.P↑.INBUF
  UNTIL LOOKB.READY OR (KC03 = '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 DEBUG;
(* used for debugging only *)
BEGIN
  WRITE(LOOKB.D);
  IF LOOKB.READY THEN WRITE(' READY');
  IF LOOKB.FIRST THEN WRITE(' FIRST');
  WRITELN;
END;

PROCEDURE PRINT;
(* Print results *)
BEGIN
  WRITELN ('# Points :', P:5, ' / Area :', SQR(MAGR)*ABS(CUMAREA):9:6,
          ' so mm / Length :', MAGR*CUMLEN:9:6, ' mm');
  IF (KC03 = 'P') AND (P <> 0) THEN
    WRITE (PTR, '# Points :', P:5, ' / Area :', SQR(MAGR)*ABS(CUMAREA):9:6,
          ' so 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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DATA MANAGER by Dale Kubler starts out where **INFORMATION SYSTEM** leaves off. Requiring 32K and one disk, it accepts up to ten user-defined fields with up to forty characters per field and 255 characters per record. As with all TBS software, data entry and editing is professional and simple to use. What makes this program stand apart from "in-mem" data managers is that it uses up to four disks on line as memory, or as much as 320K of memory storage. Because disk sorts take more time than in-mem sorts, **DATA MANAGER** enables the user to create and maintain up to 5 "key" sort files for quick access of data. A utility program is provided to calculate the number of records possible since the amount of records you can maintain is dependent on a number of variables. This program also supports the upper/lower case modification, and printouts can be programmed to almost any format and sent to line or serial printer.

Background printing is provided enabling the computer to search and print at the same time. If you already have **INFORMATION SYSTEM**, **DATA MANAGER** will accept those files. A necessity for organized people, this program sells for \$49.50.

BUSINESS MAIL SYSTEM by Dale Kubler is designed for large-scale business users. Requiring 32K, two disks and printer, this program will store up to 150,000 names in a single spread out over multiple disks. Each data disk holds 500 names.

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program the number and spacing of your labels.

With more features than can be described here, this high-powered program sells for \$125.00.

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Listing 1 continued:

```

END; (*NEWFIGURE*)

PROCEDURE CALC;
BEGIN
    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 KC0J = '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.Pt,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;
    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
        KC0J := ' ';
        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 KC0J <> '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 (KC0J = 'Q');
                (* Button is down *)
                WHILE (BYT < 5) AND (KC0J <> '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 > HJNPTS) THEN
                                        CLOSURE; (* Back at first point +/- DELTA *)
                                END; (* CASE *)
                            END; (* Get whole point *)
                    END;
                END;
                (* Next point *)
                WRITE ('ANOTHER MEASUREMENT? ');
                READ(RESPONS);
                UNTIL RESPONS = 'N';
            END.
    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:

$$\text{Area} = [(X_1 - X_0) \times (Y_1 + Y_0)] / 2.$$

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 mini-computer 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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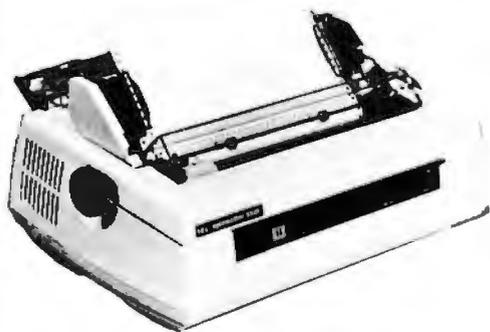
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A Power-Line Protection Circuit

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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.

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.

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. ■

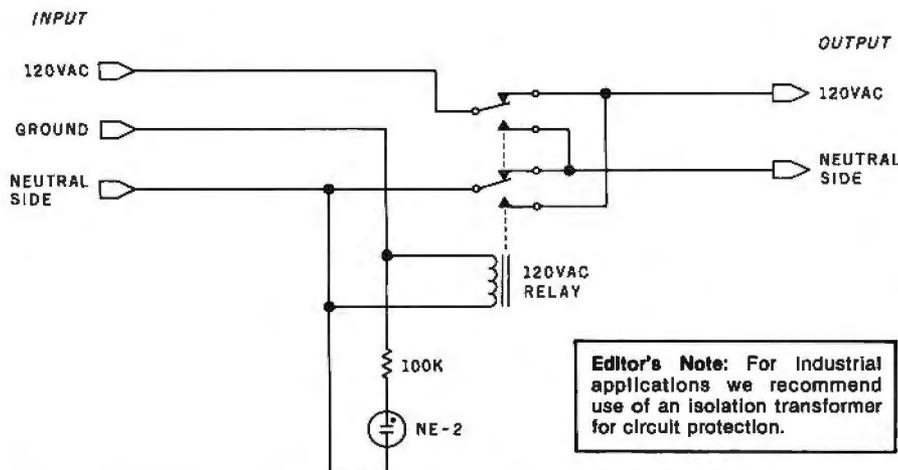


Figure 1: A simple circuit that offers some protection by using a relay to reverse connections to the power line. However, no protection is provided if the earth-ground line is defeated.

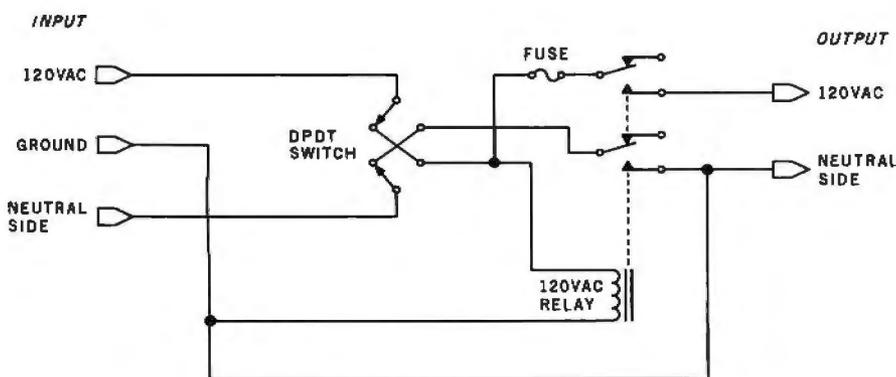
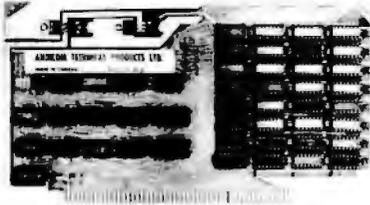


Figure 2: A better circuit that uses a double-pole, double-throw switch to present reversible power to the relay. If an attempt is made to defeat the earth ground, the power is cut off.

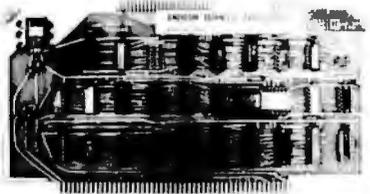
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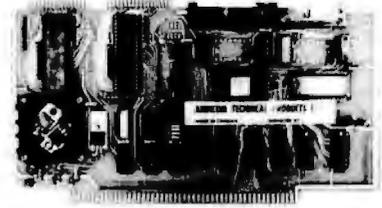
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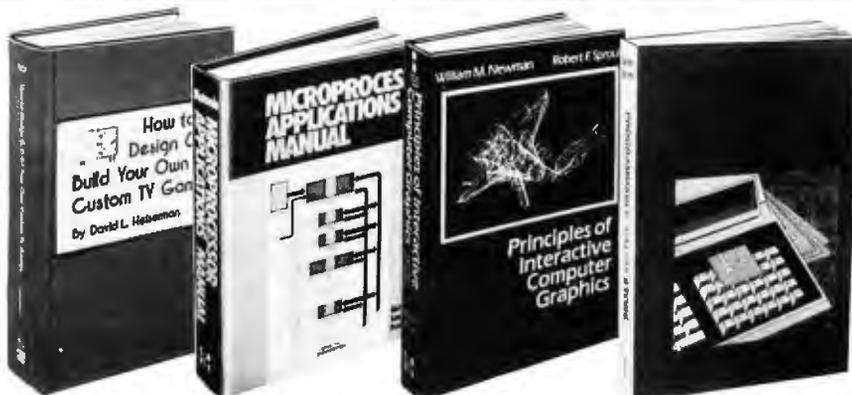
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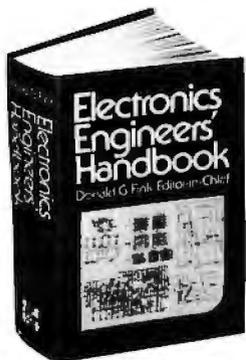
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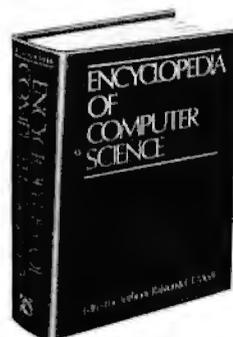
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P39456

Landing Module Simulation with Random Surface

S J Houng
E 36 Salmon St
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

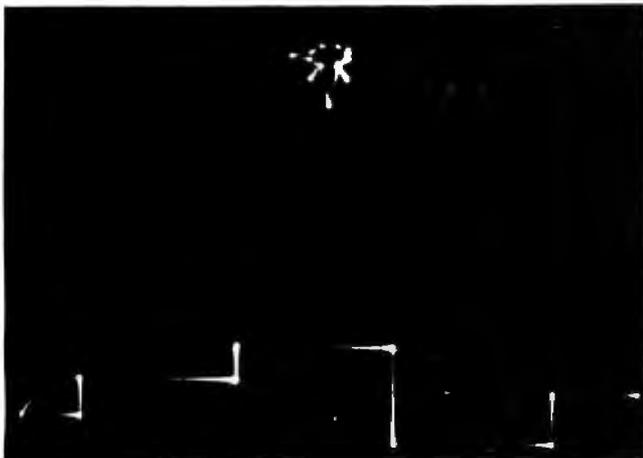


Photo 1: Landing module hovering over the five-segment random surface as it cautiously approaches its landing site.

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.

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 micro-processor 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

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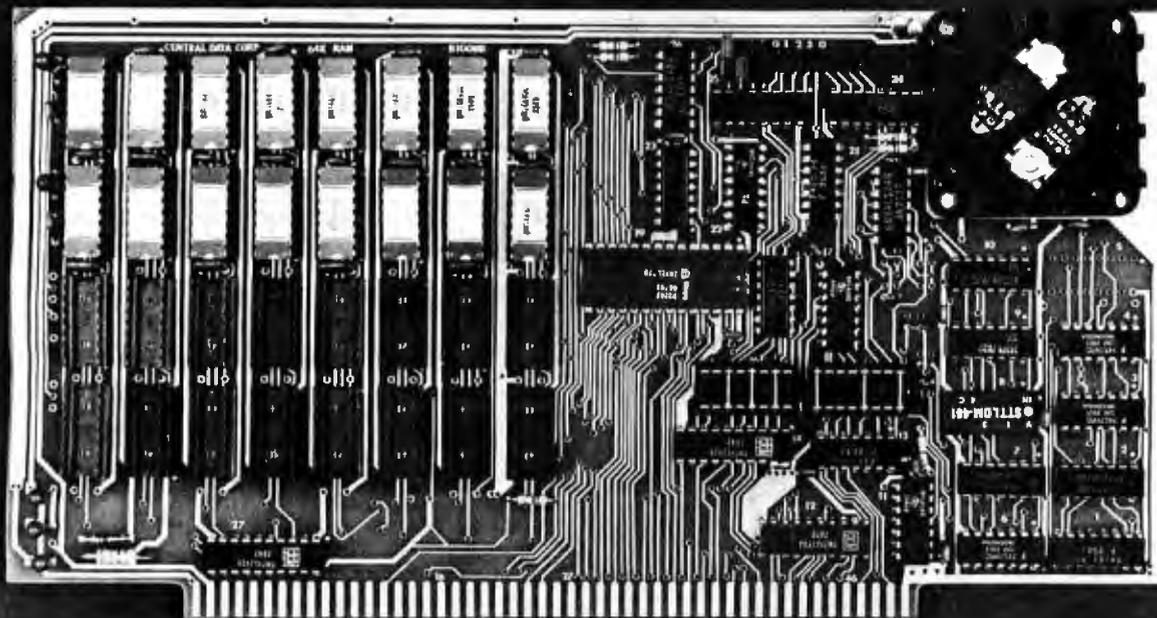
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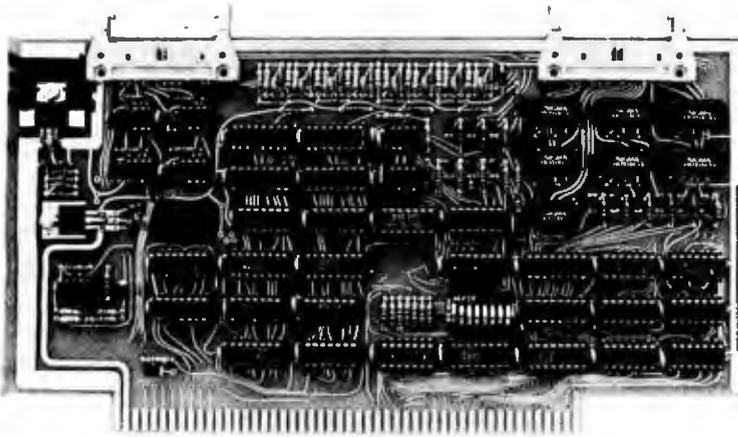
Listing 1 continued:

00052	0044	2E	02		BGT	LFIRE	52.
00053	0046	D6	09		LDA B	JR	53.
00054	0048	BD	03	LFIRE	BSR	EULER	54.
00055	004A	97	01		STA A	X2	55.
00056	004C	39			RTS		56.
00057	004D	CE	0002	EULER	LIX	##2	57.
00058	0050	57		EO	ASR B		58.
00059	0051	09			DEX		59.
00060	0052	26	FC		BNE	EO	60.
00061	0054	1B			ABA		61.
00062	0055	39			RTS		62.
00063	0056	D6	04	RAND	LDA B	RND	63.
00064	0058	17			TBA		64.
00065	0059	58			ASL B		65.
00066	005A	58			ASL B		66.
00067	005B	1B			ABA		67.
00068	005C	58			ASL B		68.
00069	005D	1B			ABA		69.
00070	005E	4C			INC A		70.
00071	005F	97	04		STA A	RND	71.
00072	0061	39			RTS		72.
00073	0062	D6	0E	SRFGEN	LDA B	ODOM	73.
00074	0064	D7	0D		STA B	TEMP	74.
00075	0066	D6	05		LDA B	RND	75.
00076	0068	D7	04		STA B	RND	76.
00077	006A	BD	EA	NXT	BSR	RAND	77.
00078	006C	7A	000D		DEC	TEMP	78.
00079	006F	26	F9		BNE	NXT	79.
00080	0071	CE	0010		LIX	##GETSRF	80.
00081	0074	C6	05		LDA B	##5	81.
00082	0076	D7	0D		STA B	TEMP	82.
00083	0078	BD	DC	NXTS	BSR	RAND	83.
00084	007A	44			LSR A		84.
00085	007B	44			LSR A		85.
00086	007C	A7	00		STA A	O+X	86.
00087	007E	08			INX		87.
00088	007F	7A	000D		DEC	TEMP	88.
00089	0082	26	F4		BNE	NXTS	89.
00090	0084	39			RTS		90.
00091	0085	7F	000F	BXING	CLR	FLAG4	91.
00092	0088	96	00		LDA A	X1	92.
00093	008A	84	3F		AND A	##3F	93.
00094	008C	81	30		CMF A	##30	94.
00095	008E	2A	09		BPL	XING	95.
00096	0090	B1	10		CMF A	##10	96.
00097	0092	2B	05		BMI	XING	97.
00098	0094	84	20		AND A	##20	98.
00099	0096	97	15		STA A	B5	99.
00100	0098	39			RTS		100.
00101	0099	84	20	XING	AND A	##20	101.
00102	009B	16			TAB		102.
00103	009C	90	15		SUB A	B5	103.
00104	009E	27	0F		REQ	OUT	104.
00105	00A0	2B	05		BMI	PLUS	105.
00106	00A2	7A	000E		DEC	ODOM	106.
00107	00A5	20	03		BRA	SAVE	107.
00108	00A7	7C	000E	PLUS	INC	ODOM	108.
00109	00AA	7C	000F	SAVE	INC	FLAG4	109.
00110	00AD	D7	15		STA B	B5	110.
00111	00AF	39		OUT	RTS		111.
00112	00B0	8D	D3	TERR	BSR	BXING	112.
00113	00B2	D6	0F		LDA B	FLAG4	113.
00114	00B4	27	02		REQ	SDFLY	114.
00115	00B6	8D	AA		BSR	SRFGEN	115.
00116	00B8	8D	01C0	SDFLY	JSR	SURF	116.
00117	00BB	39			RTS		117.
00118	00BC	4F		KEY	CLR A		118.
00119	00BD	97	0A		STA A	FLAG1	119.
00120	00BF	97	0B		STA A	FLAG2	120.
00121	00C1	86	20		LDA A	##20	121.
00122	00C3	8D	25		BSR	TKEY	122.
00123	00C5	2B	03		BMI	L	123.
00124	00C7	7C	000A		INC	FLAG1	124.
00125	00CA	86	10	L	LDA A	##10	125.
00126	00CC	8D	1C		BSR	TKEY	126.
00127	00CE	2B	03		BMI	R	127.
00128	00D0	7C	000B		INC	FLAG2	128.
00129	00D3	86	A0	R	LDA A	##A0	129.
00130	00D5	8D	13		BSR	TKEY	130.
00131	00D7	2B	03		BMI	EXT	131.
00132	00D9	7A	000B		DEC	FLAG2	132.

Listing 1 continued on page 136

IDS Announces S-100 Energy Management Module

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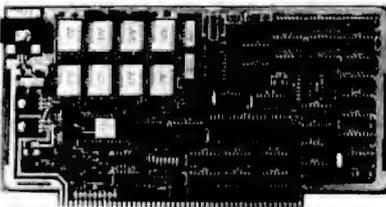
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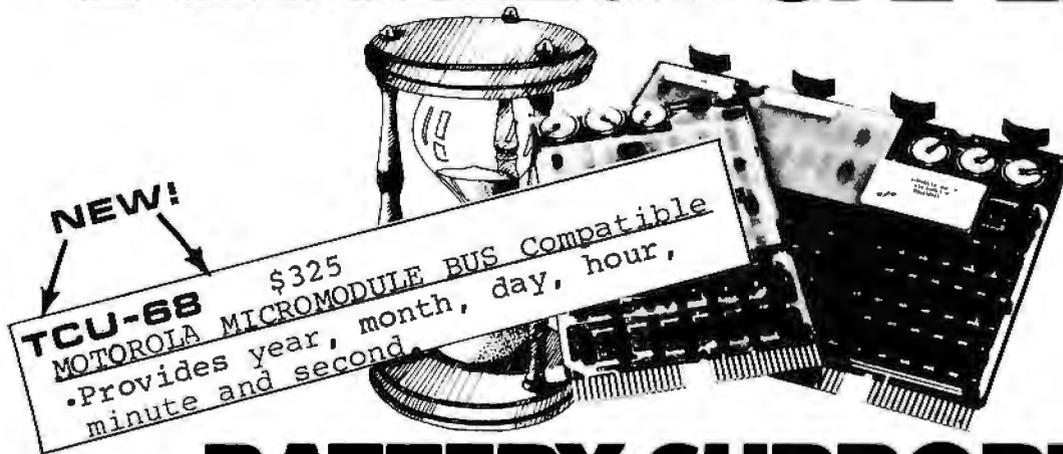
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Listing 1 continued:

```
00133 00DC 39      EXT   RTS      133.
00134 00DD 7F 000C GO   CLR   FLAG3 134.
00135 00E0 86 E0     LDA A  #E0   135.
00136 00E2 8D 06     BSR   TKEY   136.
00137 00E4 2B 03     BMI   0      137.
00138 00E6 7C 000C   INC   FLAG3  138.
00139 00E9 39        D     RTS      139.
00140 00EA 87 8022 TKEY STA A  SCNREG 140.
00141 00ED 7D 8020   TST   DISREG 141.
00142 00F0 39        RTS      142.
00143 00F1 7F 8005 BEGIN CLR   CRA    143.
00144 00F4 7F 8007   CLR   CRB    144.
00145 00F7 86 FF     LDA A  #FF   145.
00146 00F9 87 8004   STA A  FIA    146.
00147 00FC 87 8006   STA A  FIR    147.
00148 00FF 86 25     LDA A  #25   148.
00149 0101 87 8005   STA A  CRA    149.
00150 0104 87 8007   STA A  CRB    150.
00151 0107 4F        INIT  CLR A      151.
00152 0108 97 03     STA A  Y2    152.
00153 010A 86 0A     LDA A  #A    153.
00154 010C 97 01     STA A  X2    154.
00155 010E 86 60     LDA A  #60   155.
00156 0110 97 02     STA A  Y1    156.
00157 0112 86 20     LDA A  #20   157.
00158 0114 97 0E     STA A  ODOM  158.
00159 0116 96 04     LDA A  RND    159.
00160 0118 97 05     STA A  RND0  160.
00161 011A 8D 5C     START BSR   LANDER 161.
00162 011C 8D 00B0   JSR   TERR   162.
00163 011F 8D BC     BSR   GO      163.
00164 0121 D6 0C     LDA B  FLAG3 164.
00165 0123 27 F5     BEQ   START  165.
00166 0125 8D 95     MOTION BSR   KEY   166.
00167 0127 8D 0016   JSR   SYS    167.
00168 012A 8D 4C     BSR   LANDER 168.
00169 012C 8D 4A     BSR   LANDER 169.
00170 012E 8D 48     BSR   LANDER 170.
00171 0130 8D 00B0   JSR   TERR   171.
00172 0133 96 02     LDA A  Y1    172.
00173 0135 8B 80     ADD A  #80   173.
00174 0137 90 12     SUB A  SUR    174.
00175 0139 32 EA     BHI   MOTION 175.
00176 013B 81 FB     CMP A  #FB   176.
00177 013D 2B 10     BHI   CRASH  177.
00178 013F 96 01     LAND  LDA A  X2 178.
00179 0141 81 0B     CMP A  #8    179.
00180 0143 2A 0A     BPL   CRASH  180.
00181 0145 81 FB     CMP A  #FB   181.
00182 0147 2B 06     BHI   CRASH  182.
00183 0149 96 03     LDA A  Y2    183.
00184 014B 81 F0     CMP A  #F0   184.
00185 014D 2A 0B     BPL   SAFE   185.
00186 014F 8D 00B0 CRASH JSR   TERR   186.
00187 0152 8D 89     BSR   GO      187.
00188 0154 D6 0C     LDA B  FLAG3 188.
00189 0156 2E AF     BGT   INIT    189.
00190 015B 20 F5     BRA   CRASH   190.
00191 015A C6 04     SAFE  LDA B  #4   191.
00192 015C D7 03     STA B  Y2    192.
00193 015E 5F        CLR B      193.
00194 015F D7 01     STA B  X2    194.
00195 0161 D7 0A     STA B  FLAG1 195.
00196 0163 D7 0B     STA B  FLAG2 196.
00197 0165 CE A04D SF   LDX   #S     197.
00198 0168 8D 39     BSR   DSPLY  198.
00199 016A 8D 0C     BSR   LANDER 199.
00200 016C 8D 00B0   JSR   TERR   200.
00201 016F 8D 00BD   JSR   GO      201.
00202 0172 D6 0C     LDA B  FLAG3 202.
00203 0174 2E AF     BGT   MOTION 203.
00204 0176 20 ED     BRA   SF      204.
00205 017B CE 01F1 LANDER LDX   #TUP   205.
00206 017B 8D 26     BSR   DSPLY  206.
00207 017D D6 0B     LDA B  FLAG2 207.
00208 017F 2F 05     BLE  RJET    208.
00209 0181 CE 01FA   LDX   #LJ    209.
00210 0184 8D 1D     BSR   DSPLY  210.
00211 0186 CE A031 RJET  LDX   #LS    211.
00212 0189 8D 1B     BSR   DSPLY  212.
00213 018B D6 0A     LDA B  FLAG1 213.
```

Listing 1 continued on page 138

TIME after TIME



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TCU-100 • \$495

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Lockheed SUE

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TCU-410 • \$325

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- SBC/BLC compatible.

HP 2100

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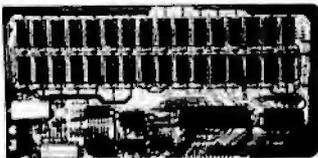
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Listing 1 continued:

00214	018D	27	05		REQ	NOJET	214.
00215	018F	CE	A03A		LIX	*MJ	215.
00216	0192	8D	0F		BSR	DSPLY	216.
00217	0194	CE	A03D	NOJET	LIX	*RS	217.
00218	0197	8D	0A		BSR	DSPLY	218.
00219	0199	D6	0B		LDA	FLAG2	219.
00220	019B	2C	03		BGE	NORJ	220.
00221	019D	CE	A04B		LIX	*RJ	221.
00222	01A0	8D	01		BSR	DSPLY	222.
00223	01A2	39		NORJ	RTS		223.
00224	01A3	A6	00	DSPLY	LDA	A 0,X	224.
00225	01A5	27	12		REQ	END	225.
00226	01A7	B7	8004		STA	A PIA	226.
00227	01AA	A6	01		LDA	A 1,X	227.
00228	01AC	9B	02		ADD	A Y1	228.
00229	01AE	8B	70		ADD	A **70	229.
00230	01B0	B7	8006		STA	A FIB	230.
00231	01B3	08			INX		231.
00232	01B4	08			INX		232.
00233	01B5	8D	03		BSR	TDELAY	233.
00234	01B7	20	EA		BRA	DSPLY	234.
00235	01B9	39		END	RTS		235.
00236	01BA	C6	80	TDELAY	LDA	B **80	236.
00237	01BC	5A		DELAY	DEC	B	237.
00238	01BD	26	FD		BNE	DELAY	238.
00239	01BF	39			RTS		239.
00240	01C0	CE	0010	SURF	LIX	*GETSRF	240.
00241	01C3	4F			CLR	A	241.
00242	01C4	E6	00		LDA	B 0,X	242.
00243	01C6	B7	8004		STA	A PIA	243.
00244	01C9	F7	8006		STA	B FIB	244.
00245	01CC	8D	EC		BSR	TDELAY	245.
00246	01CE	96	00		LDA	A X1	246.
00247	01D0	43			COM	A	247.
00248	01D1	84	3F		AND	A **3F	248.
00249	01D3	B7	8004	NEXTS	STA	A PIA	249.
00250	01D6	8D	E2		BSR	TDELAY	250.
00251	01D8	0B			INX		251.
00252	01D9	E6	00		LDA	B 0,X	252.
00253	01DB	F7	8006		STA	B FIB	253.
00254	01DE	8D	DA		BSR	TDELAY	254.
00255	01E0	8C	0014		CFX	*GETSRF+4	255.
00256	01E3	27	04		REQ	LAST	256.
00257	01E5	8B	40		ADD	A **40	257.
00258	01E7	20	EA		BRA	NEXTS	258.
00259	01E9	86	FF	LAST	LDA	A **FF	259.
00260	01EB	B7	8004		STA	A PIA	260.
00261	01EE	8D	CA		BSR	TDELAY	261.
00262	01F0	39			RTS		262.
00263	01F1	8B20		TOP	FDB	*8B20,*8424,*7C24,*7820	263.
		01F3	8424				
		01F5	7C24				
		01F7	7820				
00264	01F9	00			FCB	\$00	264.
00265	01FA	701E		LJ	FDB	*701E	265.
00266	01FC	00			FCB	\$00	266.
00267	A031				ORG	*A031	267.
00268	A031	781C		LS	FDB	*781C,*7C18,*7810,*7C18	268.
		A033	7C18				
		A035	7810				
		A037	7C18				
00269	A039	00			FCB	\$00	269.
00270	A03A	8000		MJ	FDB	*8000	270.
00271	A03C	00			FCB	\$00	271.
00272	A03D	841B		RS	FDB	*841B,*8810,*8418,*881C,*8820	272.
		A03F	8810				
		A041	841B				
		A043	881C				
		A045	8820				
00273	A047	00			FCB	\$00	273.
00274	A048	901E		KJ	FDB	*901E,*881C	274.
		A04A	881C				
00275	A04C	00			FCB	\$00	275.
00276	A04D	8540		S	FDB	*8540,*8050,*7E40,*884A	276.
		A04F	8050				
		A051	7E40				
		A053	884A				
00277	A055	784A			FDB	*784A,*8540	277.
		A057	8540				
00278	A059	00			FCB	0	278.
00279					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:

$$\begin{aligned} Z_{n+1} &= Z_n + hf(t_n, Z_n) \\ t_{n+1} &= t_n + h \\ n &= 0, 1, 2, \dots \end{aligned}$$

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 $\frac{1}{4}$ 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 oscilloscope. ■

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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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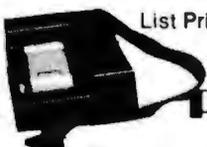


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The Dirt-Cheap Bootstrap

More Notes on Bringing Up a Microcomputer

Albert S Woodhull
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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

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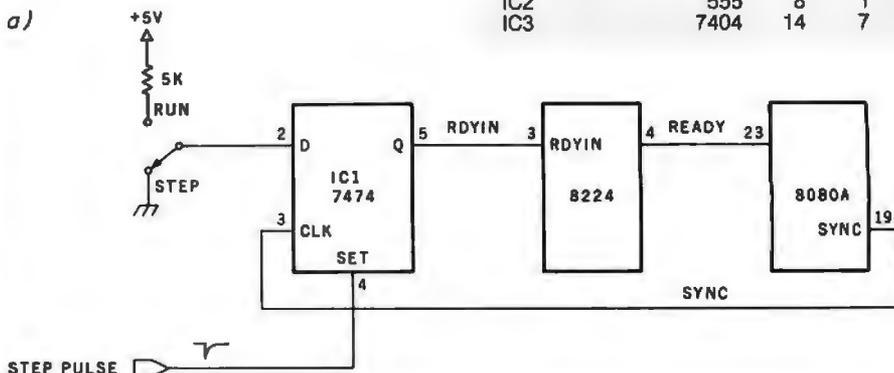


Figure 1a: A single-step mode can be implemented on an 8080A processor by using a flip-flop and the 8080A SYNC signal to clock a low-logic level through to the READY line. This puts the 8080A into a wait state. A very brief pulse to the SET input of the flip-flop ends the wait state until the next SYNC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

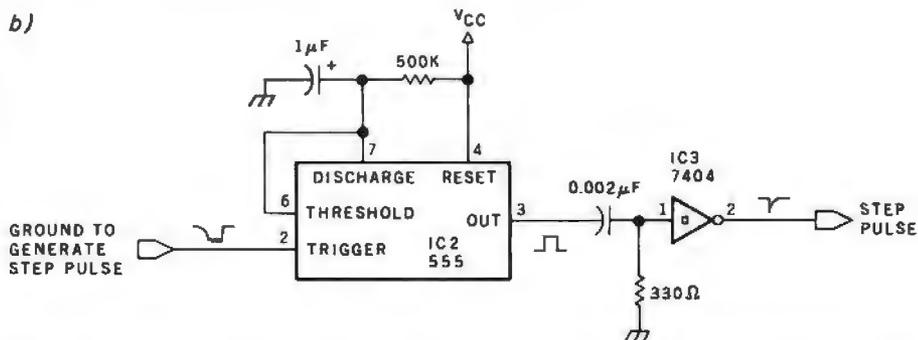


Figure 1b: The very narrow STEP pulse can be generated by a half-monostable circuit, a resistor-capacitor network at the input to a 7400 inverter. The manual switch contact must be debounced by a monostable circuit with a 0.1 to 1 second pulse width, for which a 555 timer is well-suited.

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.

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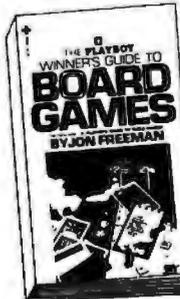
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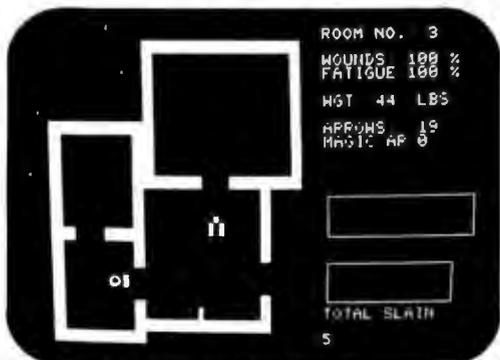
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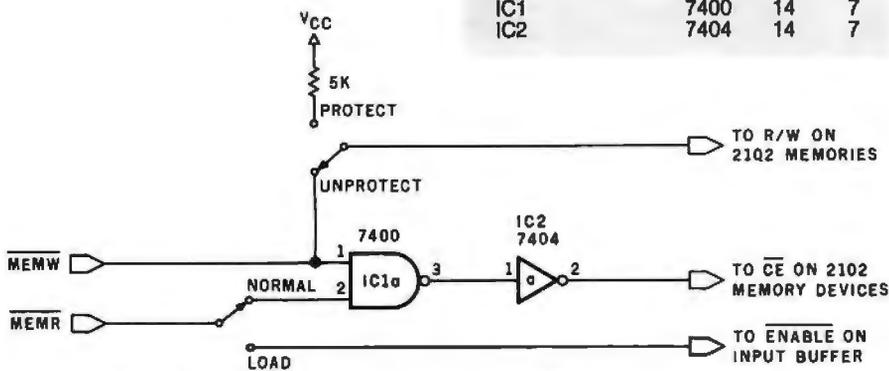


Figure 2: The LOAD/NORMAL switch routes the $\overline{\text{MEMR}}$ signal to an input buffer instead of to the memory, thus enabling the operator to control the processor by entering instruction codes from the outside. Also shown is another switch which can protect memory from inadvertent writing during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

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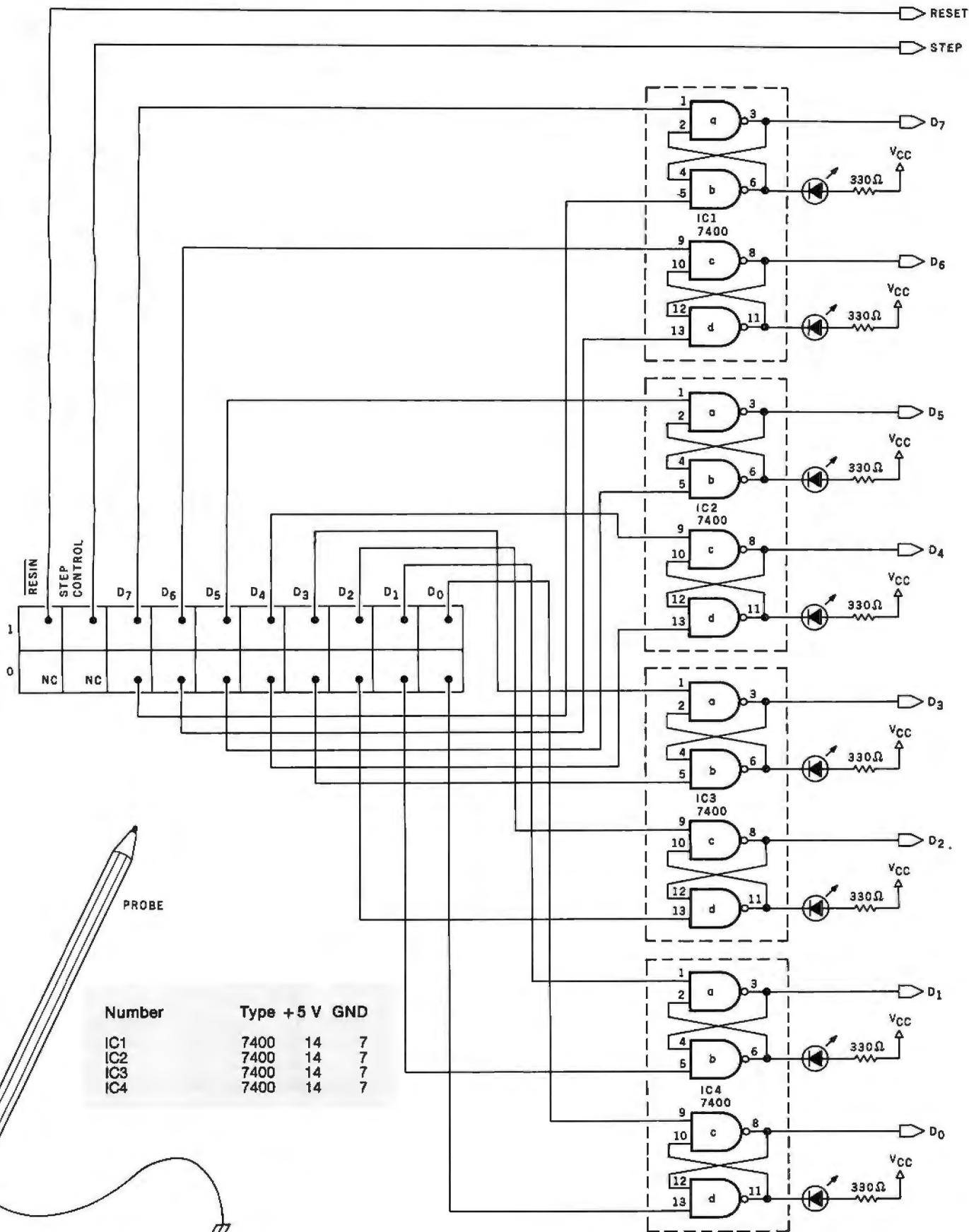


Figure 3: A small scrap of printed circuit board, an old ball-point pen, and some latch flip-flop circuits make a very inexpensive input device. With a little practice, an 8-bit number can be set up as easily and quickly as on a row of toggle switches. The surface of the printed circuit board has been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

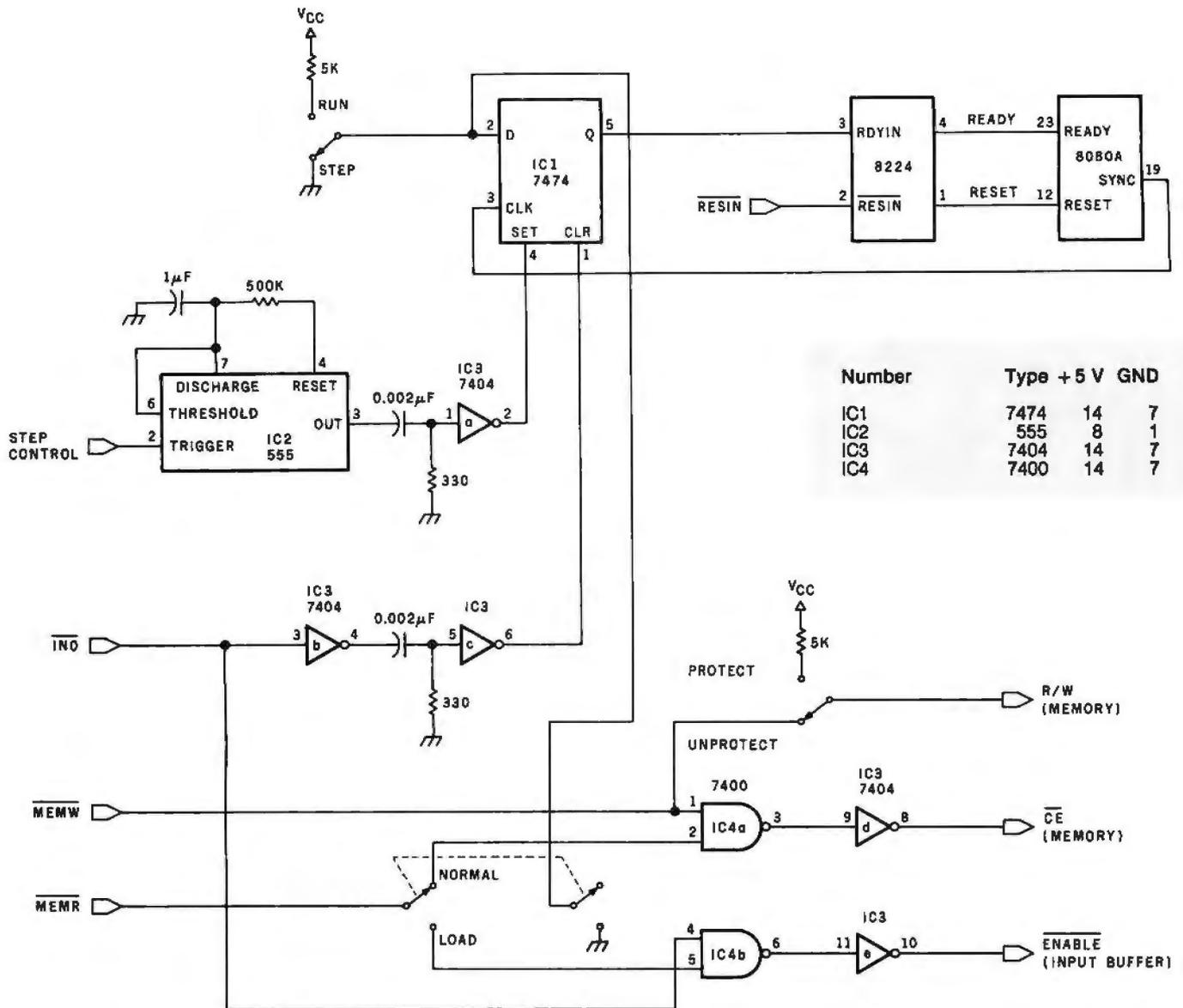


Figure 4: The complete control hardware package described in this article. $\overline{IN0}$ is a control signal produced by getting the IN status signal from the 8080A and the address bus. Its orthodox function is to enable the input buffer; in this circuit the input buffer may also be enabled by a MEMR signal when the LOAD/NORMAL switch is in the LOAD position. $\overline{IN0}$ 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, opera-

tion 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 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 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 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 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.



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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 00	IN	Input Input port address (hardware dependent)
77	MOV M,A INX H	Copy data from accumulator to memory
23		Increment HL, the memory pointer
C3 00 00	JMP	Jump Jump address, low byte 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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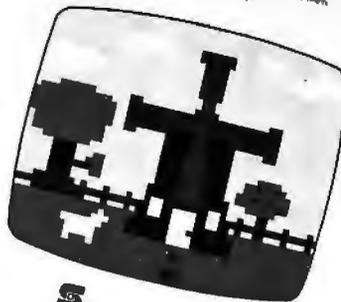
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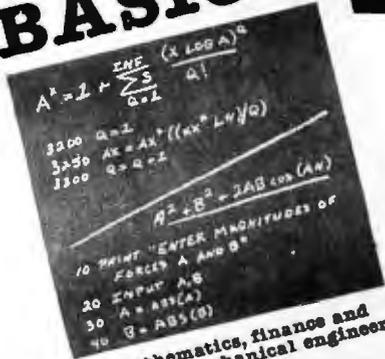
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Hydrocarbon Molecule Constructor

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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_nH_m (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 C₃H₈ ($8 = 2 \times 3 + 2$). 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

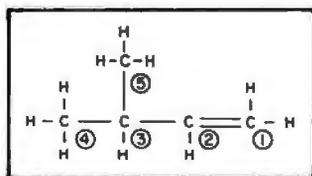


Figure 1: In the hydrocarbon 3-methyl-1-butene, each carbon atom has four connections. This is true of any hydrocarbon molecule.

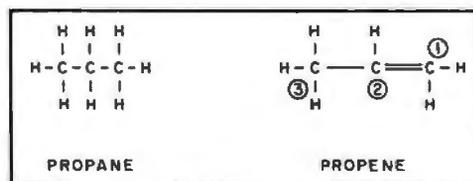


Figure 2: Examples of propane and propene. For any given hydrocarbon with C carbon atoms, the maximum number of possible hydrogen atoms, H, is $2 \times C + 2$.

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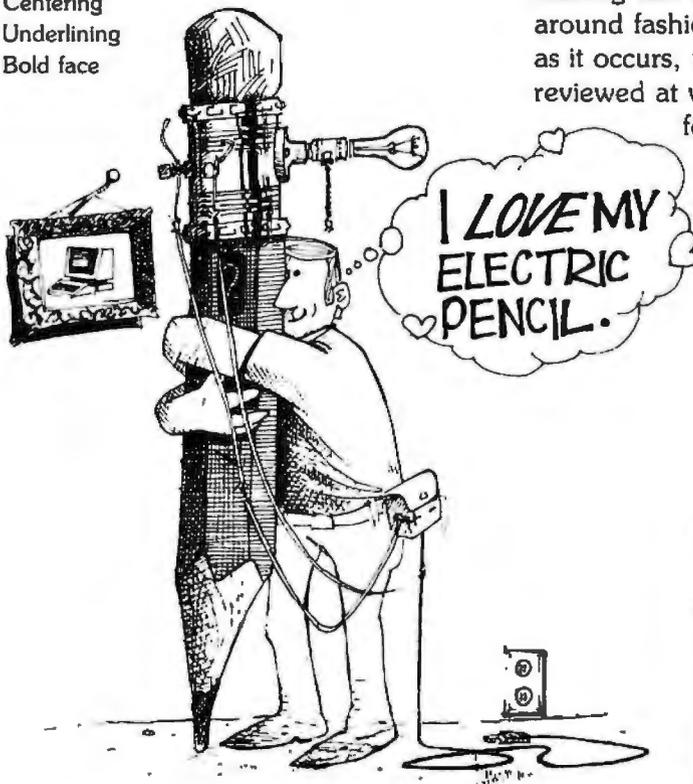
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C1	2	2	0	0
C2	1	1	0	3
C3	4	5	2	0
C4	3	0	0	0
C5	3	0	0	0

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.

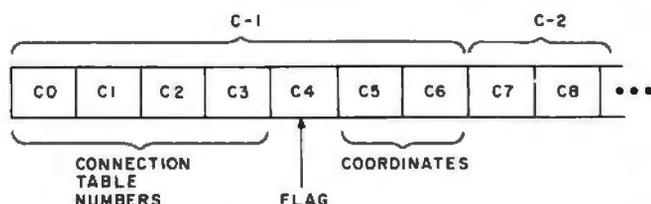


Figure 4: The connection table is stored in array C.

	(a)				(b)			
C1	2	4	0	0	4	4	0	0
C2	1	3	0	0	3	3	0	0
C3	2	4	0	0	2	2	0	0
C4	1	3	0	0	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



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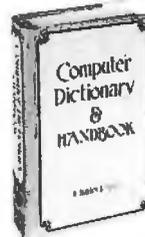
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Figure 6: A more efficient method for connecting the carbon atoms is to first connect C-1 to C-2. A random number between 0 and 3 is then selected and C-3 is bound to that carbon atom (6a,6b). C-4 is then randomly connected to one carbon atom in the 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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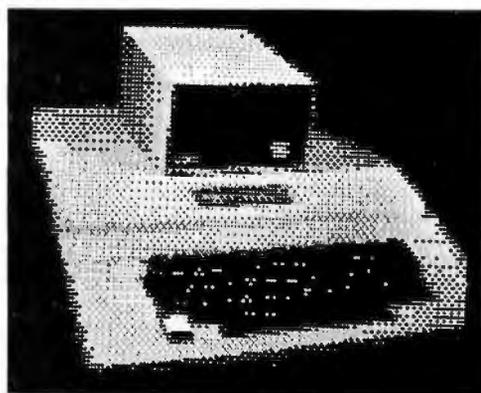
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Listing 1: An Apple II integer-BASIC program for generating hydrocarbon representations using the available high-resolution graphic routines. The high-resolution routines use the graphics tables in listing 2.

```

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', M
  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	1028-	17	17	36	28	2D	D5	DB	C3
1008-	20	04	00	24	2D	2D	24	34	1030-	18	08	18	24	24	24	DF	33
1010-	36	36	FE	1B	24	24	24	D7	1038-	36	36	3E	D8	1E	3F	07	20
1018-	E3	3F	17	36	36	0E	2D	05	1040-	24	64	2D	15	06	00	2E	2D
1020-	20	00	2D	2D	4D	62	AD	F6	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	10C0-	2D	3E	3F						
1058-	33	36	36	3E	D8	1E	3F	07	10C8-	3F	3F	3F	3F	37	2D	2D	2D	2D
1060-	20	24	64	2D	15	06	00	24	10D0-	2D								
1068-	24	24	24	3C	3F	3F	3F	3F	10D8-	3F								
1070-	3F	2D	10E0-	3F	3F	3F	37	2D	2D	2D	2D	2D						
1078-	2D	2D	2D	2D	3E	3F	3F	3F	10E8-	2D	3E							
1080-	3F	37	10F0-	3F														
1088-	2D	10F8-	3F	3F	37	2D	2D	2D	2D	2D	2D							
1090-	2D	2D	2D	3E	3F	3F	3F	3F	1100-	2D	2D	2D	2D	2D	2D	3E	3F	3F
1098-	3F	3F	3F	3F	3F	3F	37	2D	1108-	3F								
10A0-	2D	1110-	3F	37	2D													
10A8-	2D	2D	3E	3F	3F	3F	3F	3F	1118-	2D	2D	2D	2D	2D	3E	3F	3F	3F
10B0-	3F	3F	3F	3F	3F	37	2D	2D	1120-	3F								
10B8-	2D	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 POKE 806, 1	lines 2000, 2190 line 2000	Set color to white. 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 CALL S	line 2180 lines 2190, 2330	Set color to black. 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 ₁
	4166	CH ₃

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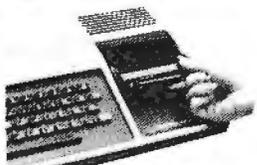
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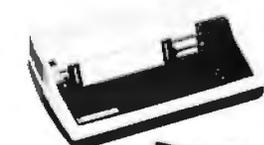
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Text continued from page 160:

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 tetrahydrene (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.



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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:

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- a binary look up routine for the symbol table; and
- routines to let the compiler perform memory



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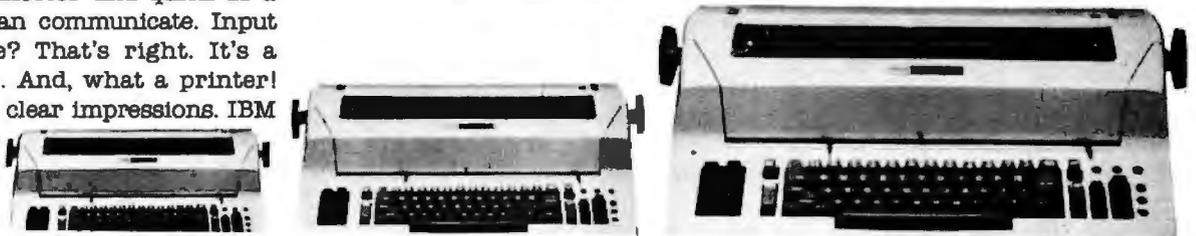
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management for line insert and delete.

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:

```

MOVIT LXI H,2000H
      LXI D,0H
      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.

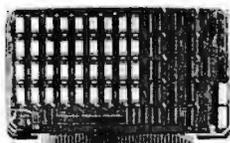
Real-Time BASIC Available Free

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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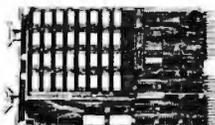
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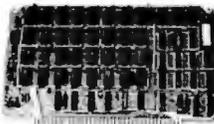
CI-6800-2 64K x 9



CI-S100 64K x 8



CI-1103 32K x 16



CI-6800 64K x 8



CI-8080 64K x 8

CI-6800-2 — 16KB to 64KB. Plugs directly into Motorola's EXORciser I or II. Hidden refresh up to 1.5 Mhz. Cycle stealing at 2 Mhz. Addressable in 4K increments with respect to VXA or VUA. Optional on Board Parity. 64K x 9 \$995.00.

CI-S100 — 16KB to 64KB. Transparent hidden refresh. No wait states at 4 Mhz. Compatible with Alpha Micro and all Major 8080, 8085 and Z80 Based S100 Systems. Expandable to 512 K bytes thru Bank Selecting. 64K x 8 \$750.00.

CI-1103 — 16KB to 64KB on a single dual height board. On board hidden refresh. Plugs directly into LSI 11/2, H11 or LSI 11/23. Addressable in 2K word increments up to 256 K Bytes. 8K x 16 \$390.00. 32K x 16 \$750.00.

CI-6800 — 16KB to 64KB on a single board. On board hidden refresh. Plugs directly into EXORciser I and compatible with Rockwell's System 65. Addressable in 4K increments up to 64K. 16K x 8 \$390.00. 64K x 8 \$750.00.

CI-8080 — 16KB to 64KB on a single board. Plugs directly into MDS 800 and SBC 80/10. Addressable in 4K increments up to 64K. 16 KB \$390.00. 64K \$750.00.

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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.

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*Details available on request.



**ANDERSON
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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

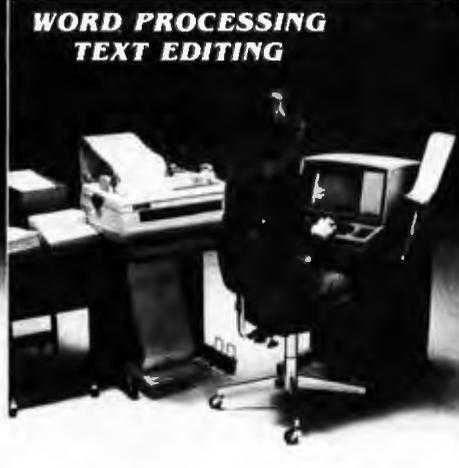
The Washington CP/M Users Group generally meets on the third Wednesday of each month at members' homes. Most members own S-100 disk systems with a variety of microprocessors, disks, terminals, printers, and boards. CP/M is the format of software exchange and the subject of frequent meetings. Annual dues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

PUTTING IT ALL TOGETHER

INVENTORY CONTROL



WORD PROCESSING TEXT EDITING



ACCOUNTING



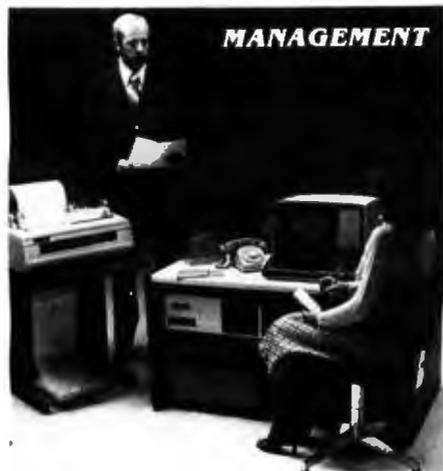
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INCLUDING:

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- Deluxe printer stands and paper trays for both printers

One Discus 29 megabyte (26 megabyte formatted) Winchester technology, fixed hard disk unit with controller, cabinet, power supply, all cables, ports and connectors, completely interfaced to DOS and BASIC, CP/M* PASCAL and Micro Mike's interrupt-driven, bank-switching timesharing (as many as four 29 megabyte hard disk units, seven users, optional)

One custom computer/hard disk desk, Executive model, three CRT stands, thirty 5 1/4" diskettes



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*Micro Mike's, Incorporated Program Library Membership, including:

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- Commodities Charts

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*All programs available separately. Total System \$23,719

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Micro Mike's, Inc. will, for a fee, deliver and set up a system anywhere in the USA. Personal user training and/or custom programming is also available.

*CP/M is a registered trademark of Digital Research.

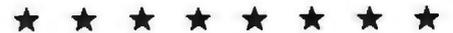
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Discus 29 megabyte Winchester technology fixed, sealed hard disk units completely interfaced to DOS and BASIC, CP/M and PASCAL for most S-100 buss computer systems, ready to go, including controller, cabinet and power supply, all cables, ports and connectors \$5,495

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Discus double density or quad capacity eight inch drives for S-100 buss systems
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Used Intertec Intertube CRTs, as-is condition, close-out \$495

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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.

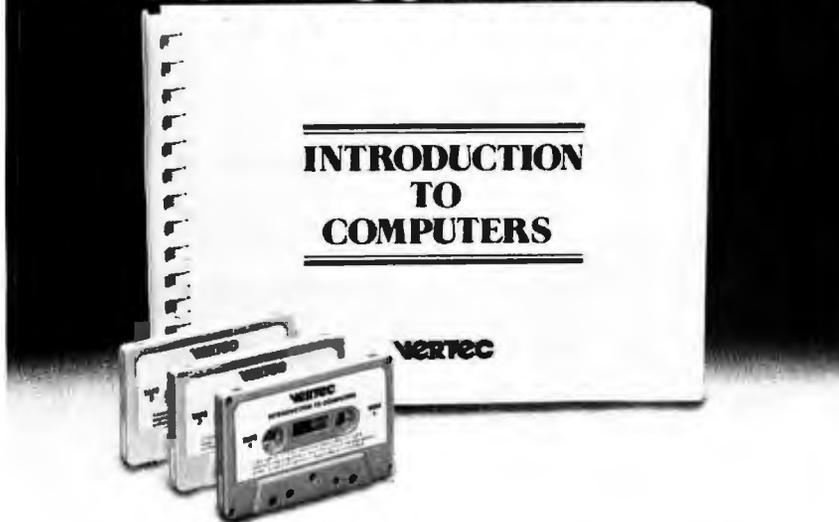
Dental Computer Newsletter

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

IS YOUR BUSINESS READY FOR A COMPUTER?



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THE COMPUTER AND HOW IT WORKS describes the types of memory, storage media, input/output devices, and types of software in understandable terms. A description of different applications software clarifies the typical tasks that a computer may perform.

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By Netronics

ASCII/BAUDOT, STAND ALONE



Computer Terminal

COMPLETE FOR ONLY \$149.95

The Netronics ASCII/BAUDOT Computer Terminal Kit is a microprocessor-controlled, stand alone keyboard/terminal requiring no computer memory or software. It allows the use of either a 64 or 32 character by 16 line professional display format with selectable baud rate, RS232-C or 20 ma. output, full cursor control and 75 ohm composite video output.

The keyboard follows the standard typewriter configuration and generates the entire 128 character ASCII upper/lower case set with 96 printable characters. Features include onboard regulators, selectable parity, shift lock key, alpha lock jumper, a drive capability of one TTY load, and the ability to mate directly with almost any computer, including the new Explorer/85 and ELF products by Netronics.

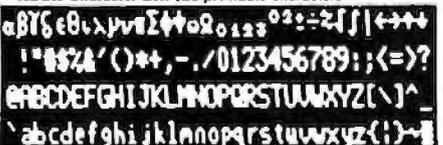
The Computer Terminal requires no I/O mapping and includes 1k of memory, character generator, 2 key rollover, processor controlled cursor control, parallel ASCII/BAUDOT to serial conversion and serial to video processing—fully crystal controlled for superb accuracy. PC boards are the highest quality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

VIDEO DISPLAY SPECIFICATIONS

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

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

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



BAUDOT Character Set: A B C D E F G H I J K L M N O P Q R S T U V W X Y Z - ; ' * 3 8 () , . 0 1 4 5 7 ; 2 / 6 8 • Cursor Modes: Home, Backspace, Horizontal Tab, Line Feed, Vertical Tab, Carriage Return. Two special cursor sequences are provided for absolute and relative X-Y cursor addressing • Cursor Control: Erase, End of Line, Erase of Screen, Form Feed, Delete • Monitor Operation: 50 or 60Hz (jumper selectable).

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

Please send the items checked below—
[] Netronics Stand Alone ASCII Keyboard/Computer Terminal Kit, \$149.95 plus \$3.00 postage & handling.
[] Deluxe Steel Cabinet for Netronics Keyboard/Terminal In Blue/Black Finish, \$19.95 plus \$2.50 postage and handling.
[] Video Display Board Kit alone (less keyboard), \$89.95 plus \$3 postage & handling.
[] 12" Video Monitor (10 MHz bandwidth) fully assembled and tested, \$139.95 plus \$3 postage and handling.
[] RF Modulator Kit (to use your TV set for a monitor), \$8.95 postpaid.
[] 5 amp Power Supply Kit In Deluxe Steel Cabinet (±8VDC @ 5 amps, plus 6-8 VAC), \$39.95 plus \$2 postage & handling.
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Start Computing For Just \$129.95 With An 8085-Based Professional Computer Kit—

Explorer/85

100% compatible with all 8080A and 8085 software & development tools!

No matter what your future computing plans may be, Level "A"—at \$129.95—is your starting point.

Starting at just \$129.95 for a Level "A" operating system, you can now build the exact computer you want. Explorer/85 can be your beginner's system. OEM controller, or IBM-formatted 8" disk small business system... yet you're never forced to spend a penny for a component or feature you don't want and you can expand in small, affordable steps!

Now, for just \$129.95, you can own the first level of a fully expandable computer with professional capabilities—a computer which features the advanced Intel 8085 cpu, thereby giving you immediate access to all software and development tools that exist for both the 8085 and its 8080A predecessor (they are 100% software compatible)—a computer which features onboard S-100 bus expansion—plus instant conversion to mass storage disk memory with either 5-1/4" diskettes or standard IBM-formatted 8" disks.

For just \$129.95 (plus the cost of a power supply, keyboard/terminal and RF modulator, if you don't have them already), Explorer/85 lets you begin computing on a significant level... applying the principles discussed in leading computer magazines... developing "state of the art" computer solutions for both the industrial and leisure environment.

Level "A" Specifications

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

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

PC Board: glass epoxy, plated through holes with solder mask • I/O: provisions for 25-pin (DB25) connector for terminal serial I/O, which can also support a paper tape reader... provision for 24-pin DIP socket for hex keypad/display... cassette tape recorder input... cassette tape control output... speaker output... LED output indicator on SOD (serial output) line... printer interface (less drivers)... total of four 8-bit plus one 6-bit I/O ports • Crystal Frequency: 6.144 MHz • Control Switches: reset and user (RST 7.5) interrupt... additional provisions for RST 5.5, 6.5 and TRAP interrupts onboard • Counter/Timer: programmable, 14-bit binary • System RAM: 256 bytes located at F800, ideal for smaller systems and for use as an isolated stack area in expanded systems... RAM expandable to 64k via S-100 bus or 4K on motherboard.

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

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

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Netronics R&D Ltd., Dept. RE 10
333 Litchfield Road, New Milford, CT 06676

Please send the items checked below—
[] Explorer/85 Level "A" Kit (ASCII Version), \$129.95 plus \$3 p&h.
[] Explorer/85 Level "A" Kit (Hex Version), \$129.95 plus \$3 p&h.
[] 8k Microsoft BASIC on cassette tape, \$64.95 postpaid.
[] 8k Microsoft BASIC in ROM Kit (requires Levels "B," "D," and "E"), \$99.95 plus \$2 p&h.
[] Level "B" (S-100) Kit, \$49.95 plus \$2 p&h.
[] Level "C" (S-100 6-card expander) Kit, \$39.95 plus \$2 p&h.
[] Level "D" (4k RAM) Kit, \$69.95 plus \$2 p&h.
[] Level "E" (EPROM/ROM) Kit, \$5.95 plus 50¢ p&h.
[] Deluxe Steel Cabinet for Explorer/85, \$49.95 plus \$3 p&h.
[] ASCII Keyboard/Computer Terminal Kit (features a full 128 character set, upper & lower case, full cursor control, 75 ohm video output convertible to baudot output, selectable baud rate, RS232-C or 20 ma. I/O, 32 or 64 character by 16 line formats, and can be used with either a CRT monitor or a TV set (if you have an RF modulator), \$149.95 plus \$2.50 p&h.
[] Hex Keypad/Display Kit, \$69.95 plus \$2 p&h.
[] Deluxe Steel Cabinet for ASCII Keyboard/Terminal, \$19.95 plus \$2.50 p&h.
[] Power Supply Kit (±8V @ 5 amps) in deluxe steel cabinet, \$39.95 plus \$2 p&h.
[] Gold Plated S-100 Bus Connectors, \$4.85 each, postpaid.
[] RF Modulator Kit (allows you to use your TV set as a monitor), \$8.95 postpaid.
[] 16k RAM Kit (S-100 Board expands to 64k), \$199.95 plus \$2 p&h.
[] 32k RAM Kit, \$329.95 plus \$2 p&h.
[] 48k RAM Kit, \$459.95 plus \$2 p&h.
[] 64k RAM Kit, \$589.95 plus \$2 p&h.
[] 16k RAM Expansion Kit (to expand any of the above up to 64k), \$139.95 plus \$2 p&h each.
[] Intel 8085 cpu User's Manual, \$7.50 postpaid.
[] Special Computer Grade Cassette Tapes, \$1.90 each or 3 for \$5, postpaid.
[] 12" Video Monitor (10 MHz bandwidth), \$139.95 plus \$3 p&h.
[] North Star Double Density Floppy Disk Kit (One Drive) for Explorer/85 (includes 3 drive S-100 controller, DOS, and extended BASIC with personalized disk operating system—just plug it in and you're up and running!), \$699.95 plus \$5 p&h.
[] Power Supply Kit for North Star Disk Drive, \$39.95 plus \$2 p&h.
[] Deluxe Case for North Star Disk Drive, \$39.95 plus \$2 p&h.
[] Experimenter's Pak (see above), \$199.90 postpaid.
[] Student Pak (see above), \$319.85 postpaid.
[] Engineering Pak (see above), \$514.75 postpaid.
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(Conn. res. add sales tax) By—
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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 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 select-able 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.

Level "C" Specifications

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

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

Level "D" Specifications

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

Level "E" Specifications

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

Order A Coordinated Explorer/85 Applications Pak!

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

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

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

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

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focus on computer related evidence, electronic funds transfer systems (EFTS), computer crimes and software taxation. The journal is published by the Center for Computer Law, 530 W 6th St, 10th Floor, Los Angeles CA 90014.

Scampus

Articles on bus structures, software, conversion circuits and other aspects of micro-computers 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 Newsletter*. 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
```

Peter B Maggs
2011 Silver Ct E
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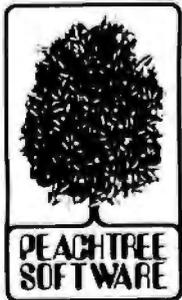
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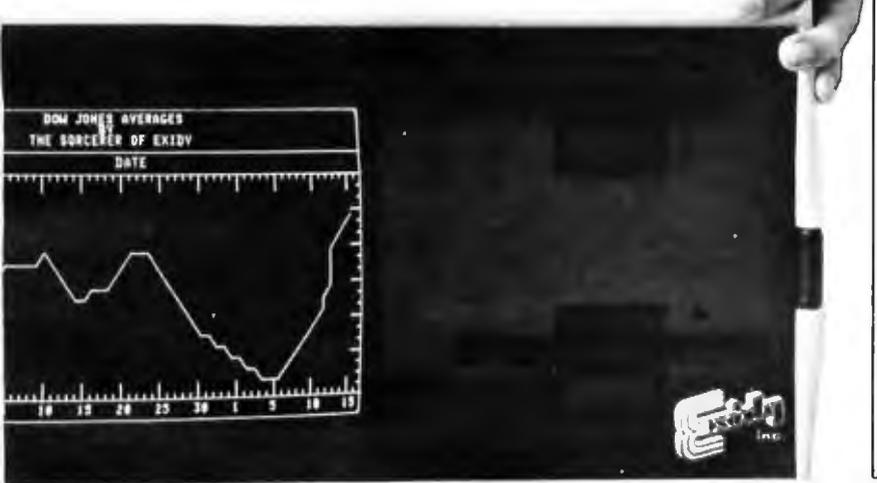
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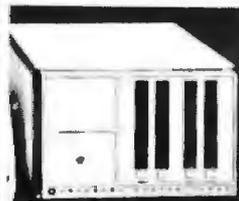
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Technical Forum

The Direct Impact of the Computer

Richard S Shuford, Editor

Some years ago, I was doing volunteer work for a non-profit 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.

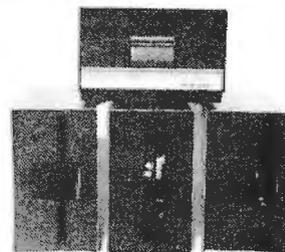
```

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 ■

```

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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:

$$B = \text{INT} (C1 \times A + C2) \quad (1)$$

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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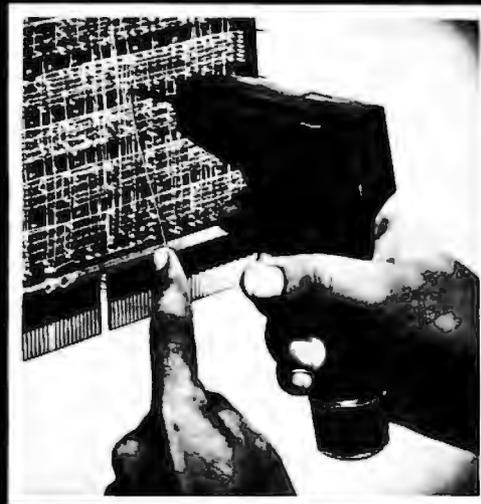
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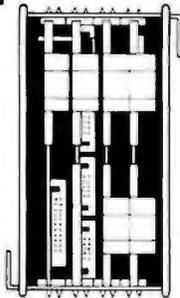
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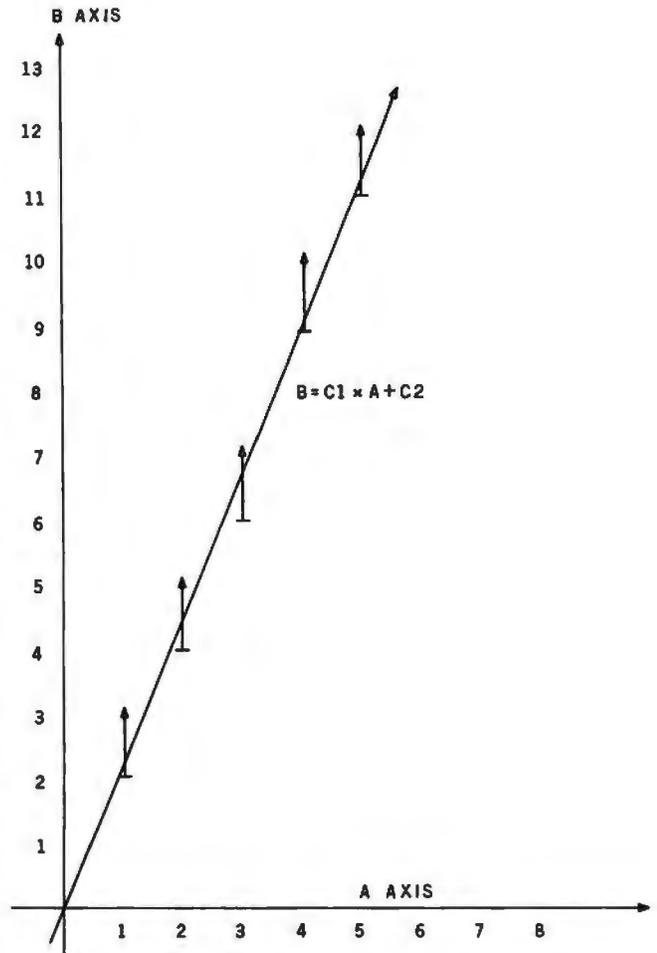


Figure 1: Fitting the numbers 2, 4, 6, 9, 11 to the straight-line equation $B = C1 \times A + C2$. Given the sequence 2, 4, 6, 9, 11, we can represent this in two dimensions by letting the horizontal axis represent the order of the number in the sequence (first, second, etc), and the vertical axis, the 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:

$$B = \text{INT} (30.58 \times M - 30.08) \quad (2)$$

A quick check with our BASIC program shows that we can get away with three bytes less with the following equation:

$$B = \text{INT} (30.57 \times M - 30) \quad (3)$$

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:

$$B = \text{INT} (30.57 \times M - 30) + \text{INT} (365.25 \times (Y - 1 - 72)) \quad (4)$$

This may be rearranged to:

$$B = \text{INT} (30.57 \times M) + \text{INT} (365.25 \times Y - 26693.25) \quad (5)$$

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.

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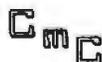
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Listing 1: BASIC routines for converting between the Julian date and the calendar (month, day, year) date and for determining the day of the week from the Julian date. In Processor Technology BASIC, the multiple-line user-defined functions (ending 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 $256 \times 256 / 365.25 = 179$ 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. ■

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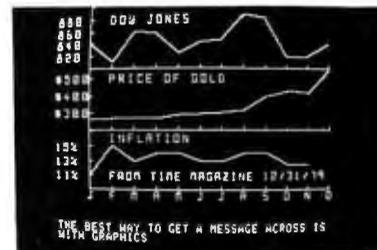
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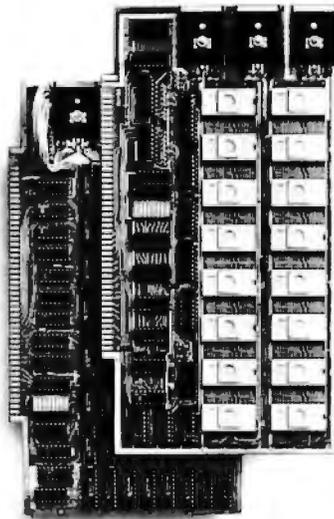
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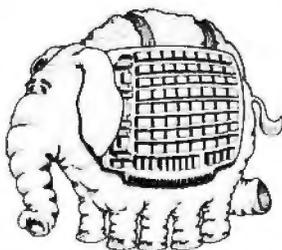
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8080 and 8085 Operation Codes

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 8) 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 other-

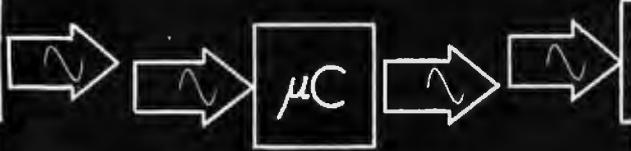
wise noted.) Regardless of the column, progression through the eight possible choices for the source (second) operand is always in the same sequence as the user moves down a column: registers B thru L; followed by memory reference; and finally, register A, the accumulator. Then, because each column has 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

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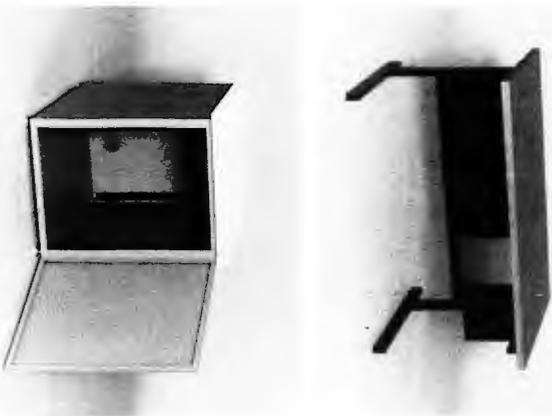
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First Nybble

	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

Second Nybble

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

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- (6). Dump BASIC program on disk for later appending.
- (7). Append BASIC program from tape.
- (8). Append BASIC program from disk.
- (9). Renumber BASIC program with standard beginning line number and increment.
- (10). Renumber BASIC program with custom beginning line number and increment.
- (11). Display contents of registers.
- (12). Display memory.
- (13). Execute machine language program starting at address in program counter.
- (14). Execute machine language program beginning at address given.
- (15). Exit to BASIC.
- (16). Compact BASIC program, removing all unnecessary spaces.
- (17). Eliminate from BASIC program range of line numbers given.
- (18). Display directory for disk drive #0.
- (19). Display directory for disk drive #1.
- (20). Trace execution of BASIC program.
- (21). Turn off Trace.
- (22). Help.

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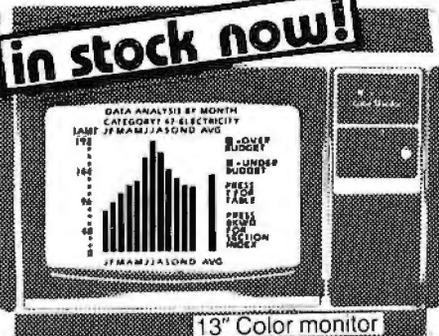
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Z80. Because of the Z80's generally higher speed, software timing loops are an exception to this upward compatibility feature. [Editor's note: There is also a slight difference in the operation of the parity flag . . . RSS]

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-

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Second Nybble	0	NOF	INZ ^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 PC,nn	JP F,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	RRCA,AP ^e	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	EXI	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 5	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.

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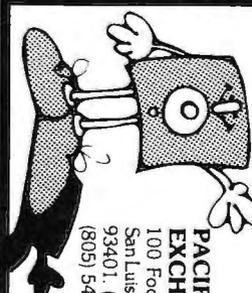
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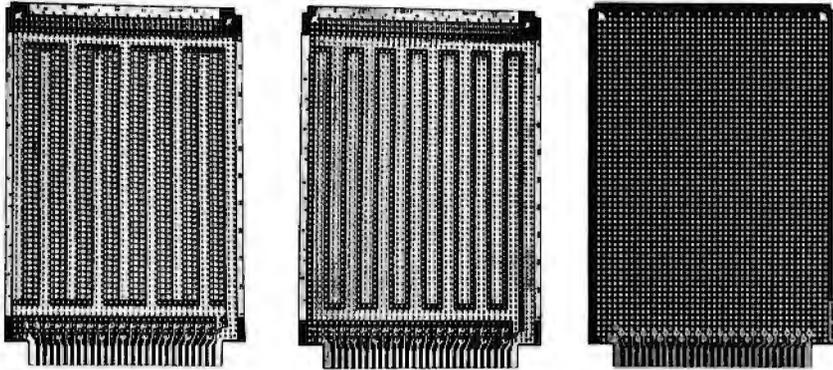


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mode instructions to shift or rotate (in either direction) any byte in memory or in any of the eight active registers are located here. Table 3 also contains the direct-mode instructions to set, reset, or test any bit in any of these bytes. All of 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

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		0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
Second Nybble	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.

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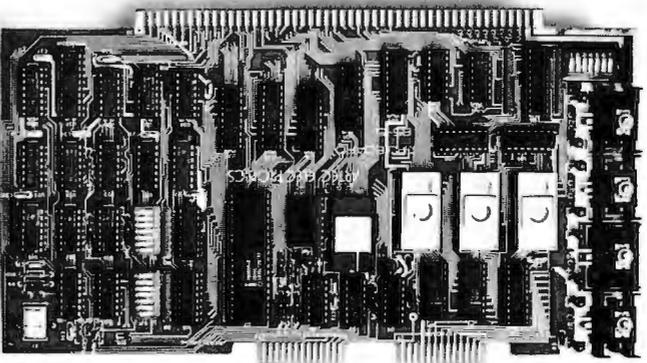


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Second Nybble	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0								LD (IX+d), B								
1			LD IX, nn					LD (IX+d), C							POP IX	
2			LD (nn), IX					LD (IX+d), D								
3			INC IX					LD (IX+d), E								
4			DEC (IX+d)					LD (IX+d), H								
5			DEC (IX+d)					LD (IX+d), L								
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												
A			LD IX, (nn)													
B			DEC IX													
C													See Table 5			
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															JP (IX)	LD SP, IX

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.

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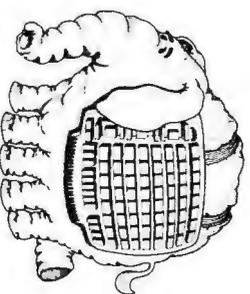
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		First Nybble															
		0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
Second Nybble	0																
	1																
	2																
	3																
	4																
	5																
	6	RLC (IX+d)	RL (IX+d)	SIA (IX+d)		BIT 0,(IX+d)	BIT 2,(IX+d)	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.

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Second Byte	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0															
1		LD IY,nn					LD (IY+d),B							POP IY	
2		LD (mm),IY					LD (IY+d),C								
3		INC IY					LD (IY+d),D							EX (SP),IY	
4							LD (IY+d),E								
5							LD (IY+d),H							PUSH IY	
6							LD (IY+d),L								
7							LD (IY+d),A								
8								ADD A,(IY+d)							
9								SUB (IY+d)							
A															
B															
C															
D															
E															
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															
		0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
Second Nybble	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.

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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 riddled 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. ■

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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	075	32	X↵T	150	00	00
001	10	E'	076	00	0	151	72	ST*
002	32	X↵T	077	77	GE	152	02	02
003	86	STF	078	00	00	153	48	EXC
004	03	03	079	92	92	154	00	00
005	87	IFF	080	01	1	155	65	X
006	01	01	081	00	0	156	43	RCL
007	02	02	082	06	6	157	04	04
008	65	65	083	22	INV	158	95	=
009	22	INV	084	77	GE	159	44	SUM
010	86	STF	085	00	00	160	05	05
011	03	03	086	92	92	161	99	PRT
012	86	STF	087	87	IFF	162	91	R/S
013	01	01	088	02	02	163	22	INV
014	86	STF	089	00	00	164	87	IFF
015	02	02	090	96	96	165	02	02
016	01	1	091	92	RTN	166	00	00
017	69	DP	092	02	2	167	92	92
018	17	17	093	94	+/-	168	22	INV
019	47	CMS	094	34	FX	169	86	STF
020	08	8	095	91	R/S	170	01	01
021	69	DP	096	43	RCL	171	92	RTN
022	17	17	097	06	06	172	76	LBL
023	01	1	098	55	÷	173	17	B'
024	42	STD	099	02	2	174	87	IFF
025	04	04	100	85	+	175	02	02
026	32	X↵T	101	93	.	176	00	00
027	91	R/S	102	05	5	177	92	92
028	76	LBL	103	95	=	178	29	CP
029	11	A	104	42	STD	179	22	INV
030	71	SBR	105	01	01	180	67	EQ
031	01	01	106	59	INT	181	01	01
032	63	63	107	42	STD	182	88	88
033	29	CP	108	02	02	183	43	RCL
034	67	EQ	109	32	X↵T	184	07	07
035	00	00	110	43	RCL	185	61	GTD
036	40	40	111	01	01	186	02	02
037	42	STD	112	22	INV	187	18	18
038	04	04	113	67	EQ	188	55	÷
039	91	R/S	114	01	01	189	01	1
040	43	RCL	115	19	19	190	52	EE
041	04	04	116	02	2	191	03	3
042	91	R/S	117	42	STD	192	95	=
043	76	LBL	118	03	03	193	42	STD
044	12	B	119	01	1	194	00	00
045	71	SBR	120	09	9	195	01	1
046	01	01	121	44	SUM	196	52	EE
047	63	63	122	02	02	197	06	6
048	29	CP	123	73	RC*	198	22	INV
049	67	EQ	124	02	02	199	64	PD*
050	00	00	125	42	STD	200	01	01
051	55	55	126	00	00	201	43	RCL
052	42	STD	127	01	1	202	00	00
053	06	06	128	52	EE	203	74	SM*
054	91	R/S	129	06	6	204	01	01
055	43	RCL	130	64	PD*	205	69	DP
056	06	06	131	02	02	206	21	21
057	91	R/S	132	73	RC*	207	93	.
058	76	LBL	133	02	02	208	05	5
059	13	C	134	59	INT	209	22	INV
060	71	SBR	135	22	INV	210	44	SUM
061	01	01	136	74	SM*	211	01	01
062	63	63	137	02	02	212	69	DP
063	43	RCL	138	55	÷	213	27	27
064	05	05	139	01	1	214	43	RCL
065	99	PRT	140	52	EE	215	07	07
066	98	ADV	141	03	3	216	22	INV
067	91	R/S	142	95	=	217	52	EE
068	76	LBL	143	22	INV	218	91	R/S
069	15	E	144	52	EE	219	61	GTD
070	71	SBR	145	97	DSZ	220	01	01
071	01	01	146	03	03	221	88	88
072	63	63	147	01	01	222	76	LBL
073	43	RCL	148	27	27	223	16	A'
074	06	06	149	48	EXC	224	42	STD

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233	02	02	252	43	RCL	271	22	INV
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235	00	00	254	22	INV	273	02	02
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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	GTD
241	95	=	260	02	02	279	00	00
242	55	+	261	75	75	280	09	09
243	02	2	262	43	RCL			

(a)	A'	B'	C'	D'	E'
	A	B	C	D	E

(b)	Atomic Weights			
	Load Atomic Number	Load Atomic Weight		Initialize
	N (Occurrence of an Atom)	Atomic Number	Sum of Weights	Run

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
1.	To load atomic weight 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.)		
7.	To change atomic weight data 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.		

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

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
1.	To find atomic weight Initialize.	E'	does not change
2.	(When program is initialized, the display is preserved.) Enter atomic number.	B,E	value of atomic weight*
3.	Repeat step 2 for new atomic number.		
4.	To find molecular weight Initialize.	E'	does not change
5.	Enter atomic number.	B	does not change
6.	Enter how many of that particular element.	A,E	A X atomic weight*
7.	Repeat steps 5 and 6 for each element.		
8.	Calculate total weight (sum weight.)	C	total weight of molecule*
9.	(Note: label C is a subtotal.) 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.

sacrifice speed of execution for ease of operation and protection of loaded data.

This program will enable you to:

- Display atomic weights by entering the corresponding atomic numbers.
- Calculate molecular weights.
- Calculate any combination of atomic weights.
- Load atomic weights either sequentially or randomly.
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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 sub-routines.

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

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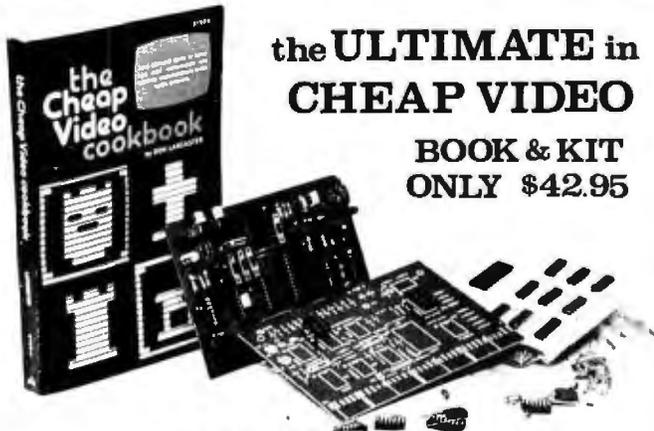
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The assembler mnemonics and hexadecimal code for the multiplication subroutine are given in listing 2. The division subroutine is given in similar form in listing 3. The multiplication subroutine is shown in hexadecimal memory-dump form in listing 4; the division code in that form in listing 5.

My colleagues 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

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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 OD
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
; 180160071849FF69018507A50649FF69008506A500850A5018505081B
; 180178A5031865018503A5026500850238A507E9018507A506E90007C0
; 1801908506C900D0E2A507C900D0DCCAD015A50249FF8502A503490BBE6
; 1801A8FF1869018503A5026900850260E9008D0600C900D0DBA070982
; 0000080008 0

```

Listing 5: Division subroutine in hexadecimal memory-dump form.

```

; 18003018D8A900AA85028503A500D005A501D015601012E8A5011808C7
; 18004849FF69018501A50049FF69008500A506D026A507F018C9010992
; 180060D032CAD012A5011849FF69018503A50049FF6900850260A50A00
; 180078018503A5008502601012E8A5071849FF69018507A50649FF08A4
; 18009069008506A5031869018503A5026900850238A501E50785010735
; 1800A8A500E5068500A5003008D0E0A501D0DCF00D38A503E901850B00
; 1800C003A502E9008502CAD015A50249FF8502A50349FF186901850A0E
; 1800D803A5026900850260002A3F3C3B3F1E3E3E3E3E1E3E7E7A7F0782
; 0000080008 ■

```

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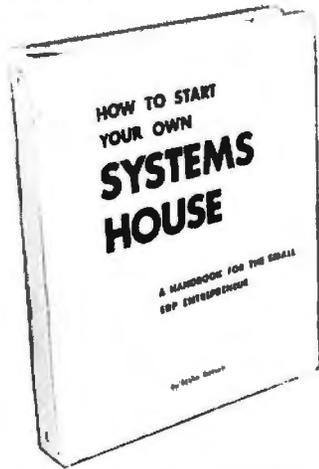
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March 11-13

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.

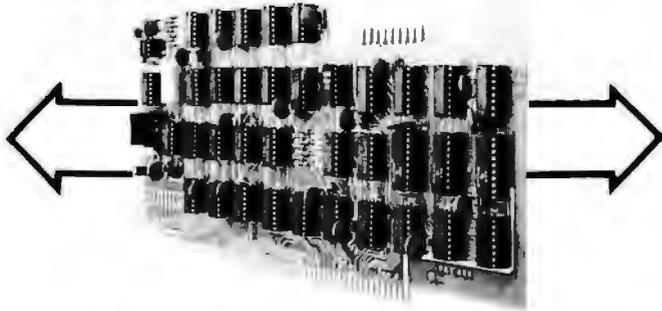
March 18-20

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-

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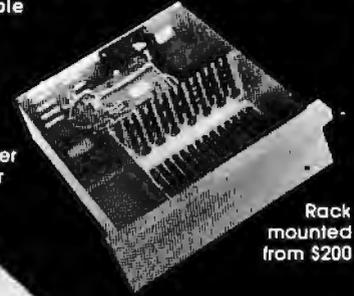


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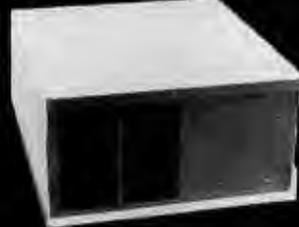
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bank CA. This traveling exhibition of components, materials, and instruments is being produced by the Electronic Representatives Association (ERA). Over eighty ERA member firms will participate, and products from over 700 electronic companies will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

March 24-26

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

March 24-28

Fourth European Conference on Electrotechnics, Stuttgart. This conference will review recent developments, trends, and applications in the field of microelectronics. Microprocessors, computer communication, industrial electronics, applications of microelectronics in the automobile and in medicine, and other topics will be covered. The conference language will be English. Contact Professor Dr W E Proebster, IBM Deutschland GmbH, Postfach 80 08 80, D-7000 Stuttgart 80 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.

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March 30

Greater Baltimore Hamboree and Computefest, 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.

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-

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.

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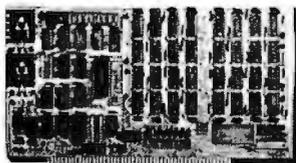
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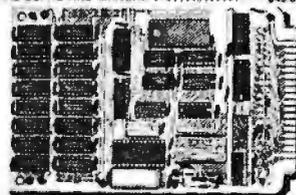
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For more information, contact the UCLA Extension at POB 24901, Dept K, UCLA Extension, Los Angeles CA 90024.

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

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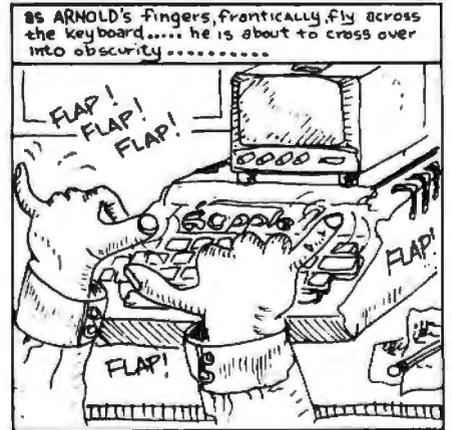
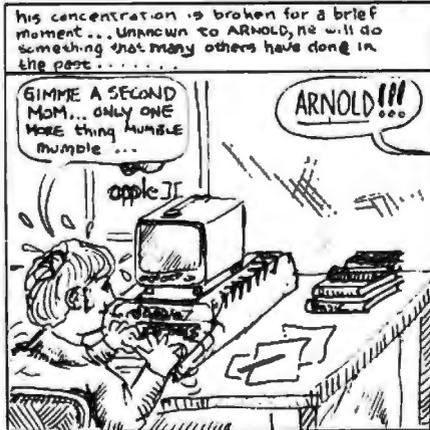
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cover information in the marketplace, information transfer and policy issues, right to access, new information technologies and applications, and other subjects. For more information, contact the Program Chairman, 8th Annual CAIS Conference, Technical 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.

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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 mini-computers, computer architecture, and new concepts in memories in the area of hardware.

For information, contact American Federation of In-

formation Processing Societies Inc, 1815 N Lynn St, Arlington VA 22209.

May 21-22

2nd Clemson Small Computer Conference, Clemson University, Clemson SC. This conference will discuss applications in engineering, science, manufacturing, small business data processing, and education. Contact William J Barnett, Electrical and Computer Engineering Dept, Riggs Hall, Clemson University, Clemson SC 29631.

May 24-25

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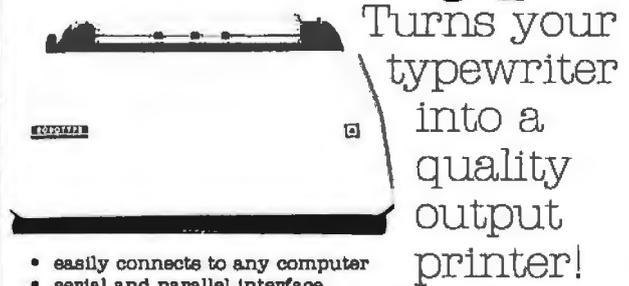
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To Err Is Human

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

Roger A McGregor
6933 S Allison Way
Littleton CO 80123

or compiler may shed light on how an automated correction can be attempted.

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?

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.

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.

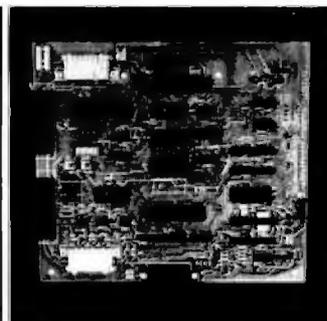
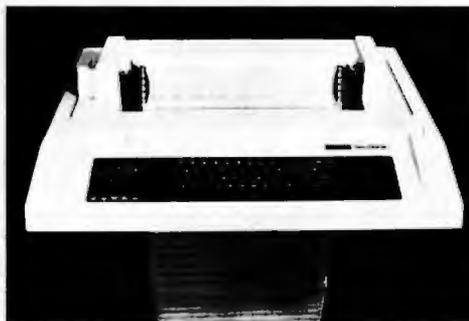
Besides alleviating reassembly problems, the error correction process tends to encourage better documented programs. Due to the nature of the checks made for the association, longer symbols have a better chance of being correctly associated. They are also usually more meaningful.

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. ■

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```

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"\LINE#0
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$(D+1,D+1)\NEXT
120!"HERE IS MY BOARD"\!"\GOSUB1000!\!"\!"ENTER MOVES BY",
130!" NUMBER AND YOUR'RE X"
140 !""\INPUT"YOUR MOVE ? ",X\IFX<1ORX>64THEN140\IF5(X)<>0THEN140
150 S(X)=1\A=X*4\C$(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)<0THEN210\Q=V(A)\X=A
210 V(A)=0\NEXT\IFQ=0ANDZ=1THEN1600\IFQ<>0THEN220
215 FORA=1TO64\IF5(A)=0THENEXIT217\NEXT\GOTO1600
217 S(A)=1\X=A
220 S(X)=1\A=X*4\C$(A-3,A)="0000"\P=5\GOSUB900
230 !"I WENT",X!\!"\GOSUB1000\GOTO140
400 !"THE COMPUTER WINS WITH BOXES",W(0,A),W(1,A),W(2,A),W(3,A)\GOTO2000
500 FORF=0TO3\G=W(F,A)\IF5(G)=0THENV(B)=U(G)+B\NEXT\RETURN
900 FORA=0TO6\C=N(A,X)\IFC=0THEN950\IFT(C)<0THEN950
910 T(C)=T(C)+P\IFT(C)<4THEN950\IFT(C)=4THENEXIT1700
920 D=INT(T(C)/5)\IFD#5<>T(C)THEN(T(C))=-1
950 NEXT\RETURN
1000 FORA=0TO3\FORB=2TO0STEP-2\FORC=0TO0\FORD=1TO4
1010 E=((C*16)+D+(A*4))*4-B\C$(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\IF5(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

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SORT	32K	49	SORT	680K	2569
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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

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

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.

For comparison of strategies, the tic-tac-toe program, written by R K Loudon ("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
=====
  =  =  =  =  =  =  =  =  =  =  =  =  =  =  =  =  =  =  =  =  =  =
13 = 14 = 15 = 16   29 = 30 = 31 = 32   45 = 46 = 47 = 48   61 = 62 = 63 = 00

YOUR MOVE ?

```

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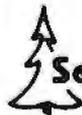
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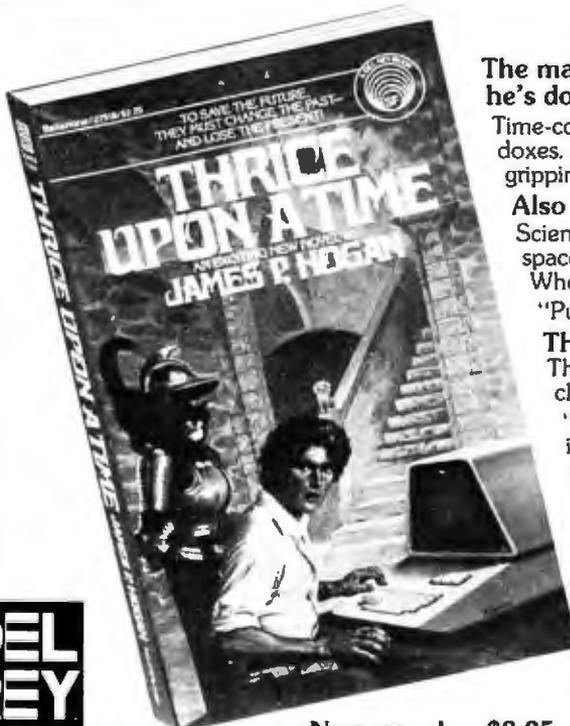
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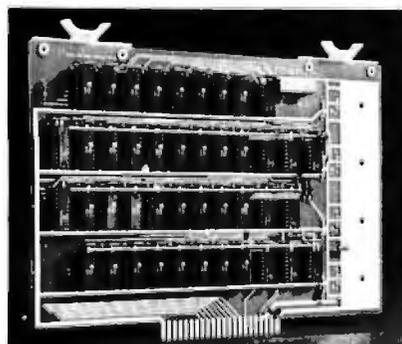
Combination	Variable	Value (Defensive Version)	Value (Aggressive Version)
All Blanks		1	1
One X	P(0)	22	7
Two Xs	P(1)	147	22
Three Xs	P(2)	1030	147
One O	P(3)	2	2
Two Os	P(4)	3	3
All Others	-	0	0

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.

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

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.



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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 DIM$(256),S(64),W(3,76),T(76),N(6,64),P(4),V(64)
15 DIMM(1,36)
20 C1$="0123456789\NP(0)=23\N(1)=147\N(2)=1030\N(3)=2\N(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 REA#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$(A-3,A)="    "C=INT(A/10)\D=A-(C*10)
110 C$(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)="XXX"\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)<0THEN210\Q=V(A)\X=A
210 V(A)=0\NEXT\IFQ=0THEN1900
220 S(X)=1\A=X*4\C$(A-3,A)="0000"\P=5\GOSUB900
230 M(1,C9)=X\C9=C9+1\GOTO145
400 !"THE COMPUTER WINS WITH BOXES",W(0,A),W(1,A),W(2,A),W(3,A)\GOTO2000
500 FDRF=0TO3\B=W(F,A)\IFS(G)=0THENV(G)=V(G)+B\NEXT\RETURN
660 Q=0\FORA=1TO76STEPZ\C=T(A)\IFC<0THEN700\IFC=3THENEXIT400
670 IFC<>0THEN680\B=1\GOSUB500\GOTO700
680 IFC5THEN690\B=INT(C/5)\B=Y(B-1)\GOSUB500\GOTO700
690 B=Y(C+2)\GOSUB500
700 NEXT\FORA=1TO64\IFV(A)<0THEN710\Q=V(A)\X=A
710 V(A)=0\NEXT\IFQ=0THEN1900
720 GOTO150
900 FORA=0TO6\C=N(A,X)\IFC=0THEN950\IFT(C)<0THEN950
910 T(C)=T(C)+P\IFT(C)<4THEN950\IFT(C)=4THENEXIT1700
920 D=INT(T(C)/5)\IFD#5<>T(C)THENT(C)=-1
950 NEXT\RETURN
1000 RETURN
1700 "  \F=C\BOSUB1000!\C=F\YOU WON",W(0,C),W(1,C),W(2,C),W(3,C)
1900 "  \IT'S A DRAW"
2000 Z$=" "
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!\X3I,M(0,A),\NEXT
2030 !"  \!\"PLAYER 2"\FORA=1TO36\IFM(1,A)=0THENEXIT2035!\X3I,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

```

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Listing 5: Sample printout of two-dimensional version of Super TIC (see listing 2).

```

O TO 9 : O 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
    
```

1	X	X	X	X	X	X	X	X	X	X	2	X	X	X	X	X	X	X	X	X
3	X	X	X	X	X	X	X	X	X	X	4	X	X	X	X	X	X	X	X	X
5	X	X	X	X	X	X	X	X	X	X	6	X	X	X	X	X	X	X	X	X
7	X	X	X	X	X	X	X	X	X	X	8	X	X	X	X	X	X	X	X	X
9	X	X	X	X	X	X	X	X	X	X	10	X	X	X	X	X	X	X	X	X
11	X	X	X	X	X	X	X	X	X	X	12	X	X	X	X	X	X	X	X	X
13	X	X	X	X	X	X	X	X	X	X	14	X	X	X	X	X	X	X	X	X
15	X	X	X	X	X	X	X	X	X	X	16	X	X	X	X	X	X	X	X	X
17	X	X	X	X	X	X	X	X	X	X	18	X	X	X	X	X	X	X	X	X
19	X	X	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	X	X	X	22	X	X	X	X	X	X	X	X	X
23	X	X	X	X	X	X	X	X	X	X	24	X	X	X	X	X	X	X	X	X
25	X	X	X	X	X	X	X	X	X	X	26	X	X	X	X	X	X	X	X	X
27	X	X	X	X	X	X	X	X	X	X	28	X	X	X	X	X	X	X	X	X
29	X	X	X	X	X	X	X	X	X	X	30	X	X	X	X	X	X	X	X	X
31	X	X	X	X	X	X	X	X	X	X	32	X	X	X	X	X	X	X	X	X
33	X	X	X	X	X	X	X	X	X	X	34	X	X	X	X	X	X	X	X	X
35	X	X	X	X	X	X	X	X	X	X	36	X	X	X	X	X	X	X	X	X
37	X	X	X	X	X	X	X	X	X	X	38	X	X	X	X	X	X	X	X	X
39	X	X	X	X	X	X	X	X	X	X	40	X	X	X	X	X	X	X	X	X
41	X	X	X	X	X	X	X	X	X	X	42	X	X	X	X	X	X	X	X	X
43	X	X	X	X	X	X	X	X	X	X	44	X	X	X	X	X	X	X	X	X
45	X	X	X	X	X	X	X	X	X	X	46	X	X	X	X	X	X	X	X	X
47	X	X	X	X	X	X	X	X	X	X	48	X	X	X	X	X	X	X	X	X
49	X	X	X	X	X	X	X	X	X	X	50	X	X	X	X	X	X	X	X	X
51	X	X	X	X	X	X	X	X	X	X	52	X	X	X	X	X	X	X	X	X
53	X	X	X	X	X	X	X	X	X	X	54	X	X	X	X	X	X	X	X	X
55	X	X	X	X	X	X	X	X	X	X	56	X	X	X	X	X	X	X	X	X
57	X	X	X	X	X	X	X	X	X	X	58	X	X	X	X	X	X	X	X	X
59	X	X	X	X	X	X	X	X	X	X	60	X	X	X	X	X	X	X	X	X
61	X	X	X	X	X	X	X	X	X	X	62	X	X	X	X	X	X	X	X	X
63	X	X	X	X	X	X	X	X	X	X	64	X	X	X	X	X	X	X	X	X
65	X	X	X	X	X	X	X	X	X	X	66	X	X	X	X	X	X	X	X	X
67	X	X	X	X	X	X	X	X	X	X	68	X	X	X	X	X	X	X	X	X
69	X	X	X	X	X	X	X	X	X	X	70	X	X	X	X	X	X	X	X	X
71	X	X	X	X	X	X	X	X	X	X	72	X	X	X	X	X	X	X	X	X
73	X	X	X	X	X	X	X	X	X	X	74	X	X	X	X	X	X	X	X	X
75	X	X	X	X	X	X	X	X	X	X	76	X	X	X	X	X	X	X	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 LINEBO
40 FORA=1T076\READW(O,A),W(1,A),W(2,A),W(3,A)\FORB=OT03\C=W(B,A)
50 FORD=OT06\IFN(D,C)=OTHENEXIT52\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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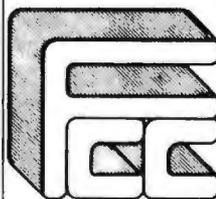


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Written by John Bokelman, originator of the now unavailable Music System from Software Technology.



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The system has been designed to be *upwardly compatible with the now unavailable Proc Tech Music System*, so users of that system may run their programs with the new interpreter. The new interpreter has been dubbed Music Language #1 or ML/1 for short. The programs written for the old Music System will be greatly improved with the new system as the tones produced are much finer and more controllable.

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The software includes a line oriented text editor, a high level music language compiler, a file management system and the advanced music synthesizer.

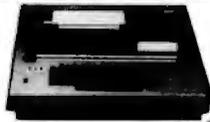
Ordering Information: The price of the system on diskette or cassette with complete documentation and with the hardware kit and ten songs is \$79.95 (cables not included). Those interested in obtaining a system should order from California Software, Box 275, El Cerrito, CA 94530. Dealer inquiries are invited. Specify CP/M, Northstar or Cuter.

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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.

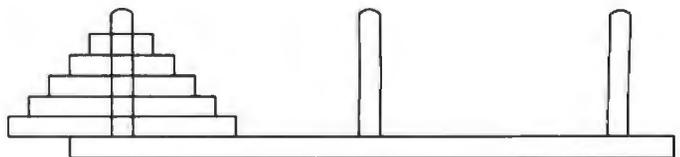


Figure 1: Initial configuration for the Towers of Hanoi problem. The objective is to move all the disks one at a time from the left rod to the right rod without ever placing a larger disk on top of a smaller disk. Intermediate moves can be made to the center rod, of course.

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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vius — 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.

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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 μ s 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 EXTENDED-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=="NIGOTO 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)* * 0 * *
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
400 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-

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 Multi-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 pro-

grammable 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 runtime 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 edi-

tion, 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 priced 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

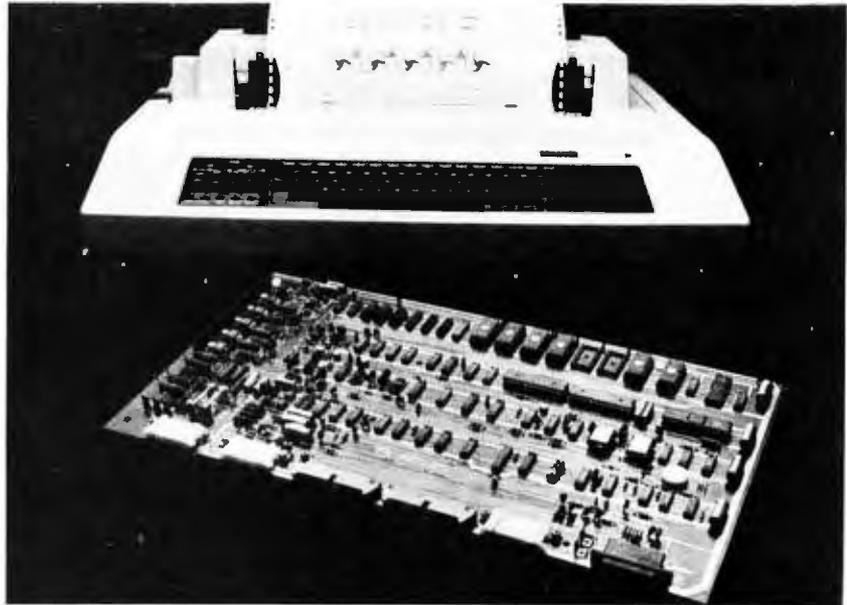
ISAR is a data base management system designed for users of TRS-DOS random file structures. The system utilizes the limited TRS-80 chaining techniques that keep as much of the program in memory as necessary to perform any given function.

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.

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



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, bi-directional 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.

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 micro-processor 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.

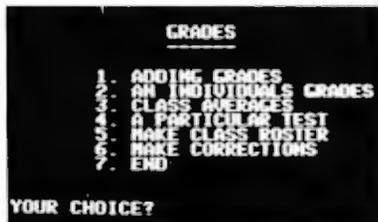
The package can be ordered on eight-inch floppy disks and includes a manual and hard copy source listing. The price for the program is \$1000 and is available from Graham-Dorian Software Systems Inc, 211 N Broadway, Wichita KS 67202.

Circle 409 on Inquiry card.

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

Machine Language Disk File Sorting Program for Apple II



Datocope, 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

Datocope 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.

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.

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 sec-

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!

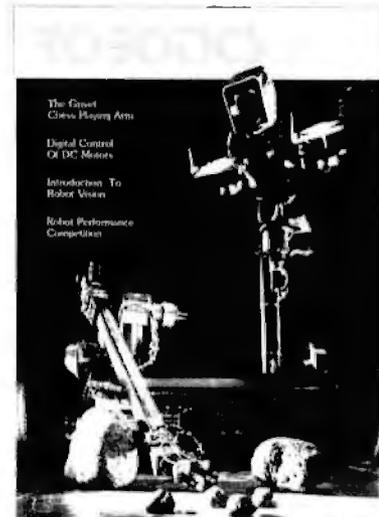
New Renaissance! is a bimonthly magazine for lighting and laser artists and technicians who desire to share their works, events, goals, and discoveries with others in the field. It features performance news and reviews; projects, plans and schematics; new techniques and products; interviews; books and 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.

tion 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

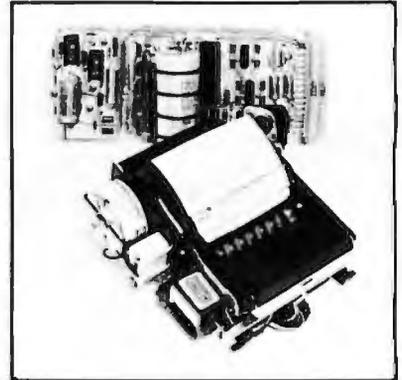
megabytes in the three-disk unit. Data transfer rates are 5.5 million bits per second (bps). The Series 7000 employs the Winchester technique, using an iron-less rotary actuator to position the heads in response to prerecorded servo-tracks on the lower side of the bottom disk.

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.

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.

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 428 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. Inter-



faces 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

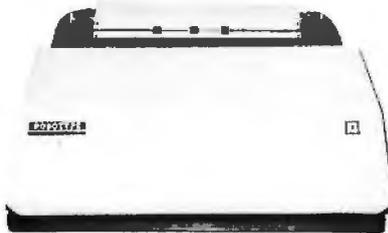
Miniature Alphanumeric Thermal Printer



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



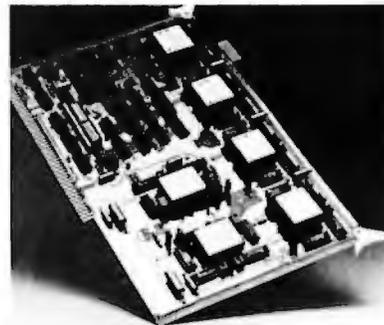
The 9000 Computer System from Compal

The Compal Model 9000 is designed for business and office environments. The system includes a 16-bit microNova 602 processor, 64 K bytes of programable 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

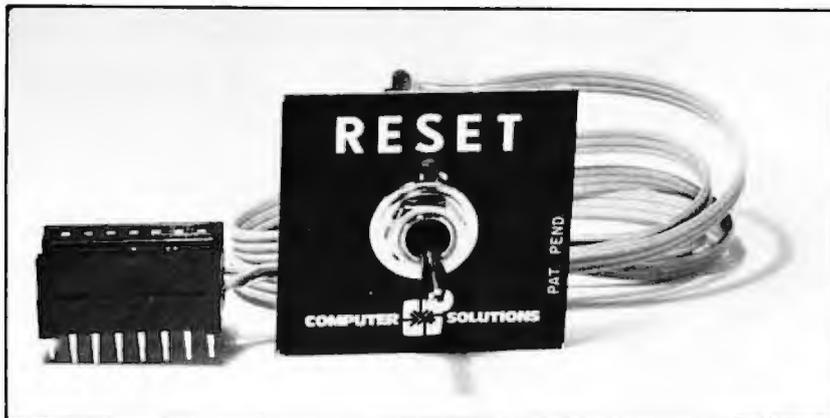
Cognivox plugs into the Sorcerer and offers a sixteen-word recognition vocabulary plus voice response with up to sixteen words or phrases. Recognition accuracies of up to 98% are possible. The unit includes a microphone and amplifier and speaker, making it a complete voice terminal. A software library 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

Prototyping Kit for High-Resolution Graphics



The SVB-80P prototyping kit is a dual-board system with stand-alone capability in an Intel multibus configura-

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.

tion. 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.

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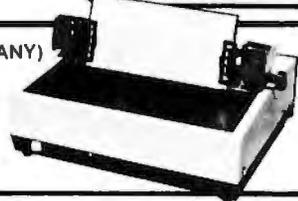
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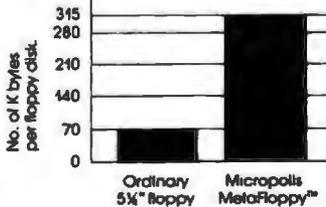
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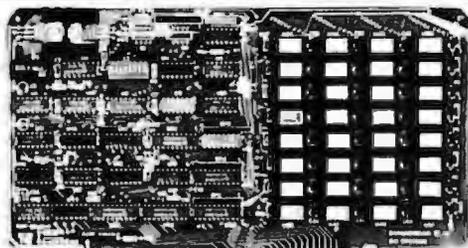
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Includes 12 temporary capacitors for 12 pins, 12 holes and other used mounting spacers. Working side shown. Component side shown epoxy glass with white markings for component location. GTO epoxy glass board with 2 ounce copper, solder plated and .038 dia holes for leads. Solder mask with solder windows on etched circuit to avoid accidental short circuits. Mounts 11 capacitors with 100 contacts (7 rows) on 125 carriers with 150 hole spacing. Vector part number N8172 or N8171 to read part plus interconnectors to replace mother board for replacement.

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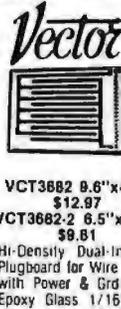
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CND-DA15P	15 Pin Male	2.35	2.15	2.00
CND-DA15S	15 Pin Female	3.25	3.10	2.90
CND-DA15C	15 Pin Cover	1.80	1.45	1.30
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CND-DB25C	25 Pin Cover	1.50	1.30	1.10
CND-DB110983-3	2 pc. Gray Hood	1.75	1.60	1.50
CND-DB1229-1A	2 pc. Black Hood	2.25	2.00	1.75
CND-DC37P	37 Pin Male	4.20	4.00	3.70
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CND-DO50S	50 Pin Female	9.40	8.00	8.00
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RNS-18WWG	18	75	.65	.60	.55	.50
RNS-20WWG	20	90	.80	.70	.65	.62
RNS-22WWG	22	1.00	.80	.85	.80	.78
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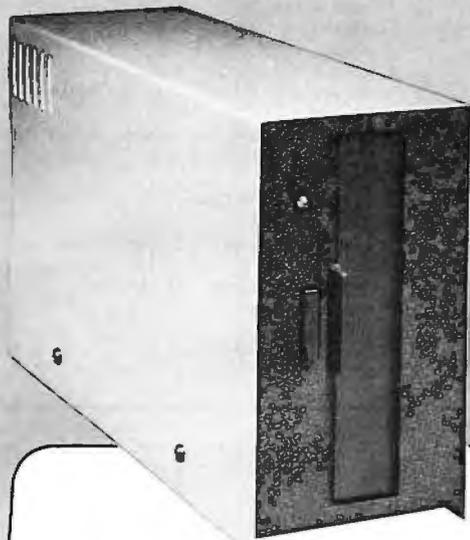
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7403	17	7474	28	74161	- 80
7404	17	7475	28	74162	1.20
7405	24	7476	40	74163	1.20
7406	24	7477	40	74164	28
7407	24	7478	40	74165	28
7408	24	7479	40	74166	28
7409	24	7480	40	74167	28
7410	27	7481	40	74168	28
7411	27	7482	40	74169	28
7412	27	7483	40	74170	1.60
7413	27	7484	40	74171	1.60
7414	27	7485	40	74172	1.60
7415	27	7486	40	74173	1.60
7416	27	7487	40	74174	1.60
7417	27	7488	40	74175	1.60
7418	27	7489	40	74176	1.60
7419	27	7490	40	74177	1.60
7420	27	7491	40	74178	1.60
7421	27	7492	40	74179	1.60
7422	27	7493	40	74180	1.60
7423	27	7494	40	74181	1.60
7424	27	7495	40	74182	1.60
7425	27	7496	40	74183	1.60
7426	27	7497	40	74184	1.60
7427	27	7498	40	74185	1.60
7428	27	7499	40	74186	1.60
7429	27	7500	40	74187	1.60
7430	12	7501	- 13	74188	1.60
7431	17	7502	- 17	74189	1.60
7432	17	7503	- 17	74190	1.60
7433	17	7504	- 17	74191	1.60
7434	17	7505	- 17	74192	1.60
7435	17	7506	- 17	74193	1.60
7436	17	7507	- 17	74194	1.60
7437	17	7508	- 17	74195	1.60
7438	17	7509	- 17	74196	1.60
7439	17	7510	- 17	74197	1.60
7440	17	7511	- 17	74198	1.60
7441	17	7512	- 17	74199	1.60
7442	17	7513	- 17	74200	1.60
7443	17	7514	- 17	74201	1.60
7444	17	7515	- 17	74202	1.60
7445	17	7516	- 17	74203	1.60
7446	17	7517	- 17	74204	1.60
7447	17	7518	- 17	74205	1.60
7448	17	7519	- 17	74206	1.60
7449	17	7520	- 17	74207	1.60
7450	17	7521	- 17	74208	1.60
7451	17	7522	- 17	74209	1.60
7452	17	7523	- 17	74210	1.60
7453	17	7524	- 17	74211	1.60
7454	17	7525	- 17	74212	1.60
7455	17	7526	- 17	74213	1.60
7456	17	7527	- 17	74214	1.60
7457	17	7528	- 17	74215	1.60
7458	17	7529	- 17	74216	1.60
7459	17	7530	- 17	74217	1.60
7460	17	7531	- 17	74218	1.60
7461	17	7532	- 17	74219	1.60
7462	17	7533	- 17	74220	1.60
7463	17	7534	- 17	74221	1.60
7464	17	7535	- 17	74222	1.60
7465	17	7536	- 17	74223	1.60
7466	17	7537	- 17	74224	1.60
7467	17	7538	- 17	74225	1.60
7468	17	7539	- 17	74226	1.60
7469	17	7540	- 17	74227	1.60
7470	17	7541	- 17	74228	1.60
7471	17	7542	- 17	74229	1.60
7472	17	7543	- 17	74230	1.60
7473	17	7544	- 17	74231	1.60
7474	17	7545	- 17	74232	1.60
7475	17	7546	- 17	74233	1.60
7476	17	7547	- 17	74234	1.60
7477	17	7548	- 17	74235	1.60
7478	17	7549	- 17	74236	1.60
7479	17	7550	- 17	74237	1.60
7480	17	7551	- 17	74238	1.60
7481	17	7552	- 17	74239	1.60
7482	17	7553	- 17	74240	1.60
7483	17	7554	- 17	74241	1.60
7484	17	7555	- 17	74242	1.60
7485	17	7556	- 17	74243	1.60
7486	17	7557	- 17	74244	1.60
7487	17	7558	- 17	74245	1.60
7488	17	7559	- 17	74246	1.60
7489	17	7560	- 17	74247	1.60
7490	17	7561	- 17	74248	1.60
7491	17	7562	- 17	74249	1.60
7492	17	7563	- 17	74250	1.60
7493	17	7564	- 17	74251	1.60
7494	17	7565	- 17	74252	1.60
7495	17	7566	- 17	74253	1.60
7496	17	7567	- 17	74254	1.60
7497	17	7568	- 17	74255	1.60
7498	17	7569	- 17	74256	1.60
7499	17	7570	- 17	74257	1.60
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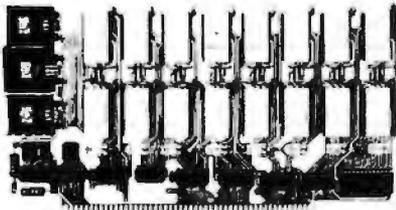
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74LS00	- 28	74LS153	- 112	74LS201	- 75
74LS01	- 28	74LS154	- 119	74LS202	- 75
74LS02	- 28	74LS155	- 119	74LS203	- 30
74LS03	- 28	74LS156	- 119	74LS204	- 75
74LS04	- 28	74LS157	- 119	74LS205	- 75
74LS05	- 28	74LS158	- 120	74LS206	- 1.20
74LS06	- 28	74LS159	- 120	74LS207	- 95
74LS07	- 28	74LS160	- 125	74LS208	- 1.10
74LS08	- 28	74LS161	- 125	74LS209	- 70
74LS09	- 35	74LS162	- 125	74LS210	- 1.60
74LS10	- 35	74LS163	- 125	74LS211	- 1.60
74LS11	- 35	74LS164	- 125	74LS212	- 1.60
74LS12	- 35	74LS165	- 125	74LS213	- 1.60
74LS13	- 35	74LS166	- 125	74LS214	- 1.60
74LS14	- 35	74LS167	- 125	74LS215	- 1.60
74LS15	- 35	74LS168	- 125	74LS216	- 1.60
74LS16	- 35	74LS169	- 125	74LS217	- 1.60
74LS17	- 35	74LS170	- 125	74LS218	- 1.60
74LS18	- 35	74LS171	- 125	74LS219	- 1.60
74LS19	- 35	74LS172	- 125	74LS220	- 1.60
74LS20	- 35	74LS173	- 125	74LS221	- 1.60
74LS21	- 35	74LS174	- 125	74LS222	- 1.60
74LS22	- 35	74LS175	- 125	74LS223	- 1.60
74LS23	- 35	74LS176	- 125	74LS224	- 1.60
74LS24	- 35	74LS177	- 125	74LS225	- 1.60
74LS25	- 35	74LS178	- 125	74LS226	- 1.60
74LS26	- 35	74LS179	- 125	74LS227	- 1.60
74LS27	- 35	74LS180	- 125	74LS228	- 1.60
74LS28	- 35	74LS181	- 125	74LS229	- 1.60
74LS29	- 35	74LS182	- 125	74LS230	- 1.60
74LS30	- 35	74LS183	- 125	74LS231	- 1.60
74LS31	- 35	74LS184	- 125	74LS232	- 1.60
74LS32	- 35	74LS185	- 125	74LS233	- 1.60
74LS33	- 35	74LS186	- 125	74LS234	- 1.60
74LS34	- 35	74LS187	- 125	74LS235	- 1.60
74LS35	- 35	74LS188	- 125	74LS236	- 1.60
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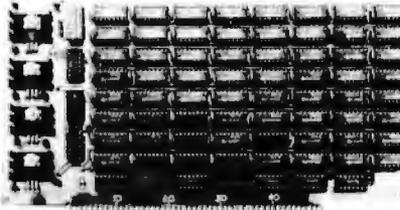
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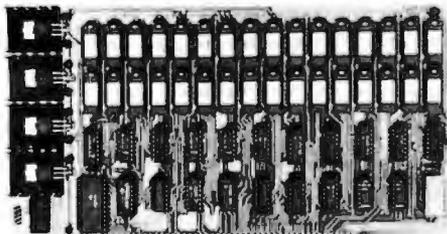
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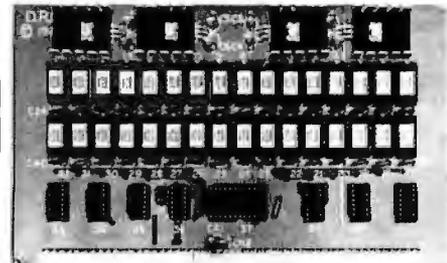
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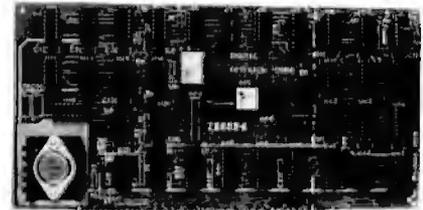
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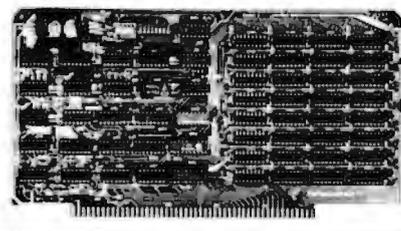
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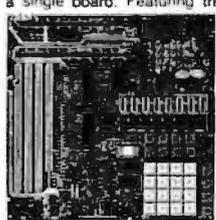


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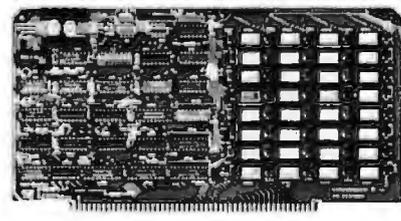
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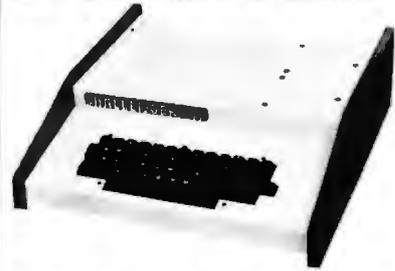
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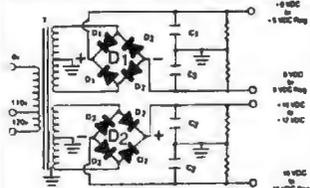
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 - CUSTOM GRAPHICS INTERFACE SERVICE** - Service (d) above plus we interface it to a custom Graphics Driver and supply it as a .COM object file. Specify your video board. (2x3 cell graphics w/ reverse video types only) \$39.44
 Specify disk type:
 ANY 8" IBM - MICROPOLIS MOD II
 NORTHSTAR SD or DD - CROMEMCO 8" or 5"
 ADD \$6.00 FOR DISKETTE OR
 SEND US A BLANK WITH BOOK
 Calif. residents add 6% tax on diskette and book
- THE OLD ASSOCIATION**
 3744 PESCADERO DRIVE
 SANTA BARBARA, CA 93105
 (805) 682-8587
 CP/M is a trademark of Digital Research Corp.

Circle 268 on inquiry card.



11542-1 KNOTT ST.
GARDEN GROVE,
CA 92641
(800) 854-6411
(714) 891-2663

IMSAI CONNECTORS

100 PIN - SOLDERTAIL
\$3.00 each
10 for **\$2.75 each**

2708's
450NS
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or
8/\$60

CERAMIC CAPS
.1 @ 12 VOLTS
10¢ ea
or
100/\$9.00

2114's

LO-PWR
300 NS.
1-16 PCS.
\$5.25 ea.
17 UP
\$5.00 ea.

4116's
(250NS)

ADD ON MEMORY
FOR APPLE, TRS 80,
HEATH, ETC.
8 for \$64.00
or
16 for \$120.00

2716's
5-VOLT ONLY

450 NS.
\$32.00 ea.
or
8 for \$240

LO-PRO SOCKETS

	1-24	25-99	100 up
14 PIN	.15	.14	.13
16 PIN	.16	.15	.14
18 PIN	.19	.17	.15
20 PIN	.27	.25	.23
24 PIN	.35	.31	.27
28 PIN	.40	.33	.29
40 PIN	.50	.46	.41

SA800 DISK DRIVE

INSTALLED IN DUAL
CABINET W/PWR SUPPLY
ASSEMBLED & TESTED
(1) DRIVE INSTALLED
\$695.00
(2) DRIVES INSTALLED
\$1125.00

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TAX: 6% CALIF. RES.

**MICROBYTE
16K RAM BOARD**

- FULLY S-100 COMPATIBLE
- USES LO-PWR 4KX1, MM5257's
- 2 MHZ OR 4 MHZ
- 4K BANK ADDRESSABLE
- EXTENDED MEMORY MANAGEMENT
- NO DMA RESTRICTIONS
- ASSEMBLED & TESTED 2MHZ \$250 - 4MHZ \$265

**MICROBYTE
32K RAM BOARD**

- FULLY S-100 COMPATIBLE
- USES LO-PWR 4KX1, MM5257's
- 2MHZ OR 4MHZ
- BANK ADDRESSABLE
- EXTENDED MEMORY MANAGEMENT
- 8-BIT OUTPUT PORT
- NO DMA RESTRICTIONS
- ASSEMBLED & TESTED 2MHZ \$525 - 4MHZ \$540

REGULATORS

320T-5.....	.90
320T-12....	.90
340T-5.....	.80
340T-12....	.70
78H05.....	4.75
78L12.....	.35

MISC. COMPONENTS

	1-9	10-99	100 up
LM33970	.65	.59
LM348 ...	1.00	.92	.85
LM377 ...	1.10	1.00	.95
LM38080	.75	.70
LM3900 ..	.55	.50	.44
DM8216 ..	2.10	2.00	1.90
8080A ...	4.50	4.25	4.00
8251	5.00	4.80	4.50

BECKIAN ENTERPRISES

ALL PRIME QUALITY — NEW PARTS ONLY
SATISFACTION GUARANTEED.

EDGE CARD CONNECTORS: GOLD PLATED:

Abbreviations: S/E Solder Eye . S/E Sold Tail: W/W Wire Wrap.

PART # DESCRIPTION. Row Sp.				150" CONTACT CENTER CONNECTORS. PART # DESCRIPTION. Row Sp.				D' TYPE SUBMINIATURE CONNECTORS.										
BRAND: TEXAS INST.				1-9pc. 10-24pcs. 25pcs. Up.				1-9pc. 10-24pcs. 25pcs. Up.										
4070	50/100	Imai/Crom.	.250	43.95ea.	43.55ea.	43.15ea.	15105	0/12 S/E PET/NSC	.140	1.80	1.65	1.50	DE 9P	Male	1.80ea.	1.40ea.	1.30ea.	
4090	50/100	Imai W/W	.260	4.30ea.	3.85ea.	3.45ea.	15110	0/12 S/T PET/NSC	.140	1.85	1.65	1.50	DE 9S	Female	2.25ea.	2.00ea.	1.90ea.	
BRAND: SULLINS: U.L. Reg.								15137	0/12 S/T PET/NSC	.200	1.80	1.54	1.45	DE 110903-1	2 pc. Grey Hood.	1.50ea.	1.35ea.	1.20ea.
129885	50/100	Solder Eye	.140	6.80ea.	6.10ea.	5.45ea.	15175	0/ S/E Sglc Row	.140	1.70	1.50	1.30	DA 15P	Male	2.35ea.	2.15ea.	2.00ea.	
129870	50/100	S/T Imsai	.250	4.50ea.	4.10ea.	3.70	15270	10/20 S/E	.140	2.15	1.95	1.70	DA 15S	Female	3.25ea.	3.10ea.	2.90ea.	
129875	50/100	W/W Imsai	.250	5.25	4.75	4.20	15275	10/20 S/T	.140	2.00	1.85	1.60	DA 51211-1	1 pc. Grey Hood	1.40ea.	1.20ea.	1.15ea.	
129880	50/100	S/T Altair	.140	4.95	4.45	3.95	15435	12/24 S/E PET	.140	2.80	2.35	2.10	DA 51228-1	2 pc. Black Hood	2.50ea.	2.25ea.	2.00ea.	
129990	50/100	S/T Cromem.	.250	4.75	4.25	3.80	15440	12/24 S/T PET	.140	2.85	2.40	2.15	DA 110903-2	2 pc. Grey Hood	1.80ea.	1.35ea.	1.30ea.	
OTHER .125" CONTACT CTR CONNECTORS:								15445	12/24 S/T PET	.200	2.75	2.50	2.20	DB 25P	Male	2.80ea.	2.60ea.	2.40ea.
12305	22/44	S/E No Ears	.140	4.15	3.75	3.35	15505	15/30 S/E GRI Key	.140	2.50	2.25	2.00	DB 25S	Female	3.80ea.	3.40ea.	3.20ea.	
12750	38/72	S/T	.140	5.40	4.85	4.35	15510	15/30 S/T GRI Key	.140	2.40	2.15	1.95	DB 51212-1	1 pc. Grey Hood	1.50ea.	1.30ea.	1.10ea.	
12790	40/80	W/W	.260	6.30	5.65	5.00	15515	15/30 W/W GRI Key	.200	2.80	2.35	2.10	DB 51228-1	2 pc. Black Hood	1.90ea.	1.85ea.	1.45ea.	
.100" CONTACT CTR CONNECTORS:								15800	18/30 S/E	.140	3.35	3.05	2.70	DB 110903-3	2 pc. Grey Hood	1.75ea.	1.50ea.	1.35ea.
10048	13/26	S/E No Ears	.140	3.40	3.05	2.15	15810	18/30 S/T	.140	3.00	2.70	2.40	DC 37P	Male	4.20ea.	4.00ea.	3.70ea.	
10280	25/50	S/E TRS 80	.140	4.50	4.05	3.60	15815	18/30 W/W	.200	3.80	3.20	2.90	DC 37S	Female	8.00ea.	5.75ea.	5.50ea.	
10175	20/40	S/E TRS 80	.140	5.95	5.35	4.75	15710	22/44 S/E KIM/VEC	.140	2.98	2.80	2.75	DC 110903-4	2 pc. Grey Hood	2.25ea.	2.00ea.	1.75ea.	
10180	20/40	W/W TRS 80	.200	3.30	3.00	2.15	15875	25/50 S/E	.140	4.05	4.20	3.75	DD 50P	Male	5.50ea.	5.10ea.	4.75ea.	
10180	20/40	S/T TRS 80	.140	3.20	2.90	2.55	15880	25/50 S/T	.140	4.65	4.10	3.85	DD 50S	Female	8.00ea.	8.00ea.	8.00ea.	
19485	38/72	S/E Vector	.140	5.50	4.90	4.40	15885	25/50 W/W	.200	4.05	4.35	3.90	DD 51218-1	1 pc. Grey Hood	2.40ea.	2.20ea.	2.00ea.	
10490	38/72	W/E Vector	.200	5.80	5.25	4.65	16115	38/72 S/E	.140	8.50	8.55	8.20	DD 110903-5	2 pc. Grey Hood	2.60ea.	2.40ea.	2.10ea.	
10500	38/72	S/T Vector	.140	5.70	4.20	4.80	16120	38/72 S/T	.140	8.55	8.55	8.20	D 20418-2	Hardware Set (1 Hood Set)	.90ea.	.80ea.	.70ea.	
10535	40/80	S/E PET	.140	5.85	5.35	4.75	16125	38/72 W/W	.200	8.75	8.10	5.40						
10540	40/80	W/W PET	.200	8.00	5.40	4.80	16145	38/72 S/T	.200	8.50	8.55	8.20						
10550	40/80	S/T PET	.140	5.80	5.25	4.65	16235	43/88 S/T Mot 8800	.140	8.80	8.95	5.30						
10585	43/88	S/E COS/ELF	.140	8.95	8.25	5.55	16240	43/88 W/W Mot 8800	.200	7.80	7.85	8.25						
10005	43/88	S/T COS/ELF	.140	8.80	5.95	5.30	16280	43/88 S/T Mot 8800	.200	8.50	8.55	8.20						
19595	43/88	W/W COS/ELF	.200	8.80	8.20	5.95	16725	43/88 S/E Mot 8800	.140	7.20	8.50	5.75						
10615	43/88	S/T COS/ELF	.200	8.80	8.10	5.40												

I.C. SOCKETS GOLD. W/WRAP 3 TURN

14 pin	\$8.40 ea.
18 pin	0.44 ea.

8080A PRIME.

\$8.00 ea.

EIA 8 CONDUCTOR CABLES 8ft. Long. CLASS #1 Type Cables.

1 to 4 pcs.	\$23.00
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18 pin	0.17 ea.

CONNECTORS FOR CENTRONICS 700 SERIES. Amphenol 57-30380

1 to 4 pcs.	\$9.00 ea.
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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.

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8" Siemens FDD120-8D
All Siemens options included in this drive may be configured hard or soft and single or double density. We find this to be an extremely reliable drive. \$430.00

Fully Shugart compatible.



5 1/4" BASF Magical Miniature Mini drive only 2/3 the size of others is reliable and durable and quickly gaining in popularity with our customers. Single or dual density fast access times \$259.00



Tarbell... 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 5 1/4" Drives as above, but 34 cond. For one drive 24.95, two 29.95.



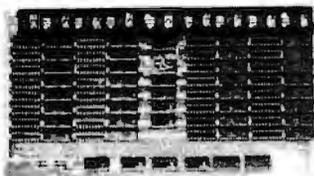
"Power One" Model CP206 Power Supply adequate for at least two drives. 2.8A/24V 2.5A/5V, 0.5A/-5V beautiful quality. \$99.00



CABINETS for FDD120 and 801R drives, or CP206 supply. Matte finish in mar resistant black epoxy paint and stacking design 29.95



DISKETTES
(Mrx, Verbatim, Georgia Magnetics)
8" \$39.95/10
5 1/4" \$34.95/10



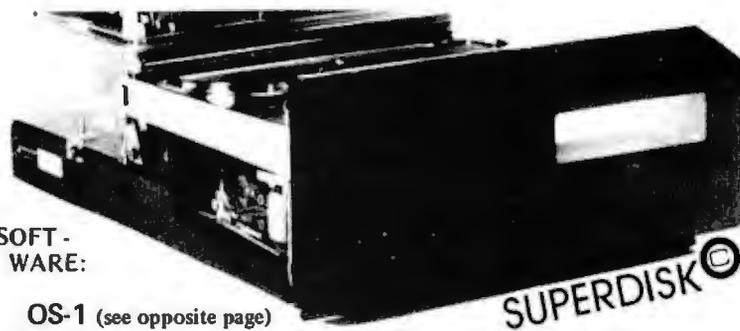
STATIC RAM MEMORY, S-100

32K - \$549.00 16K - \$349.00

"BACK TO SCHOOL" KEYBOARD SPECIAL



CHERRY "PRO" Keyboard \$119.00
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BOTH ONLY \$134.95 !!!!!!!



10MB DRIVE
\$3300

S-100 DMA CONTROL

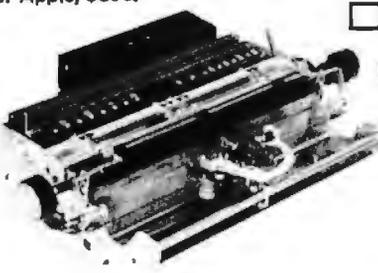
POWER UNIT
\$395.00

SOFTWARE:

OS-1 (see opposite page)
Call for up to the minute pricing on S-100 DMA controller, LSI-11 controller, cabinetry, etc.

PS: OS-1 runs on the TRS-80, and can transform it from a toy computer to a real business machine !!!

For the first time in something like 10 years, a new STANDARD in removable media has evolved. Selected by Datapoint, and others who have not yet announced, this drive is beautifully simple and easy, if not trivial to maintain. 920kBy/sec. transfer rate, 3600 RPM 39 lbs and only 125 Watts.



Daisy Wheel Printers

Qume Sprint 3/45

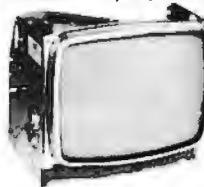
- PRINTER (factory warr.) \$1499.00
- POWER SUPPLY (Boschert) 349.00
- (shown mounted on rear of printer)
- COMBINATION SPECIAL \$1699.00
- Cases available 200.00
- S-100 interface card 149.00

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



Televideo 912B Televideo 920C
(\$860.00) (\$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

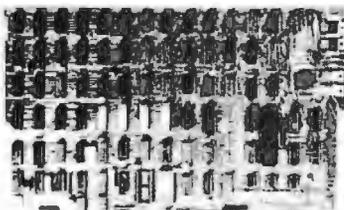
Solder Tail

1 CENT/ Pin !! (0.75/1000's)

8 14 16 18 20 22 24 28 40

Electrolabs

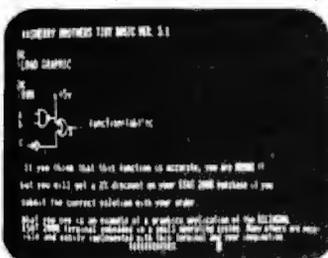
POB 6721, Stanford, CA 94305
415-321-5601 800-227-8266
Telex: 345567 (Electrolab Pla)
Visa MC Am. Exp.



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



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 compatibility with CP/M software!

OS-1

FEATURES

(Because OS-1 is truly a comprehensive "OS", and not merely a file handling "DOS", we have changed the name from "Superdos" to "OS-1")

VIRTUAL I/O - copy with a single command between floppy and hard disk, or from TTY to printer to tape to disk... etc., etc.

No messy I/O routines to write, & no awkward transfers.

SECURITY - 9 modes of file protection, user and login protection.

MULTI-USER - up to 256 passwords. (non-simultaneous users)

16MBy FILE SIZE - but no limit to no. of directories per device, thus allowing EASY implementation of gigantic storage devices.

"SET TTY" - for printer or crt: tabs, page width, buffer, cursor, UC/LC, fonts, formfeed, arbitrary control characters etc., etc.

"LOGIN" - automatically executes user selected programs and "set TTY".

OCCUPIES 12KBy - only 50% larger than CP/M, but 500% more features.

CP/M & CDOS COMPATIBLE - your library is guaranteed to run!

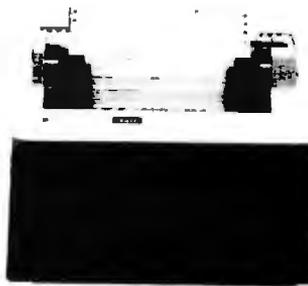
* (Naturally, we are not giving away the version of CP/M written by Digital Research. Please pardon our pun, but they might object. What we ARE giving you is a greatly enhanced version of CP/M which resides on OS-1, and allows the user of OS-1 to run any and all of his programs, packages or system utilities 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
- Asynchronous 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)	4116 (set of 8, 16K, mem-ory expansion for TRS-80,	2732	95.00
MEMORY & EPROM	Apple, Exidy)	8748-8	49.00
2114	\$ 5.99	8755-8	49.00
2114-2	6.99	CPU	
pd 411	2.50	6502	6.25
2107	2.00	Z-80	9.95
		Z-80A	12.05
		8080A	8.99
		8085	22.00
		8741	79.00

ELECTROLABS

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 415-321-5601 800-227-8266
 Telex: 345567 (Electrolab Pla)

FLOPPY CONTROLLERS

1771	\$26.95
1791	\$37.95
Pd372	39.00

MISCELLANEOUS (CALL US!!)

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 Tiltng & Advertising** - using synchronization capability. **Interactive graphics** - using light pen accessory.

BASIC CONFIGURATION -

LSI-11 \$1995. S-100 \$1265.
 For TRS-80/Exidy Add \$695.00
 Includes: Data Board - 32K (480 x 512 x 1 pixel) D-A 16 level video generator. Video Synchronization Circuitry. Address Control & Timing Board.

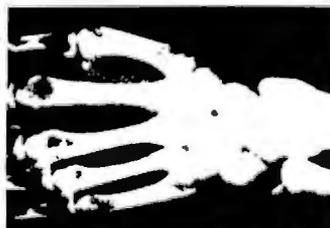
FEATURES - High speed. DMA or 2KBy window memory mapped interface. Full NTSC commercial color capability. Low power consumption. Excellent Software **Options - Accessories - Software**
 Options include: light pen, auxiliary outputs, text mode, memory and much more. **Accessories** include: b&w and color cameras and monitors. **Software:** "Plot" 2D or 3D, "Tiltng", "Contour", "Image Enhancement", "Vector Curve Generation".

Call for price and details

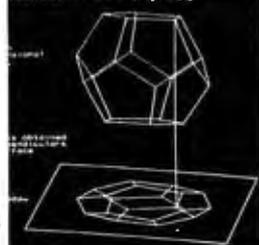
*CPM and **UNIX

trademarks of Digital Research and Western Electric respectively.

Circle 272 on inquiry card.



Illustrates the idea of projecting

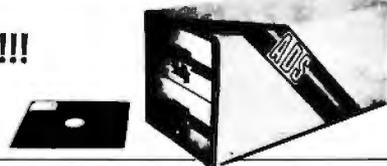


MATCHMAKER TECHNOLOGY

TURNKEY DISK SUBSYSTEMS

DISK IS IN!!!

For those who wish to avoid the aggravation, fussing, irritation, annoyance etc., of assembling your own subsystem, plug in and GO!!!



- ✓ SORCERER
- ✓ TRS-80
- ✓ APPLE
- ✓ HP1B
- ✓ PET

APPLE

- FEATURES:**
- 2 8" Floppy DISK DRIVES (Single Sided)
 - Color Coordinated Cabinet with Power Supply
 - Expanded version of APPLE-DOS
 - Single Density Disk Controller
 - Full Cabling, Connectors + Documentation
 - Assembled and Tested
 - Plug In and GO!!! \$1695.00

- OPTIONS:**
- 2 8" Double Sided Drives (In place of Single Sided) \$2395.00
 - 16K Internal Memory Expansion Kit 69.00

PET

Prices and specifications same as for APPLE except PET Operates via PET-DOS

TRS-80

Prices and specifications same as for SORCERER with following exceptions:

- Expansion Interface necessary
- Space for up to 48K plug-in dynamic memory on Controller Card
- Software package as above \$ 995.00

SORCERER

- FEATURES:**
- 2 8" Single Sided Floppy Disk Drives
 - Single and/or Double Density
 - Color Coordinated Cabinet with Power Supply
 - Full RS-232 Interface
 - OS-1 Disk Operating System (Fully CP/M compatible) CP/M is a registered trademark of Digital Research
 - Full Cabling, Connectors + Documentation
 - Assembled and Tested
 - One S-100 Slot available for Memory Expansion
 - Plug In and GO!!! \$2195.00

- OPTIONS:**
- 2 8" Double Sided Drives (In place of Single Sided) \$2845.00
 - 32K Dynamic RAM Memory Board, Assembled and Tested \$ 299.00
 - 16K Dynamic RAM Internal Memory Expansion Kit \$ 69.00
 - Deluxe Business Software package includes: C BASIC WORD PROCESSING SOFTWARE INTERACTIVE "Big 4": General Ledger, Accts. Payable, Accts. Rec. and Payroll \$ 695.00
 - 10 MBY Removeable Hard Disk - Call for Details

ANOTHER Fine Product brought to you exclusively by the folks at:

In California: 415-321-5601
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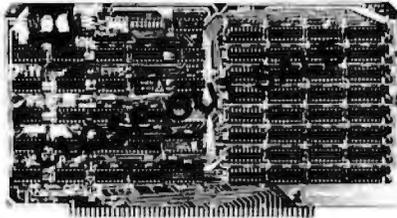
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OUR BEST SELLING MEMORY EXPANDORAM

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
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MEM-64133K (64K KIT)	\$449.95
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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

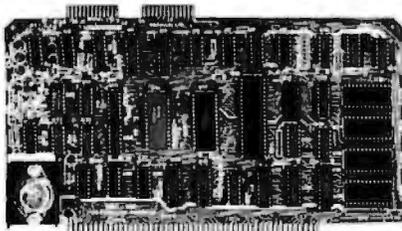
256X240 S-100 HI-RES GRAPHICS BOARD
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SOLID STATE MUSIC I/O-4

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 accommodates 2708, 2716, or 2732
One parallel and one serial I/O port
4-channel counter timer chip (Z-80 CTC)
Software programmable serial baud rates
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 \$249.95 || CPC-30100A (2 MHz A&T) | \$299.95 |
| CPC-30200K (4 MHz KIT) | \$299.95 |
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DOUBLE DENSITY DISK CONTROLLER

Read/write single or double density, 8" or 5 1/2" 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!!!!
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Single or double density floppy disk controller
985600 bytes on 8" double sided diskettes
259840 bytes on double sided 5 1/4" diskettes
S-100 bus (IEEE) standard compatible
IBM 3740 format in single density
8" and 5 1/4" drives controlled simultaneously
Operates with Z-80, 8080, and 8085 CPU's
Controls up to 4 drives
Vectored interrupt operation optional
IOD-1160K (KIT)
 \$335.95 || 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)
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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

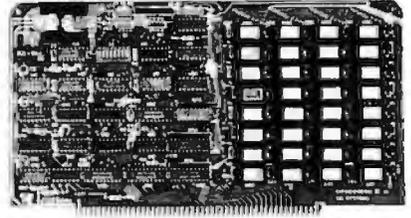
EXPANDABLE 8K/32K, 2/4MHz, KIT/A&T

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
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 \$295.95 || MEM-16631A (16K A&T) | \$345.95 |
MEM-32632K (32K KIT)	\$369.95
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1K OF STATIC RAM AND 12 2708 SOCKETS
MEM-12340A(A & T, NO PROMS)
 \$135.00 |

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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
IOI-1045B (BARE BOARD)
 \$45.00 || IOI-1045K (KIT) | \$169.95 |
| IOI-1045A (A & T) | \$224.95 |

SALE SALE SALE SALE SALE EPROMS

BUY NOW AND SAVE

1702A	\$4.95
2708	\$8.95
2516	\$34.95
2716(T.I.)	\$4.95
2716(5 VOLT)	\$34.95
2758	\$34.95
2532	\$74.95
2732	\$74.95

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SPECIAL PACKAGE PRICE RS-232 SET \$6.50

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MICRO WORKS 2708 PROGRAMER

FITS STANDARD SWPT 6800 I/O SLOT
LIMITED SUPPLY(A & T) \$75.00

VECTOR GRAPHICS S-100 CARD CAGE

17" RACK WITH 18 SLOT MOTHERBOARD
ENC-118100(A & T) \$210.00

SPECIAL CLEARANCE SALE 4K EPROM BOARD

HOLDS UP TO 16 INEXPENSIVE 1702A's
MEM-04220K(KIT NO PROMS) \$45.00
MEM-04220A(A & T NO PROMS) \$79.95

CP/M 2.0

Digital Research has done it again! This new release of their industry standard disk operating system is bound to be an even bigger hit than the original version. All of the fundamental life-size restrictions of release 1 have been eliminated, while maintaining full compatibility with the earlier versions. This new release can be field-configured by the user for a single mini-disk up through a multiple drive hard-disk system with 128 megabyte capacity. Field configuration can be accomplished easily through use of the Macro Library (DISKDEF) provided with CP/M 2.0

A powerful operating system for only ... \$150.00

JADE'S NEW MOTHERBOARDS THE ISO-BUS

WE'RE PROUD OF OUR MOTHER !

6-SLOT

BARE BOARD	\$24.95
KIT	\$49.95
ASSEMBLED & TESTED	\$59.95

12-SLOT

BARE BOARD	\$39.95
KIT	\$89.95
ASSEMBLED & TESTED	\$99.95

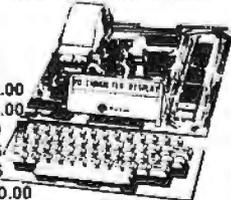
18-SLOT

BARE BOARD	\$59.95
KIT	\$129.95
ASSEMBLED & TESTED	\$149.95

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THE HEAD-START IN MICROCOMPUTERS

KIM-1 compatible
On-board printer
Full ACSII keyboard



AIM-65 w/1K RAM..	\$375.00
AIM-65 w/4K RAM..	\$450.00
8K BASIC ROM..	\$100.00
POWER SUPPLY..	\$59.95
CASE for AIM-65..	\$49.95
4K Assembler/Editor..	\$80.00

Special Package Price \$599.00

4K AIM-65, 8K BASIC ROM, Power Supply, and Case

JADE MEMORY EXPANSION KITS FOR TRS-80 APPLE EXIDY

Everything you need to add 16K of memory to your computer. Your kit comes neatly packaged with easy to follow instructions. In just minutes your computer is ready to tackle more advanced software.

\$69.00

SALE SALE SALE SALE SALE TRANSISTORS

LOOK UP THE SPECS AND STOCK UP

2N456A	10/\$1.00
2N718	10/\$1.00
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2N3392	10/\$1.00
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MICROPROCESSORS		6800 PRODUCT	
FB	\$16.95	6821P	\$5.25
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Z80A (4MHz)	\$14.95	6834P	\$16.95
CDP1802CD	\$24.95	6850P	\$4.80
6502	\$11.95	6852P	\$7.50
6800	\$12.50	6860P	\$9.25
6802	\$20.00	6862P	\$12.00
8008-1	\$15.95	6875L	\$7.30
8035	\$24.00	6880P	\$2.50
8035-8	\$24.00	CHARACTER GENERATORS	
8080-A	\$10.00	2513 Upper	\$7.95
8085	\$23.00	2513 Lower	\$6.75
TMS9900TL	\$49.95	2513 Upper (5 volt)	9.75
8080A SUPPORT DEVICES		2513 Lower (5 volt)	\$13.00
8212	\$5.00	MCM6571 up scan	\$13.00
8214	\$4.65	MCM6571A down scan	\$18.95
8216	\$2.95	PROMS	
8224 (2MHz)	\$4.30	1702A	\$5.00
8226	\$2.75	2708	\$8.95
8228	\$6.40	2716	\$39.95
8238	\$6.40	2716 (5v)	\$39.95
8243	\$8.00	2758 (5v)	\$30.00
8251	\$7.50	DYNAMIC RAMS	
8253	\$20.00	4116/416D	8 for \$74.95
8255	\$6.40	2104/4096	\$4.75
8257	\$19.95	2107B-4	\$3.95
8259	\$19.95	TMS4027/4096	\$4.75
8275	\$69.95	STATIC RAMS	
8279	\$17.70	21L02 (450ns)	\$1.50
USRT		21L02 (250ns)	\$1.75
S2350	\$10.95	2101-1	\$2.95
UARTS		2111-1	\$3.25
AY5-1013A	\$5.25	2112-1	\$2.95
AY5-1014A	\$8.25	2114L (450ns)	\$5.75
TR1602B	\$5.25	2114L (300ns)	\$5.95
TMS6011	\$5.95	TMS4044 (450ns)	\$8.00
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132 COLUMN DOT MATRIX PRINTER

Up to 198 CPS
1.75 to 9.5 inch adjustable tractor and friction feed.
Parallel and serial interface.



98 character ASCII set.
80 to 132 columns.
6 or 8 lines per inch
Eight software selectable character sizes.
110, 300, 600, or 1200 baud.

PRM-33440 \$950.00
PRM-33441(GRAPHICS & 2K BUFFER) . \$1050.00

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MAGNIFICENT MAGNETIC MEDIA I

5 1/4" single sided, single density, box of 10	
MMD-5110103 (SOFT SECTOR)	\$29.95
MMD-5111003 (10 SECTOR)	\$29.95
MMD-5111603 (16 SECTOR)	\$29.95
5 1/4" double sided, double density, box of 10	
MMD-5220103 (SOFT SECTOR)	\$39.95
8" single sided, single density, box of 10	
MMD-8110103 (SOFT SECTOR)	\$34.95
8" single sided, double density, box of 10	
MMD-8120103 (SOFT SECTOR)	\$55.95
8" double sided, double density, box of 10	
MMD-8220103 (SOFT SECTOR)	\$57.95

SPST DIP SWITCHES



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 \$1.28
SWD-107	7	\$1.20 \$1.30
SWD-108	8	\$1.25 \$1.34
SWD-109	9	\$1.30 \$1.40
SWD-110	10	\$1.35 \$1.48



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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Let your computer talk to other computers!
Bell Systems 103 compatible
300 baud, answer or originate
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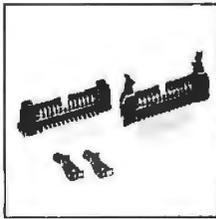
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RN IDH Series - Headers

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

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.

Wire Wrap

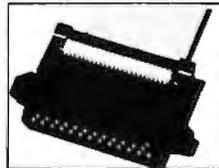
Pins	Straight	Right Angle	1-9	10-24	25-99
10	IDH-10W	IDH-10WR	1.95	1.65	1.55
20	IDH-20W	IDH-20WR	2.75	2.50	2.40
26	IDH-26W	IDH-26WR	3.50	3.25	3.15
34	IDH-34W	IDH-34WR	4.25	3.95	3.75
40	IDH-40W	IDH-40WR	4.75	4.50	4.25
50	IDH-50W	IDH-50WR	5.95	5.60	5.40

- 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

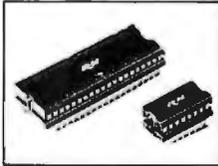
Pins	1-9	10-24	25-99
20	4.15	3.75	3.30
26	4.75	4.30	3.80
34	5.70	5.10	4.50
40	6.50	5.80	5.25
50	7.00	6.30	5.40

25 Pin 'D' Subminiature



	1-9	10-24	25-99
Plug	6.00	5.25	4.70
Socket	6.35	5.60	5.00

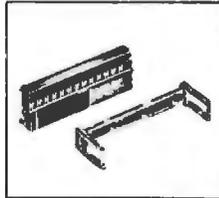
RN Cable Plugs



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.

RN 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.

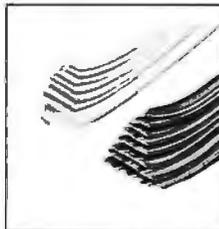
RN Transition Connectors



	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.

RN 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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7400 TTL

SN7400N	16	SN7400N	29	SN74100N	20
SN7401N	18	SN7401N	35	SN74101N	20
SN7402N	18	SN7402N	49	SN74102N	1.05
SN7403N	18	SN7403N	35	SN74103N	20
SN7404N	18	SN7404N	50	SN74104N	20
SN7405N	20	SN7405N	35	SN74105N	20
SN7406N	28	SN7406N	59	SN74106N	1.25
SN7407N	29	SN7407N	59	SN74107N	1.25
SN7408N	20	SN7408N	59	SN74108N	1.25
SN7409N	20	SN7409N	59	SN74109N	1.25
SN7410N	18	SN7410N	1.75	SN74110N	1.25
SN7411N	25	SN7411N	45	SN74111N	20
SN7412N	25	SN7412N	49	SN74112N	70
SN7413N	40	SN7413N	49	SN74113N	70
SN7414N	20	SN7414N	41	SN74114N	70
SN7415N	25	SN7415N	65	SN74115N	70
SN7416N	25	SN7416N	65	SN74116N	70
SN7417N	25	SN7417N	65	SN74117N	70
SN7418N	25	SN7418N	65	SN74118N	70
SN7419N	25	SN7419N	65	SN74119N	70
SN7420N	25	SN7420N	65	SN74120N	70
SN7421N	25	SN7421N	65	SN74121N	70
SN7422N	39	SN7422N	39	SN74122N	39
SN7423N	25	SN7423N	49	SN74123N	49
SN7424N	25	SN7424N	49	SN74124N	49
SN7425N	25	SN7425N	49	SN74125N	49
SN7426N	25	SN7426N	49	SN74126N	49
SN7427N	25	SN7427N	49	SN74127N	49
SN7428N	25	SN7428N	49	SN74128N	49
SN7429N	25	SN7429N	49	SN74129N	49
SN7430N	25	SN7430N	49	SN74130N	49
SN7431N	25	SN7431N	49	SN74131N	49
SN7432N	25	SN7432N	49	SN74132N	49
SN7433N	25	SN7433N	49	SN74133N	49
SN7434N	25	SN7434N	49	SN74134N	49
SN7435N	25	SN7435N	49	SN74135N	49
SN7436N	25	SN7436N	49	SN74136N	49
SN7437N	25	SN7437N	49	SN74137N	49
SN7438N	25	SN7438N	49	SN74138N	49
SN7439N	25	SN7439N	49	SN74139N	49
SN7440N	25	SN7440N	49	SN74140N	49
SN7441N	25	SN7441N	49	SN74141N	49
SN7442N	25	SN7442N	49	SN74142N	49
SN7443N	25	SN7443N	49	SN74143N	49
SN7444N	25	SN7444N	49	SN74144N	49
SN7445N	25	SN7445N	49	SN74145N	49
SN7446N	25	SN7446N	49	SN74146N	49
SN7447N	25	SN7447N	49	SN74147N	49
SN7448N	25	SN7448N	49	SN74148N	49
SN7449N	25	SN7449N	49	SN74149N	49
SN7450N	25	SN7450N	49	SN74150N	49

Cromemco Incorporated

8K Bytesaver II

Memory Capacity: 8K bytes
Memory Type: 2708 PROM or equivalent
Memory Access Time: 450 nanoseconds
Wait States at 4MHz: none per machine cycle
Bus: S-100
Power Requirements: +8V @ 0.8A
+15V @ 0.4A
-18V @ 0.2A
Operating Environment: 0-65°C

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-WI) for \$245.

Assembled
8KBS-W...\$245.00

DISCRETE LEADS

200 dia.

XC556R red	5/51	X2C90R red	5/51
XC556G green	4/51	X2C90G green	4/51
XC556Y yellow	4/51	X2C90Y green	4/51
XC556B blue	4/51	X2C90Y yellow	4/51

180 dia.

XC22R red	5/51	XC252R red	5/51
XC22G green	4/51	XC252G green	4/51
XC22Y yellow	4/51	XC252Y green	4/51
XC22B blue	4/51	XC252C clear	4/51

170 dia.

MV10 red	4/51	XC111R red	5/51
MV10B blue	4/51	XC111G green	4/51
MV10Y yellow	4/51	XC111Y yellow	4/51
MV10C clear	4/51	XC111C clear	4/51

085 dia.

MV50 red	6/51	XC111R red	5/51
MV50B blue	6/51	XC111G green	4/51
MV50Y yellow	6/51	XC111Y yellow	4/51
MV50C clear	6/51	XC111C clear	4/51

INFRARED LED
1/4" (A) x 1/8" flat
5/51

TIMEX T1001
LIQUID CRYSTAL DISPLAY
CLASS II
FIELD EFFECT

6 DIGIT - 8" CHARACTERS
THREE SEQUENTIAL DIGITS
3.00" X 1.20" PACKAGE
INCLUDES CONNECTOR

T1001-Transmissive \$7.95
T1001A-Reflective 8.25

DISPLAY LEADS

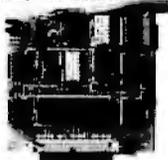
TYPE	POLARITY	HT	PRICE	TYPE	POLARITY	HT	PRICE
MAN 1	Common Anode-red	270	2.95	MAN 6730	Common Anode-red	1	580 90
MAN 2	5 x 7 Dot Matrix-red	300	4.95	MAN 6740	Common Cathode-red	0	580 90
MAN 3	Common Cathode-red	125	2.5	MAN 6750	Common Cathode-red	± 1	580 90
MAN 4	Common Cathode-red	157	1.95	MAN 6760	Common Anode-red	± 1	580 90
MAN 5	Common Anode-green	300	1.25	MAN 6770	Common Anode-red	± 1	580 90
MAN 7Y	Common Anode-yellow	300	89	DL701	Common Anode-red	± 1	300 99
MAN 7Z	Common Anode-red	300	75	DL702	Common Anode-red	± 1	300 99
MAN 74	Common Cathode-red	300	1.25	DL703	Common Anode-red	± 1	300 99
MAN 82	Common Anode-yellow	300	49	DL704	Common Cathode-red	± 1	600 1.49
MAN 84	Common Cathode-yellow	300	99	DL741	Common Anode-red	± 1	630 1.49
MAN 3620	Common Anode-orange	300	46	DL745	Common Anode-red	± 1	630 1.49
MAN 3630	Common Anode-orange	± 1	300 99	DL747	Common Anode-red	± 1	630 1.49
MAN 3940	Common Cathode-orange	300	99	DL748	Common Cathode-red	± 1	630 1.49
MAN 4810	Common Anode-orange	300	99	DL750	Common Cathode-red	± 1	630 1.49
MAN 4840	Common Cathode-orange	400	89	DL358	Common Cathode-red	± 1	250 36
MAN 4710	Common Anode-red	400	99	FD170	Common Cathode-red	± 1	357 75
MAN 4730	Common Anode-red	± 1	400 99	FD358	Common Cathode-red	± 1	357 75
MAN 4740	Common Cathode-red	400	99	FD359	Common Cathode-red	± 1	357 75
MAN 4810	Common Anode-orange	300	99	FD360	Common Cathode-red	± 1	357 75
MAN 4840	Common Cathode-orange	400	99	FD361	Common Anode-red	± 1	357 75
MAN 6610	Common Anode-orange-D	550	99	5082-7730	Common Anode-red	± 1	300 99
MAN 6630	Common Anode-orange	± 1	580 99	5082-3400	Common Anode-red	± 1	300 99
MAN 6650	Common Cathode-orange-D	550	99	5082-3400	Common Cathode-red	± 1	300 99
MAN 6660	Common Cathode-orange	± 1	580 99	5082-7300	Common Cathode-red	± 1	300 99
MAN 6680	Common Anode-orange	580	99	5082-7302	4 x 7 Seg Digit-LAMP	600 18.95	
MAN 6690	Common Cathode-orange	580	99	5082-7304	Doverage character (+1)	600 18.00	
MAN 6710	Common Anode-red-D	580	99	5082-7304	4 x 7 Seg Digit-Headcode	600 22.50	

RCA LINEAR

CA3013T	2.15	CA3028N	2.00	CA3031T	2.48	CA3035T	2.48
CA3023T	2.26	CA3038N	1.60	CA3037T	1.35	CA3039N	1.35
CA3024T	1.95	CA3043N	1.60	CA3046N	1.30	CA3059N	1.35
CA3025T	1.95	CA3048N	1.60	CA3062N	1.35	CA3069N	1.35
CA3026T	1.95	CA3053N	1.60	CA3070T	2.00	CA3080N	1.35
CA3027T	1.95	CA3058N	1.60	CA3081N	2.00	CA3082N	1.35
CA3028T	1.95	CA3063N	1.60	CA3083N	2.00	CA3084N	1.35
CA3029T	1.95	CA3068N	1.60	CA3085N	2.00	CA3086N	1.35
CA3030T	1.95	CA3073N	1.60	CA3087N	2.00	CA3088N	1.35
CA3031T	1.95	CA3078N	1.60	CA3089N	2.00	CA3090N	1.35
CA3032T	1.95	CA3083N	1.60	CA3091N	2.00	CA3092N	1.35
CA3033T	1.95	CA3088N	1.60	CA3093N	2.00	CA3094N	1.35
CA3034T	1.95	CA3093N	1.60	CA3095N	2.00	CA3096N	1.35
CA3035T	1.95	CA3098N	1.60	CA3097N	2.00	CA3098N	1.35
CA3036T	1.95	CA3103N	1.60	CA3099N	2.00	CA3100N	1.35
CA3037T	1.95	CA3108N	1.60	CA3101N	2.00	CA3102N	1.35
CA3038T	1.95	CA3113N	1.60	CA3103N	2.00	CA3104N	1.35
CA3039T	1.95	CA3118N	1.60	CA3105N	2.00	CA3106N	1.35
CA3040T	1.95	CA3123N	1.60	CA3107N	2.00	CA3108N	1.35
CA3041T	1.95	CA3128N	1.60	CA3109N	2.00	CA3110N	1.35
CA3042T	1.95	CA3133N	1.60	CA3111N	2.00	CA3112N	1.35
CA3043T	1.95	CA3138N	1.60	CA3113N	2.00	CA3114N	1.35
CA3044T	1.95	CA3143N	1.60	CA3115N	2.00	CA3116N	1.35
CA3045T	1.95	CA3148N	1.60	CA3117N	2.00	CA3118N	1.35
CA3046T	1.95	CA3153N	1.60	CA3119N	2.00	CA3120N	1.35
CA3047T	1.95	CA3158N	1.60	CA3121N	2.00	CA3122N	1.35
CA3048T	1.95	CA3163N	1.60	CA3123N	2.00	CA3124N	1.35
CA3049T	1.95	CA3168N	1.60	CA3125N	2.00	CA3126N	1.35
CA3050T	1.95	CA3173N	1.60	CA3127N	2.00	CA3128N	1.35
CA3051T	1.95	CA3178N	1.60	CA3129N	2.00	CA3130N	1.35
CA3052T	1.95	CA3183N	1.60	CA3131N	2.00	CA3132N	1.35
CA3053T	1.95	CA3188N	1.60	CA3133N	2.00	CA3134N	1.35
CA3054T	1.95	CA3193N	1.60	CA3135N	2.00	CA3136N	1.35
CA3055T	1.95	CA3198N	1.60	CA3137N	2.00	CA3138N	1.35
CA3056T	1.95	CA3203N	1.60	CA3139N	2.00	CA3140N	1.35
CA3057T	1.95	CA3208N	1.60	CA3141N	2.00	CA3142N	1.35
CA3058T	1.95	CA3213N	1.60	CA3143N	2.00	CA3144N	1.35
CA3059T	1.95	CA3218N	1.60	CA3145N	2.00	CA3146N	1.35
CA3060T	1.95	CA3223N	1.60	CA3147N	2.00	CA3148N	1.35
CA3061T	1.95	CA3228N	1.60	CA3149N	2.00	CA3150N	1.35
CA3062T	1.95	CA3233N	1.60	CA3151N	2.00	CA3152N	1.35
CA3063T	1.95	CA3238N	1.60	CA3153N	2.00	CA3154N	1.35
CA3064T	1.95	CA3243N	1.60	CA3155N	2.00	CA3156N	1.35
CA3065T	1.95	CA3248N	1.60	CA3157N	2.00	CA3158N	1.35
CA3066T	1.95	CA3253N	1.60	CA3159N	2.00	CA3160N	1.35
CA3067T	1.95	CA3258N	1.60	CA3161N	2.00	CA3162N	1.35
CA3068T	1.95	CA3263N	1.60	CA3163N	2.00	CA3164N	1.35
CA3069T	1.95	CA3268N	1.60	CA3165N	2.00	CA3166N	1.35
CA3070T	1.95	CA3273N	1.60	CA3167N	2.00	CA3168N	1.35
CA3071T	1.95	CA3278N	1.60	CA3169N	2.00	CA3170N	1.35
CA3072T	1.95	CA3283N	1.60	CA3171N	2.00	CA3172N	1.35
CA3073T	1.95	CA3288N	1.60	CA3173N	2.00	CA3174N	1.35
CA3074T	1.95	CA3293N	1.60	CA3175N	2.00	CA3176N	1.35
CA3075T	1.95	CA3298N	1.60	CA3177N	2.00	CA3178N	1.35
CA3076T	1.95	CA3303N	1.60	CA3179N	2.00	CA3180N	1.35
CA3077T	1.95	CA3308N	1.60	CA3181N	2.00	CA3182N	1.35
CA3078T	1.95	CA3313N	1.60	CA3183N	2.00	CA3184N	1.35
CA3079T	1.95	CA3318N	1.60	CA3185N	2.00	CA3186N	1.35
CA3080T	1.95	CA3323N	1.60	CA3187N	2.00	CA3188N	1.35
CA3081T	1.95	CA3328N	1.60	CA3189N	2.00	CA3190N	1.35
CA3082T	1.95	CA3333N	1.60	CA3191N	2.00	CA3192N	1.35
CA3083T	1.95	CA3338N	1.60	CA3193N	2.00	CA3194N	1.35
CA3084T	1.95	CA3343N	1.60	CA3195N	2.00	CA3196N	1.35
CA3085T	1.95	CA3348N	1.60	CA3197N	2.00	CA3198N	1.35
CA3086T	1.95	CA3353N	1.60	CA3199N	2.00	CA3200N	1.35
CA3087T	1.95	CA3358N	1.60	CA3201N	2.00	CA3202N	1.35
CA3088T	1.95	CA3363N	1.60	CA3203N	2.00	CA3	

TRS-80 E.S. SERIAL I/O

- Can input into basic
- Can use LIST 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 \$39.95 Part No. 8010A, assembled \$79.95 Part No. 8010 C. No connectors provided, see below



EIA/RS-232 connector Part No. DB25P \$6.00, w/h 5', 8 conductor cable \$10.95 Part No. DB25PB



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 B & 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



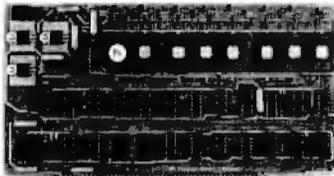
Baud rate is continuously adjustable from 0 to 30,000

- 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 PICEON

Saves programs on PROM permanently (until erased via UV light) up to 8K bytes. Programs may be directly run from the program saver such as fixed routines or assemblers.

- S-100 bus compatible
- Room for 8K bytes of EPROM non-volatile memory (2708's).
- On-board PROM programming
- Address relocation of each 4K of memory to any 4K boundary within 64K
- Power on jump and reset jump option for "turnkey" systems and computers without a front panel
- Program saver software available
- Solder mask both sides
- Full silkscreen for easy assembly. Program saver software in 1 2708 EPROM \$25. Bare board \$35 including custom coil, board with parts but no EPROMS \$139, with 4 EPROMS \$179, with 8 EPROMS \$219.



WAMECO PRODUCTS WITH

ELECTRONIC SYSTEMS PARTS

- FDC-1** FLOPPY CONTROLLER BOARD will drive shugart, pertek, remex 5" & 8" drives up to 8 drives, on board PROM with power boot up, will operate with CPM (not included). PCBD \$42.95
- FPB-1** Front Panel. (Finally) IMSAI size hex displays. Byte or instruction single step. PCBD \$42.95
- MEM-1A** 8Kx8 fully buffered, S-100, uses 2102 type RAMS. PCBD \$24.95, \$168 Kit
- QMB-12** MOTHER BOARD, 13 slot, terminated, S-100 board only \$34.95 \$89.95 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

T.V. TYPEWRITER

- Stand alone TVT
- 32 char/line, 16 lines, modifications for 64 char/line included
- Parallel ASCII (TTL) input
- Video output
- 1K on board memory
- Output for computer controlled cursor
- Auto scroll
- Non-destructive cursor
- Cursor inputs: up, down, left, right, home, EOL, EOS
- Scroll up, down
- Requires +5 volts at 1.5 amps, and -12 volts at 30 mA
- All 7400, TTL chips
- Char. gen. 2513
- Upper case only
- Board only \$39.00 Part No. 106, with parts \$145.00 Part No. 106A



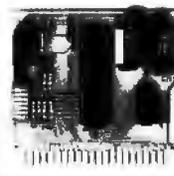
TAPE INTERFACE

- Play and record Kansas City Standard tapes
- Converts a low cost tape recorder to a digital recorder
- Works up to 1200 baud
- Digital in and out are TTL-serial
- Output of board connects to mic. in of recorder
- Earphone of recorder connects to input on board
- No coils
- Requires +5 volts, low power drain
- Board only \$7.60 Part No. 111, with parts \$29.95 Part No. 111A



UART & BAUD RATE GENERATOR

- Converts serial to parallel and parallel to serial
- Low cost on board baud rate generator
- Baud rates: 110, 150, 300, 600, 1200, and 2400
- Low power drain +5 volts and -12 volts required
- TTL compatible
- All characters contain a start bit, 5 to 8 data bits, 1 or 2 stop bits, and either odd or even parity
- All connections go to a 44 pin gold plated edge connector
- Board only \$12.00 Part No. 101, with parts \$35.00 Part No. 101A, 44 pin edge connector \$4.00 Part No. 44P



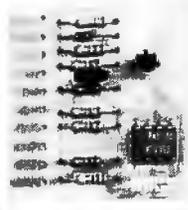
HEX ENCODED KEYBOARD

This HEX keyboard has 19 keys, 16 encoded with 3 user definable. The encoded TTL outputs, 8-4-2-1 and STROBE are debounced and available in true and complement form. Four onboard LEDs indicate the HEX code generated for each key depression. The board requires a single +5 volt supply. Board only \$15.00 Part No. HEX-3, with parts \$49.95 Part No. HEX-3A, 44 pin edge connector \$4.00 Part No. 44P.



RS-232/ TTL INTERFACE

- Converts TTL to RS-232, and converts RS-232 to TTL
- Two separate circuits
- Requires -12 and +12 volts
- All connections go to a 10 pin gold plated edge connector, kit \$ 9.95 Part No. 232A 10 Pin edge connector \$3.00 Part No. 10P.



RS-232/TTY INTERFACE

This board has two active circuits, one converts RS-232 to 20mA, and the other converts 20mA to RS-232. Requires +12 and -12 volts. \$9.95 Part No. 600A Kit.



S-100 BUS ACTIVE TERMINATOR

Board only \$14.95 Part No. 900, with parts \$24.95 Part No. 900A



DC POWER SUPPLY

- Board supplies a regulated +5 volts at 3 amps, +12, -12, and -5 volts at 1 amp.
- Power required is 8 volts AC at 3 amps, and 24 volts AC C.T. at 1.5 amps.
- Board only \$12.50 Part No. 6085, with parts excluding transformers \$42.50 Part No. 6085A



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.



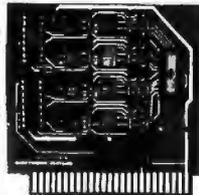
FLOPPY DISK STORAGE BINDER

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. B00



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 • 5-100 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 87 key array • Full 128 character ASCII output • Positive logic with outputs resting low • Data Strobe • Five user-definable spare keys • Standard 22 pin dual card edge connector • Requires +5VDC, 325 mA. Assembled & Tested. Cherry Pro Part No. P70-05AB. \$119.95.



ASCII KEYBOARD

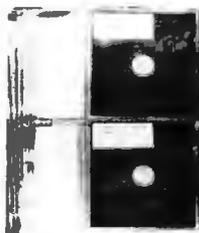
53 Keys popular ASR-33 format • Rugged G-10 P.C. Board • Tri-mode MOS encoding • Two-Key Rollover • MOS/DTL/TTL Compatible • Upper Case lockout • Data and Strobe inversion option • Three User Definable Keys • Low contact bounce • Selectable Parity • Custom Keycaps • George Risk Model 753. Requires +5, -12 volts. \$59.95 Kit.

ASCII TO CORRESPONDENCE CODE CONVERTER

This bidirectional board is a direct replacement for the board inside the Trendata 1000 terminal. The on board connector provides RS-232 serial in and out. Sold only as an assembled and tested unit for \$229.95. Part No. TA 1000C

DISK JACKET™

Made from heavy duty .0095 matte plastic with reinforced grommets. The mini-diskette version holds two 5-1/4 inch diskettes and will fit any standard three ring binder. The pockets to the left of the diskette can be used for listing the contents of the disk. Please order only in multitudes of ten. \$9.95/10 Pack.



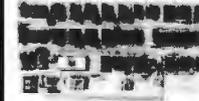
ATARI 800

Computer with 8K \$995.00, disk drive \$549.00, printer \$599.99



VIDEO TERMINAL

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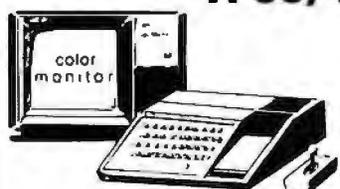


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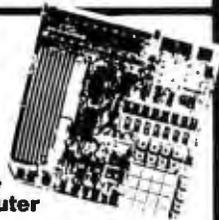


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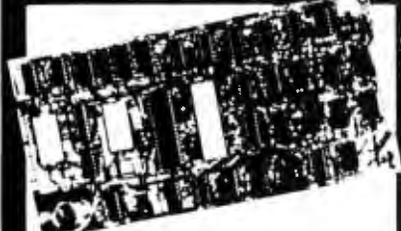


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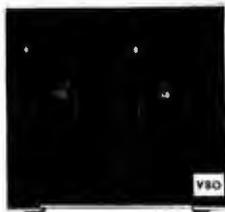
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FOR SALE: Three 6800 systems at my cost less 50 to 70%. AMI PROTO processor, Davis 16 K random-access-memory boards, MSI/GSI disks, IDS printers. Buy system or components. Send SASE for complete list of components and prices. Phil Reagan, 1557 Jackson St #106, Oakland CA 94612, (415) 839-3499.

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 Brallsford 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.

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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.

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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.

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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, 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.

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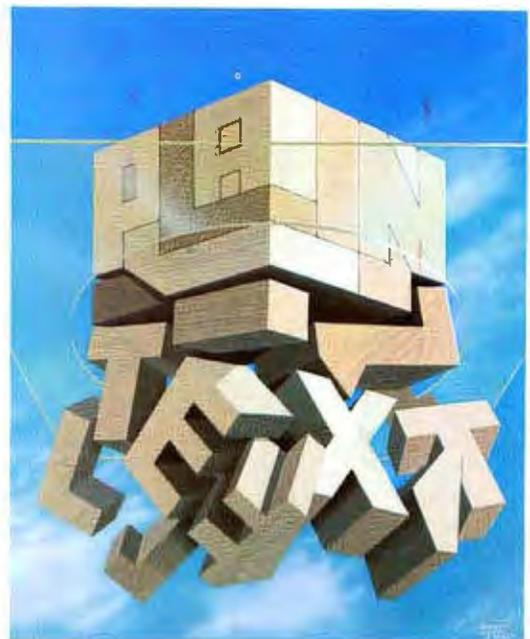
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"Add Nonvolatile Memory to Your Computer" by Steve Ciarcla (page 36) proved to be the most popular among those readers who voted. Second place in the BOMB voting went to James L Peterson for "Text Compression" (page 106). These two authors receive 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). ■



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September 1977



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March 1979

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