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the small systems journal

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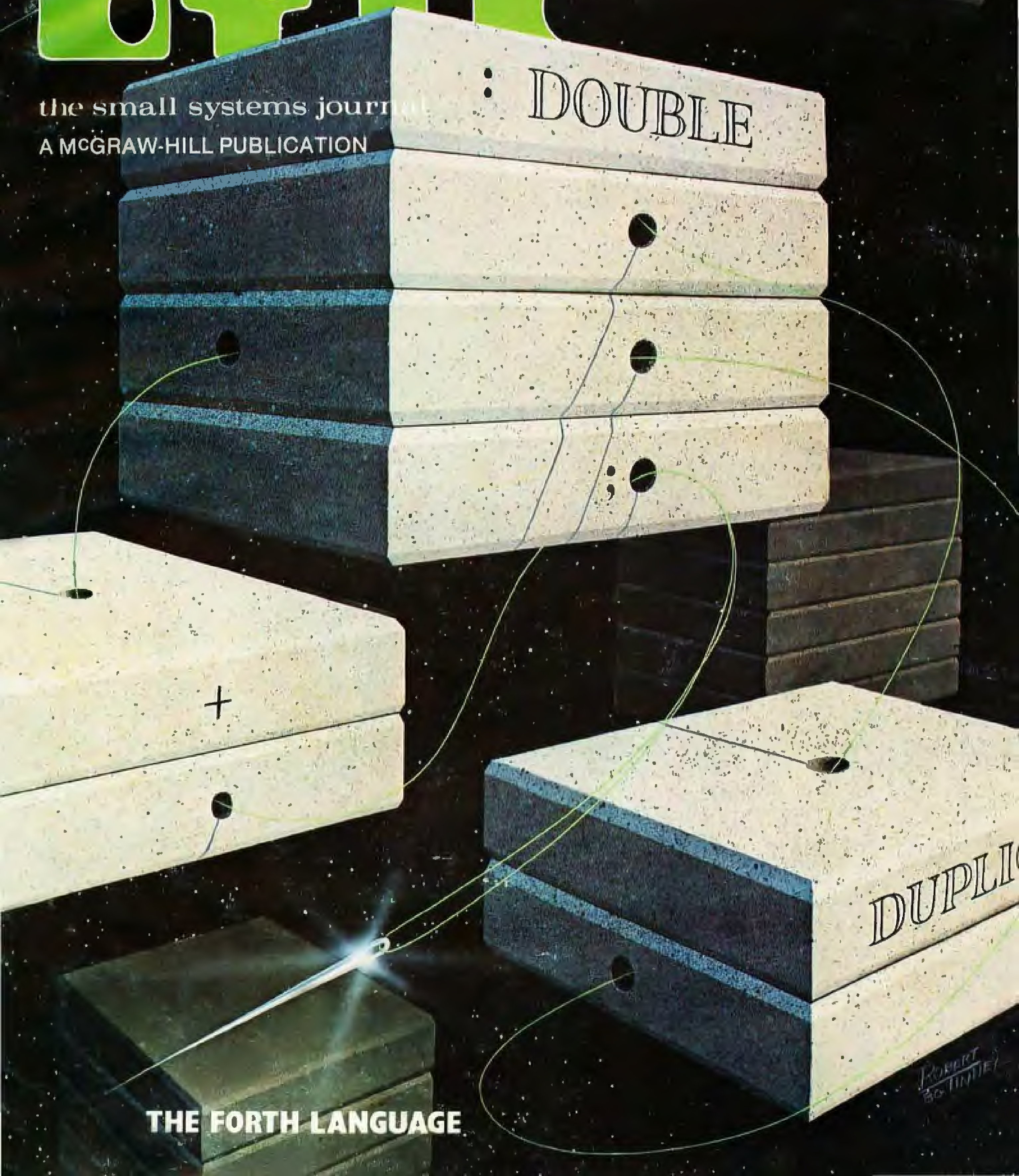
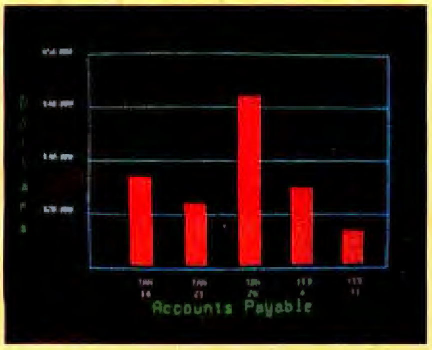
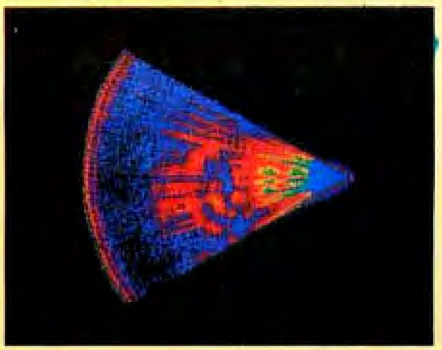


THE FORTH LANGUAGE



Management Information Display



Ultrasonic heart sector scan

High-resolution display with alphanumerics

Get the professional color display that has BASIC/FORTRAN simplicity

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Here's a color display that has everything: professional-level resolution, enormous color range, easy software, NTSC conformance, and low price.

Basically, this new Cromemco Model SDI* is a two-board interface that plugs into any Cromemco computer.

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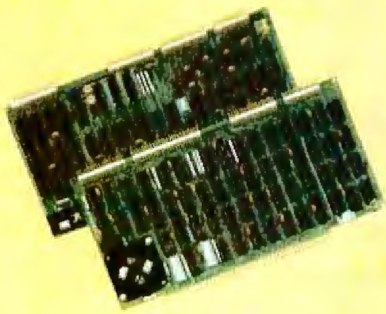
*U.S. Pat. No. 4121283



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In The Queue

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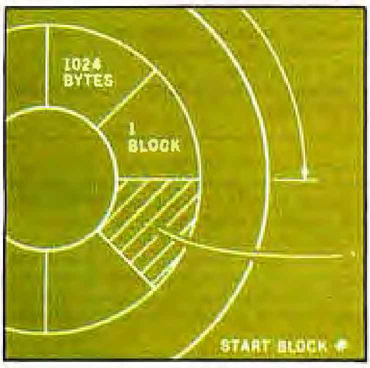

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Foreground

Background

Nucleus

ON THE COVER

This month's cover by Robert Tinney shows a rocket-like needle threading its way through granite cubes labeled: DOUBLE , DUPLICATE , and + . The threaded path of the needle is a representation of the process used in FORTH and other threaded languages to create a new word (here, DOUBLE) with previously defined words (here, DUPLICATE and +).

Other aspects of this fascinating language are described in the editorial, "Threads of a FORTH Tapestry," and in the theme articles for this issue.

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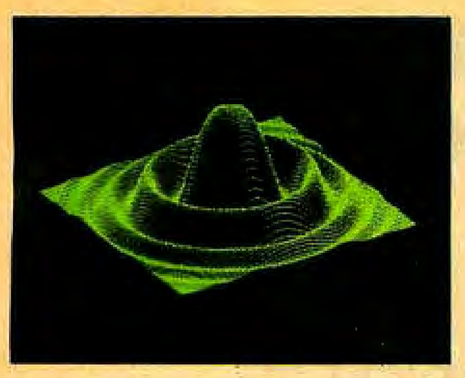

MICROANGELO

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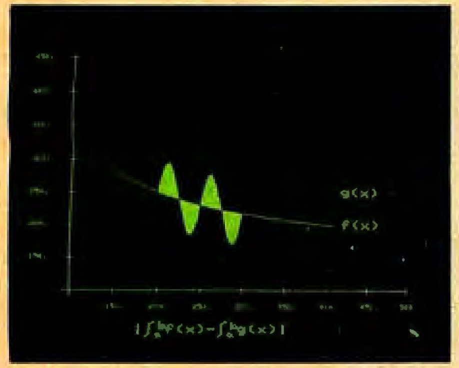

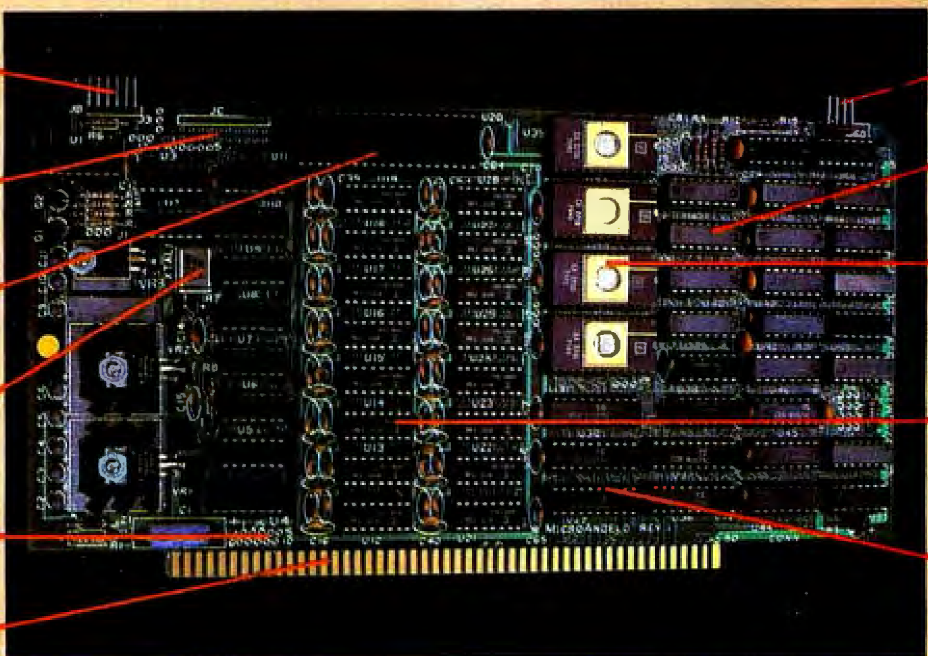

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Editorial

Threads of a FORTH Tapestry

Editor's Note: *This month's editorial is by BYTE Editor Gregg Williams. Gregg was responsible for the preparation of this month's special section devoted to the FORTH language. Carl Helmers returns next month with an editorial....*CM

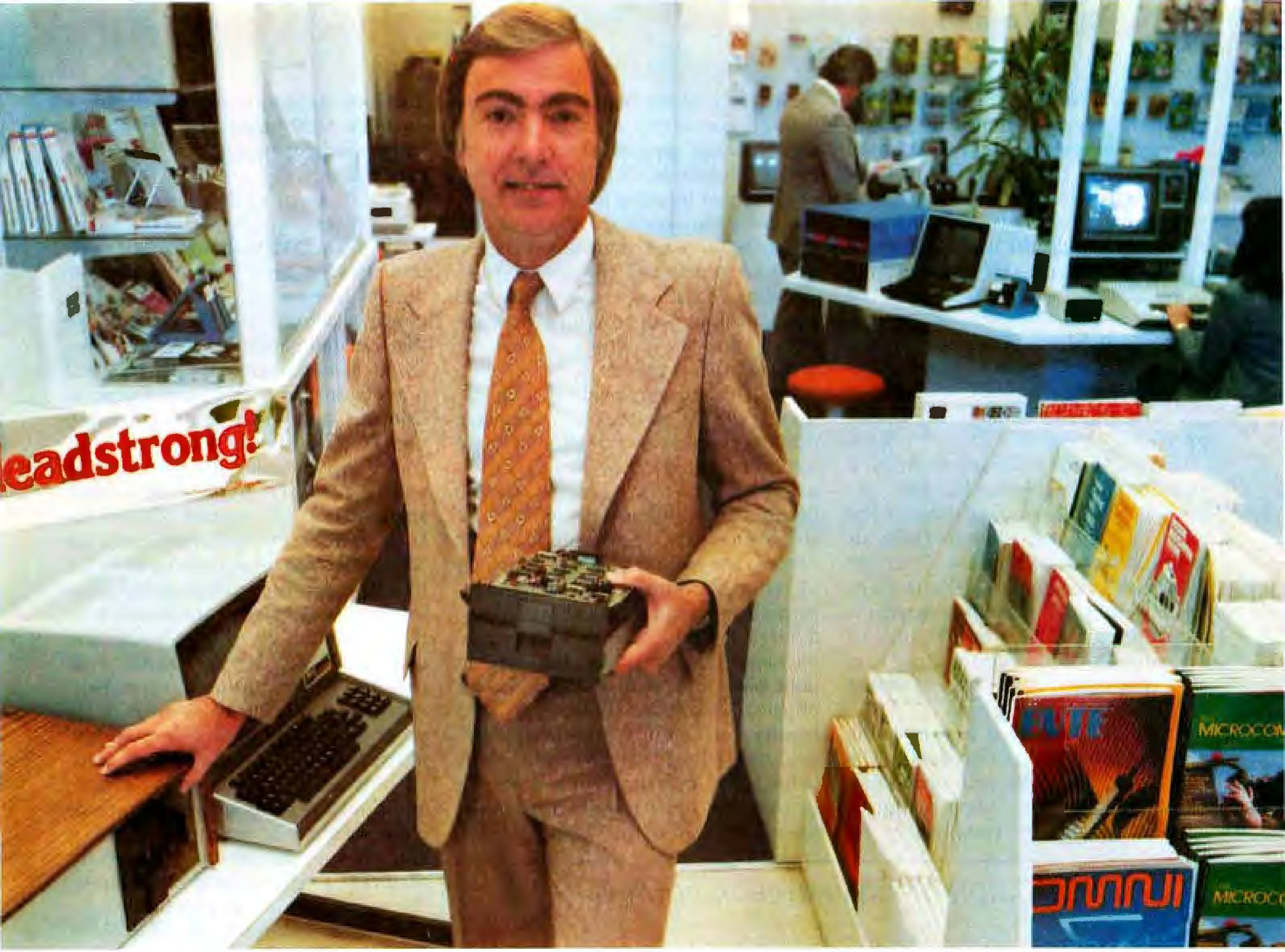
What do a portable heart monitor, the new Craig Language Translator, a peach-sorting machine, and a movie called *Battle Beyond the Stars* have in common? The answer is FORTH, a not-so-new language as comfortable in industrial machinery as it is in a personal computer. In fact, it was originally used by its inventor, Charles H Moore, to control the telescope and equipment at the Kitt Peak Observatory.

Although I have known about FORTH for about a year, it was only during the preparation of this issue that I began to actively keep my ears open for mention of this unusual language. I have uncovered a lot of information (and some experience) about FORTH and its variations. The language is so unusual that no single line of thought could give you a picture of what the language is like. Instead, the following sections represent several threads from the rich tapestry called FORTH.

FORTH in the Real World

No language I know of is as comfortable in real-world situations as FORTH. Here are some examples of the breadth of applications that have been created using FORTH:

- Elicon Inc of Brea, California, is using FORTH software to drive the same kind of computer-controlled cameras that were used to film the sophisticated space-battle scenes in *Star Wars*. New World Productions of Venice, California, is using this camera system to film the spaceship sequences in the motion picture *Battle Beyond the Stars*. In a related development, Magicam Inc (which devised a number of the special effects for the recent movie *Star Trek*) is in the process of converting control of its master-slave camera pair from an analog computer to a digital computer running FORTH software. In the Magicam process, the master camera follows actors on a special blue stage while the computer guides the slave camera across a detailed model. Later, the two images are optically combined, producing the effect of the actors actually being in the landscape depicted on the model.
- Allen Test Products of Kalamazoo, Michigan, has developed an ignition analyzer for use in service stations and automobile repair shops that analyzes the behavior of automobile ignition systems and displays both diagnostic and corrective information. Formerly, the voltage waveform from a spark plug was displayed on an oscilloscope, after which a mechanic would attempt repairs based on his interpretation of the waveforms.
- Atari Inc is using FORTH in two of its divisions and is rumored to be contemplating other uses for the language. In its Coin-Operated Division,



which develops and markets the stand-alone games found in pinball arcades and restaurants, a 6502-based development system employs FORTH software to debug and test arcade circuit boards. In addition, Atari has developed its own custom version of the language, called game-FORTH, that is awaiting its first use to replace machine code as the language used to create arcade games. Someday soon, you may play a coin-operated game without knowing that you are actually running a FORTH program.

In the Consumer Group of Atari, a version of FORTH that has been extended to allow manipulation of the video screen and game peripherals has been developed for the Atari 800 computer. Although no definite plans have been made, Atari may market it as an option for the Atari 800, or, like the Coin-Operated Division, use it in a "transparent" mode to implement games and other programs.

- FORTH is used in a portable 1802-based computer that aids in the treatment of patients with infrequent heart flutter. The device, small enough to be worn comfortably by the patient during his or her daily activities, constantly updates a "snapshot" of the patient's heart activity every 7 seconds. In addition to recording this information in real time, the device analyzes the data for evidence of a heart murmur. When a murmur is detected, the device stores the data containing the evidence and signals the patient to return with the device to the doctor's office for analysis and diagnosis.
- In another medical application, FORTH is the sole language used in a computer at the Cedar-Sinai Medical Center in Los Angeles, California. Using FORTH, a Digital Equipment Corporation PDP-11/60 simultaneously performs, among others, the following tasks: manages 32 remote terminals; stores patient information from an optical reader into a large data base; runs a statistical package that analyzes the patient data base in search of trends in the physical makeup, treatment, and results of similar patients; and analyzes blood samples and heart behavior in real time while a patient is exercising on a treadmill machine. Spencer SooHoo, in the pulmonary medicine section, is also developing a portable 6800-based FORTH system to be used for monitoring intensive-care patients.
- A stripped-down version of FORTH was used to create the hand-held Craig M100 Language Translator under time, size, and other design constraints. This same language also runs the software inside the translator unit. In a related product, a hand-held ASCII terminal manufactured by MSI Data Corporation of Costa Mesa, California, also uses FORTH internally.
- In what must be the most interesting FORTH application I have encountered, a central California fruit farming cooperative uses an 8080-based machine running FORTH to adaptively sort and grade peaches. Infrared sensors send information to the computer on the coloring and quality of pitted peach halves that pass the sensors on a conveyer belt. After analyzing this data, the FORTH program causes flippers to knock the peach halves into appropriately graded bins—extra fancy, fancy, etc. In addition, the program keeps track of the percentage of peaches in each bin and changes its selection criteria to maintain a certain fixed ratio among the various grades of peaches.
- Last but not least, FORTH is used in several aerospace applications. A FORTH-like language called IPS (running on an 1802-based system) is orbiting Earth in an amateur radio satellite called the OSCAR Phase III. Avco Inc is using another 1802-based system (again, for the small size and power consumption of the 1802 microprocessor) to monitor temperature and take care of ground-to-satellite and satellite-to-ground telemetry in a military satellite.

Who Should Try FORTH?

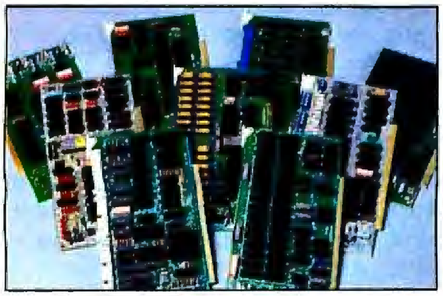
FORTH is an easy language: a high school student, Arnold Schaeffer, wrote an arcade-type game called BREAKFORTH. (See "Breakforth into FORTH," by A Richard Miller and Judy Miller, on page 150.)

FORTH is a difficult language: it easily beats APL as a "write-only language"; you can write a program in the language, but you can't easily read what you've written.

Given these two valid extremes, your initial reaction might be, "This doesn't make sense." True, learning

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

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



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Consider some of the features: Reliable operation to 4MHz and beyond. Full compatibility with 8- and 16-bit CPUs, peripherals and other devices. *Eight* levels of prioritized interrupts. Up to 16 individually-addressable DMA devices, with IEEE Standard overlapped operation. User-selectable functions addressed by DIP-switch or jumpers, eliminating soldering. And that's just for openers.

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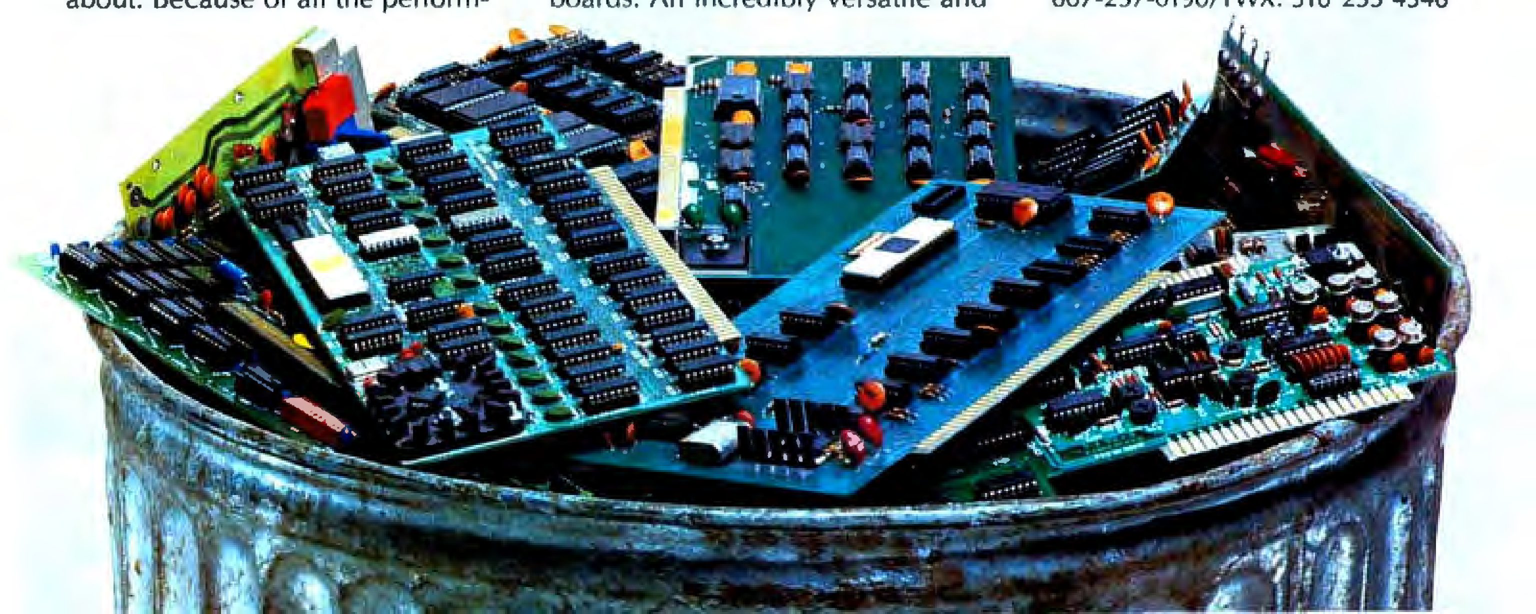

FORTH takes some time; it's somewhat like learning a foreign language. So far, my experiences with FORTH remind me of my attempts at learning a smattering of Russian; both languages are so different from any I've seen before—French or Spanish, BASIC or FORTRAN—that I have to mentally shift gears to work in the new language.

You should give FORTH a try if you are excited by what you see here. Especially important in this respect are the articles, "What is FORTH? A Tutorial Introduction," by John James, and " A FORTH Glossary," pages 100 and 186, respectively. Your best bet is to get to a computer that can run a version of FORTH; or, better yet, get someone who knows the language to demonstrate it to you.

My first experience with FORTH was at the Fourth West Coast Computer Faire in May 1979. A member of the FORTH Interest Group was demonstrating the language using an Apple II and an Advent television screen. First, he defined a word called COUNT, like this:

```
: COUNT   0  DO I . LOOP ;
```

Then he said { 6 COUNT } (*note:* the braces are not part of the expression; see the accompanying text box), the computer replied with { 0 1 2 3 4 5 OK }. I was instantly hooked on learning more about FORTH. What he had done closely paralleled the *iota* function in APL, and anything that even resembled APL was going to get my full attention.

If you are at all dissatisfied with the capabilities of your current computer, or if you feel that there should be more to computers than BASIC and assembly language, you should try FORTH. Once you get accustomed to its peculiar syntax, you can make it do nearly anything you want it to. In fact, you can even make it have features it did not previously have. Assembly language is like this to some extent, but FORTH is a higher-level language with the same abilities—only magnified. FORTH is what I call a "homebrew" language; its enthusiasts carry with themselves the same look-how-this-works enthusiasm as do most hardware hackers who build their own hardware. If we ever have a homebrew *software* issue, FORTH will certainly be included.

FORTH is the ultimate software hacker's language because, like a bag of components before a hardware hacker, you can do anything you want to with it. It can be argued that assembly language is the ultimate programming language; strictly speaking, this is true, but it takes so much more time to craft a piece of software in assembly language that it is practically ruled out in most cases.

However, this total freedom carries with it complete responsibility. Since, for example, the FORTH program you write is free to use an array subscript that is out of bounds, you must be responsible enough to either (a) put in error-checking routines (you can take them out later), or (b) build your program up from small tested modules to assure that your program will never execute an improper subscript. If you would rather have the language system do this kind of work for you, stick to BASIC or whatever you're running now.

Text continued on page 128

Why not kill two birds with one stone?

If you have an Apple* and you want to interface it with parallel and serial devices, we have a board for you that will do both. It's the AIO.™

Serial Interface.

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

Parallel Interface.

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

Two boards in one.

The AIO is the only board on the market that can interface the Apple to both serial and parallel devices. It can even do both at the same time. That's the kind of innovative design and solid value that's been going into SSM products since the beginning of personal computing.

The AIO comes complete with serial PROM's, serial and parallel cables, and complete documentation including software listings. See the AIO at your local computer store or contact us for more information.

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Maybe we can save you a call.

Many people have called with the same questions about the AIO. We'll answer those and a few more here.

Q: Does the AIO have hardware handshaking?
A: Yes. The serial port accommodates 3 types—RTS, CTS, and DCD. The parallel port handles ACK, $\overline{\text{ACK}}$, BSY, STB, and $\overline{\text{STB}}$.

Q: What equipment can be used with the AIO?
A: A partial list of devices that have actually been tested with the AIO includes: IDS 440 Paper Tiger, Centronics 779, Qume Sprint 5, NEC Spinwriter, Comprint, Heathkit H14, IDS 125, IDS 225, Hazeltine 1500, Lear Siegler ADM-3, DTC 300, AJ 841.

Q: Does the AIO work with Pascal?
A: Yes. The current AIO serial firmware works great with Pascal. If you want to run the parallel port, or both the serial and parallel ports with Pascal, order our "Pascal Patcher Disk."

Q: What kind of firmware option is available for the parallel interface?
A: Two PROM's that the user installs on the AIO card in place of the Serial Firmware PROM's provide: Variable margins, Variable page length, Variable indentations, and Auto-line-feed on carriage return.

Q: How do I interface my new printer to my Apple using my AIO card?
A: Interconnection diagrams for many popular printers and other devices are contained in the AIO Manual. If your printer is not mentioned, please contact SSM's Technical Support Dept. and they will help you with the proper connections.

Q: I want to use my Apple as a dumb terminal with a modem on a timesharing service like The Source. Can I do that with the AIO?
A: Yes. A "Dumb Terminal Routine" is listed in the AIO Manual. It provides for full and half duplex, and also checks for presence of a carrier.

Q: What length cables are provided?
A: For the serial port, a 12 inch ribbon cable with a DB-25 socket on the user end is supplied. For the parallel port, a 72 inch ribbon cable with an unterminated user end is provided. Other cables are available on special volume orders.

The AIO is just one of several boards for the Apple that SSM will be introducing over the next year. We are also receptive to developing products to meet special OEM requirements. So please contact us if you have a need and there is nothing available to meet it.

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The man, the lig

Programming Knowledge Is Not Enough

Isaac Newton explained it over 300 years ago. Introductory physics students learn it less than three months into their first course. Yet now it seems to be treated as an argument over words, rather than principles, in BYTE's Letters column. I speak of the description of circular motion under the influence of gravity, and in particular of Delmer Hinrichs' recent contribution "Marsport Forces Resurface" (January 1980 BYTE, pages 16 and 17).

In the situation described, there is *only one force* acting: gravity, given by GMm/r^2. The other relation Hinrichs presents does *not* show how to calculate another kind of force, but is simply a statement of Newton's second law of motion, namely, if any net force acts on a body, an accelerated motion will be observed. For circular motion, the acceleration is equal to v^2/r, and the force giving rise to such motion, *from whatever physical source*, is called a *centripetal* force; ie: a force *toward the center* of the circle, which is quite the opposite of Mr Hinrichs' "centrifugal" force (of which there is *none* in the situation under discussion). The physics here is thus simply to note that the gravitational force acts centripetally, and thus can be equated to m times the acceleration, or ma.

It is unfortunate that many people have not yet realized that programming, once one is past the initial hurdles, is no longer a self-sufficient discipline, but must be viewed as a tool within the context of some other discipline in order to acquire real value. If the discipline is economics, for example, the programmer must be a reasonably accomplished economist if one is to trust his results; if the discipline is physics, then the physics must be understood thoroughly, and not just pulled out of some handbook; and so on....

S Leslie Blatt
Professor of Physics
The Ohio State University
Van de Graaff
Accelerator Laboratory
1302 Kinnear Rd
Columbus OH 43212

More Marsport Commentary

In Delmer Hinrichs' second letter in the January 1980 BYTE, he continues to miss the point about the nature of forces in circular motion. (See "Marsport, Here I Come," April 1979 BYTE, page 84.) As he points out, the National Aeronautics and Space Administration (NASA) explains circular orbits in terms of *centripetal* force and gravitational force, while Mr Hinrichs says, "The attraction of gravity is exactly balanced by the *centrifugal* force at all times." This is not just a matter of "slightly different" terminology. As can be confirmed with a dictionary, a centripetal force is one directed toward the center of motion, but a centrifugal force is one directed away from the center of motion. Thus the terminology of Mr Hinrichs is in fact opposite that of NASA.

Perhaps the confusion results from the use of two names, centripetal and gravitational, which suggests the existence of two forces. However, gravita-

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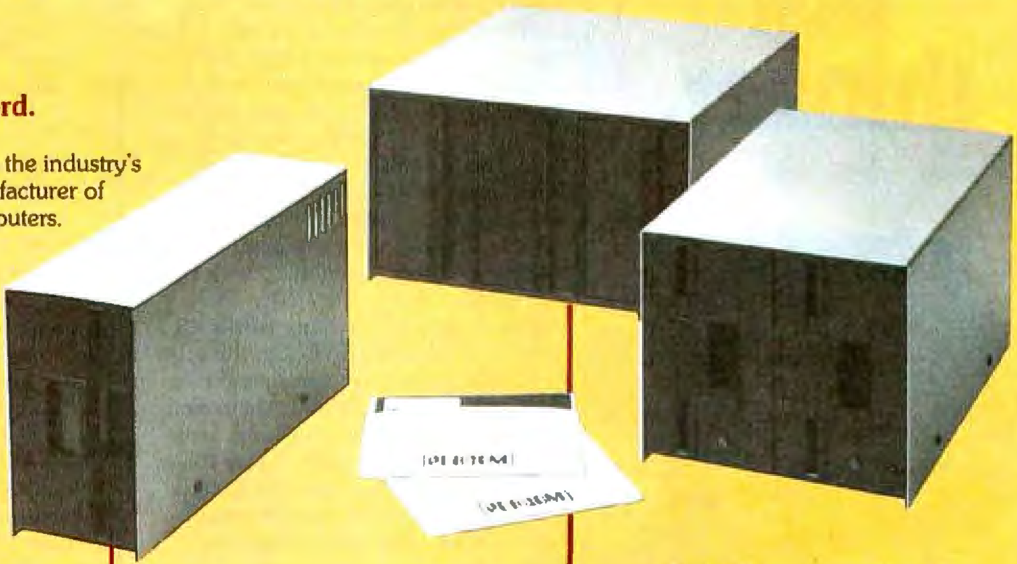

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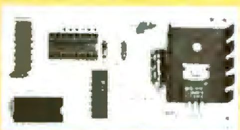
Available in 1-, 2- and 3-drive configurations, Percom drives for the TRS-80* computer start as low as $399.

The gift of speech



Called Speak-2-Me-2tm, this clever interface module makes a Texas Instruments' Speak & Spell† the voice of your computer — announcing, imploring, commanding with expressions and sentences created from the Speak & Spell† vocabulary.

Speech is controlled either at the keyboard or by your own Level II BASIC programs. Or by Percom minidiskette word games (available soon).

Speak-2-Me-2tm is installed in the battery compartment of your Speak & Spell†, and power is provided from an ordinary calculator power pak. Supplied with an interconnecting cable, operating software and a comprehensive users manual, Speak-2-Me-2tm costs only $69.95.

the Separator:tm End "CRC error. Track locked out!"

This plug-in adapter virtually eliminates data read errors, a problem that plagues TRS-80* computer systems. The SEPARATORtm, so called, is installed in the Expansion Interface without modifying the host system. When installed, data and clock signals are reliably separated during playback, an essential function that the separator circuitry of the host computer performs very poorly. Price is only $29.95.

Note. Opening the Expansion Interface may void the Tandy limited 90-day warranty.

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tional forces are centripetal; ie: directed toward the center (of Mars in this case). In other words, for circular orbits the gravitational force and the centripetal force are one and the same and cannot balance one another.

You might then wonder why two names and two formulas are used for the same force. The answer is that the two different formulas come from two separate types of analysis, one independent of motion, the other requiring motion. The formula for gravitational force, $F_2 = GMm/r^2$, comes from measurements of forces between two masses. The two masses might be orbiting each other, in contact, on a collision course, or moving apart. The gravitational-force formula works the same in all of these cases. On the other hand, the formula for centripetal force, $F_1 = mv^2/r$, comes from measurements of forces needed to keep a single mass moving in a circular path. These forces can be of any type. Examples include tension in a string, friction between a car's tires and the road surface, electricity, magnetism, and gravity. The centripetal force equation works the same in all of these cases. Notice that both of these formulas apply to circular orbits and can be set equal because the centripetal force is supplied by gravity.

As a high school physics teacher with a Master's degree in physics, I have discussed this subject with over a dozen physicists and hundreds of students. All of the physicists and most of the students would agree with what I have written here.

Robert Reiland
RR 1
Portersville PA 16051

A Message About the Reminder

My article in the January 1980 BYTE "A Computer-Generated Reminder Message" (page 160) has prompted several people to contact me, raising various questions related to the article.

The data conversion routines caused the most comment. They require a BASIC processor which maintains at least seven full decimal digits of precision; many do not. To determine if a given BASIC maintains seven digits of precision, enter "PRINT 9999999". If "9999999" is printed, the BASIC maintains sufficient precision. References for further study of data-processing algorithms may be found in the following articles:

Fliegel and Pan Fladen, "A Machine Algorithm for Processing Calendar Dates," *Communications of the ACM (CACM)*, volume 11, October, 1968.

Robertson, "Remark on Algorithm 398," *Collected Algorithms from CACM*.

Stone, "Tableless Date Conversion," Algorithm 398, *CACM*, volume 13, October, 1970.

Tantzen, "Conversions Between Calendar Date and Julian Day Number," Algorithm 199, *CACM*, volume 6, August, 1963.

The only known error in the January article appears on page 172. The reference to line 9500 should be deleted, since the line was deleted from the program listing.

Another area of questions concerned the conversion of the program to other disk BASICs. I have been asked about TSC BASIC, North Star BASIC, and other versions. The usual two areas of concern are the required seven digits of precision and disk input/output (I/O) methods. Without reference to specific implementations, Microsoft-like BASICs should prove the easiest to convert. Other implementations which do not use FIELD statements are also convertible, though with some increase in difficulty.

Edgar M Pass
Computer Systems Consultants Inc
1454 Latta Ln NW
Conyers GA 30207

Here's a Good Book on Curve Fitting

In response to F R Ruckdeschel's appeal for a good, balanced reference book on curve fitting (Letters, March 1980 BYTE, page 16), I heartily recommend *Applied Linear Statistical Models* by John Neter and William Wasserman (Richard Irwin & Sons, 1974).

This book features a unified approach to both simple and multiple cases of linear and polynomial regression techniques, and through the use of indicator variables, it also offers a regression approach to basic and multifactor analysis of variance.

It is a good book for both beginners and statisticians alike, since it starts out at an introductory level, introduces matrix theory early, and goes on to show how matrix operations (operations on two-dimensional arrays, which most computer languages can handle) can be applied to a large variety of statistical analyses.

After I had struggled for years in the seemingly muddy area of statistics, this book has been instrumental for me in

clearing the water. And for the experimentally minded computerist, this text winds up with a comprehensive section on experimental design.

Richard Shide
918 4 Ave S
Fargo ND 58103

Getting Into a Metric Gear

As an avid cyclist, I was glad to see the Programming Quickie in the March 1980 BYTE ("Gear-Ratio Calculation for Bicycle Derailleurs," page 68), but as an ardent proponent of "metrication" I was sorry to see that, contrary to your stated policy, you did not include a metric equivalent. Metric countries use a more rational and intuitively meaningful measure of the gear ratio than our silly system does; they simply measure how far the bicycle will travel in one complete turn of the pedals. The following program (listing 1) should serve to make the principle clear.

Listing 1.

```
PROGRAM GEARS;
CONST PI = 3.14159;
VAR
  DIAMETER,
  CIRCUMFERENCE,
  DEVELOPMENT,
  CHAINWHEEL, SPROCKET: REAL,
BEGIN WRITE ('WHEEL DIAMETER IN
        METERS: ');
  READ (DIAMETER);
  CIRCUMFERENCE := PI * DIAMETER;
  REPEAT WRITE ('TEETH ON CHAIN
        WHEEL: ');
    READLN (CHAINWHEEL);
    WRITE ('TEETH ON SPROCKET: ');
    READLN (SPROCKET).
    DEVELOPMENT := (CHAINWHEEL /
    SPROCKET) * DIAMETER;
  WRITELN ('DEVELOPMENT: ',
  DEVELOPMENT: 4:2, ' METERS.')
  UNTIL EOF
END.
```

David A Mundie
104 Oakhurst Cir
Charlottesville VA 22903

Beware of Handshakes

If any BYTE readers are thinking about installing a dot-matrix printer in their microcomputer system, I have a friendly warning to pass on: pay close attention to your manufacturer's recommendations, or know the risk you're taking if you ignore them.

For example, North Star Computers, Inc recommends that owners connect the Anadex DP-8000 to the parallel interface of its Horizon computer. But comparing printer specifications, I chose to save a few bucks by building a Heath H-14 line printer for the Horizon's serial interface.

I saved some money: the printer kit cost $625 plus shipping, plus an additional $82.98 at the Heathkit Electronic

Circle 13 on inquiry card. →

Center in Seattle when the H-14 flunked its initial power-on tests. The service personnel replaced two defective CMOS (complementary metal-oxide semiconductor) integrated circuits and repaired three open-foil breaks in the 5 V supply at no charge, but they detected erroneous installation of seven transistors. (Considering the obvious textual errors in the documentation, which would you believe—the text or the pictorials? I guessed wrong and followed the pictorial: customer error!)

My H-14 printer tested perfectly at 4800 bps (bits per second) under HDOS in Seattle. It went ape at 4800 bps on the Horizon after I got it home. A quick phone call to my friendly Horizon dealer divulged the fact that North Star DOS does not test for handshaking signals! (The Heath manual advises to run no faster than 110 bps without handshaking.)

So now I have a 110 bps line printer dawdling along, while the 4 MHz Z80A and I are twiddling our respective *thumbs!* Does anybody out there want to trade an in-warranty Anadex DP-8000 printer for an in-warranty Heath H-14 plus some extra cash?

John R Dye
4807 Fifteenth Ave SE
Lacey WA 98503

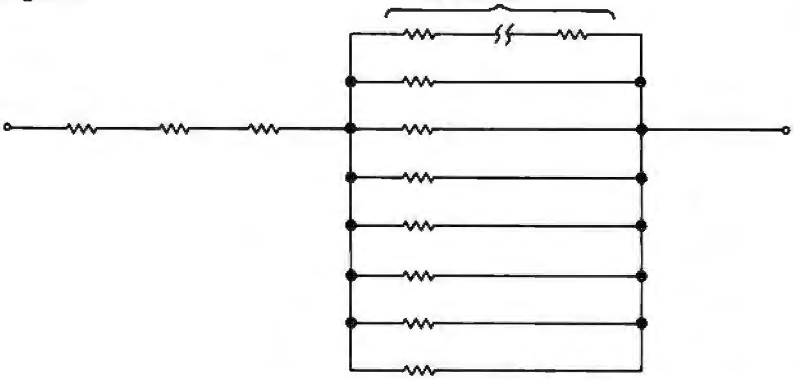
Specialized Business Program

As a charter subscriber to BYTE, I quite often see references by many of your software reviewers and article writers to the lack of *good* software available for microcomputers in the business field. I thought, to give some perspective, that I would tell BYTE readers about the Electric Log. It is highly specialized and useful in no field other than the operation of a television station; therefore it is directed to a very small group of very small businesses (less than 8000 in the entire US).

The point I would like to make is this: since there is an adequate supply of standard business packages available, the opportunity in business software lies in the specialized application field. These will never be marketed in magazines outside the trade, never by computer companies, and never with any great publicity. There is more of this done than you realize, and this may be the undercurrent that stimulates small business to invest in microcomputers.

Pete Charlton
The Management
POB 111
Aledo TX 76008

Figure 1.



Pass the Pi

Emory Sprenkle remarked in his letter (February 1980 BYTE, page 16) that 1/(113/355) is a good rational approximation of π, and is easily remembered. In fact, 355/113 is the *best* rational fraction approximation to π having no more than three digits in the numerator.

I was reminded of the following problem which appeared a few years ago in *American Mathematical Monthly*:

> What is the smallest number of perfect 1-ohm resistors needed to create a network with an equivalent resistance of π ohms, $\pm 10^{-6}$ ohms?

This problem leads one to discover how positive rational fractions may be presented as *continued fractions*.The solution shown in figure 1 includes three resistors in series with a network consisting of sixteen series-connected resistors in parallel with seven parallel-connected resistors, making twenty-six in all.

W Lloyd Milligan
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A Build-It-Yourself Modem for Under $50

Steve Ciarcia
POB 582
Glastonbury CT 06033

I receive many personal-computer club newsletters. Some of the larger clubs around the country have put me on their mailing lists to keep me informed of what's going on in their area. One I recently received was significant because it demonstrated the tremendous advancements in personal computing in a very subtle way.

It was not the content of this newsletter that was important. It contained the usual new business, old business, and other information. The significant point was the preparation of the document itself.

According to an editorial, this publication has an editor/publisher and four columnists spread across the state. Each columnist prepares his textual material on his own personal computer, using a word-processing program. He then telephones the editor's computer and down-loads the text to it. The editor, using his computer, combines the four individual columns, along with his work, and lays out the complete newsletter. Finally, the editor telephones the print shop and transmits the entire newsletter for typesetting and printing.

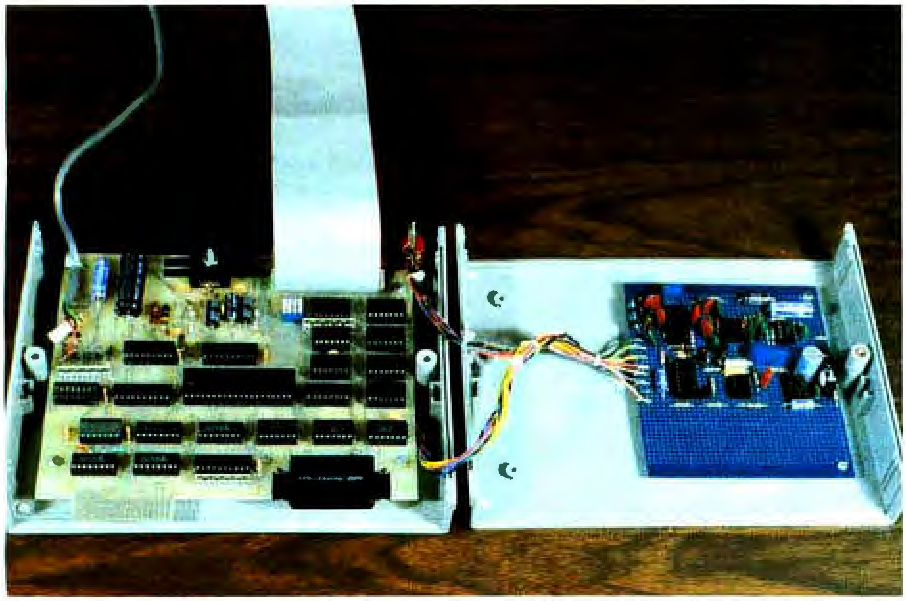

Photo 1: *The prototype modem circuit of figure 1 was assembled on the blue perforated circuit board as shown. It was then installed under the top cover of a COMM-80 I/O-expansion unit, shown at left. The COMM-80 was described in the June Circuit Cellar. (See "I/O Expansion for the TRS-80, Part 2: Serial Ports," June 1980 BYTE, page 42.) The COMM-80 and this modem are sufficient to turn a Radio Shack TRS-80, or a computer that uses a similar bidirectional bus, into a timesharing terminal. The modem can be used on any computer.*

The significant point is that all the communication is between computers and is conducted over the telephone lines.

Transmitting and receiving data using the telphone is not a difficult task if you have the correct equipment. Virtually any microcomputer can be configured for this activity. To communicate properly, the system must be a serial terminal or *emulate* one and be attached to the phone lines through a *modem*.

A "terminal" describes any equipment with hardware and software designed to facilitate serial data communication with prescribed data rates and protocol. My June 1980 article on the COMM-80 was such a hardware package. (See "I/O Expansion for the TRS-80" June 1980 BYTE, pages 42 thru 62.) With the COMM-80 attached and using the communication software provided, the TRS-80 computer emulates a terminal. Any other computer system calling itself a "terminal" and using the same data rates and protocol would be able to communicate with it. This includes all users of The Source and MicroNet timesharing services.

A *modem* is the device that allows the computer to be connected to a telephone.

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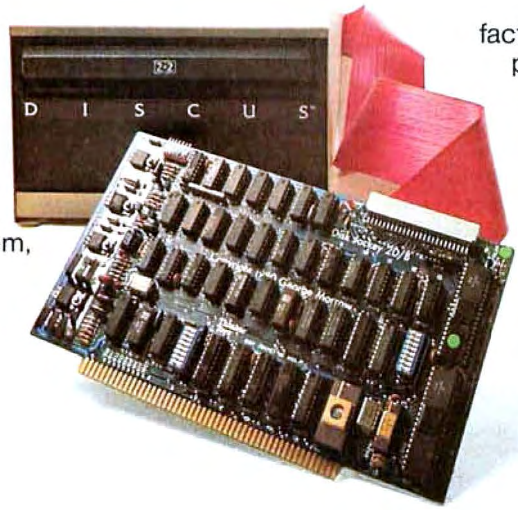

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Photo 2: *Comparison of two generations of modems. At right is an early model made by Anderson-Jacobson, shown with the covers open. The old modem uses discrete semiconductor components and toroidal inductors. On the left is an example of a current model of modem: a Novation Cat acoustic-coupled modem, which is popular with home-computer hobbyists.*

Photo 3: *First of a series of photos (3 thru 9) showing how you can easily contruct an acoustic-coupler pickup. My design for the pickup uses such "exotic" materials as a hot-water pipe foam insulation, a pair of 2-inch, 8-ohm dynamic speakers, a foam-backed dinner placemat, rubber cement, and adhesive tape.*

Step 1 of the process (shown here) is to cut a wedge-shaped piece from the insulating foam. The foam I used had an inside diameter of 1⅞ inches with a ½-inch wall, giving an outside diameter of about 2⅞ inches. The high side of the wedge should have a height of about 1 inch, the low side about ⅜ inch.

Next, cut and trim a rectangular piece of foam measuring ½ by ¼ by 3½ inches. This is used to help fit the speaker snugly into the hole in the wedge-shaped piece previously cut.

Solder the electrical connections to the speaker before proceeding to apply rubber-cement to the rectangular foam piece and wrap it around the voice coil of the speaker. Hold it in place until the cement sets.

are not unlike those associated with the cassette data-storage system on a personal computer. Like the telephone, the cassette recorder is incompatible with digital data and has a very narrow bandwidth (a few thousand hertz). Since all personal computers accommodate cassette data storage, there is obviously a reasonable solution.

Rather than using digital voltage levels, as in a direct-wired communication link, audio-frequency tones are recorded instead. In most systems, one tone of a given frequency signifies a logic 0 and a tone of a different frequency signifies a logic 1. When we change or shift the tones to correspond with the logic input, we are performing *frequency-shift-keyed* (FSK) *modulation*. When we play back the tape into the computer, a demodulator distinguishes the tones and separates them back into 1s and 0s.

How Does a Modem Work?

Terminal-to-terminal communication is more complex than a simple cassette system even though it employs similar techniques. Transmission over the two-wire phone system from one terminal, called the *originating* terminal, to another, called the *answering* terminal, uses FSK tones. The major distinction is that terminals, unlike cassette recorders, can operate in full-duplex mode and communicate in both directions over the same pair of wires. Rather than using a single pair of tones, which would be confusing if both terminals tried to transmit at the same time, a modem uses two sets of tones.

One set of tones (1070 Hz and 1270 Hz) is used by the originating terminal and another (2025 Hz and 2225 Hz) is used by the answering terminal. If your computer were connected to a timesharing computer, your computer would be the originating system and all your data would be sent with FSK tones of 1070 Hz and 1270 Hz for logic 0 and 1, respectively. The timesharing computer would answer you with 2025 Hz (logic 0) and 2225 Hz (logic 1) FSK data.

Almost universally, if you are dialing up a large computer network, you are the originating terminal. An *originate-only* modem, which is all

Text continued on page 28

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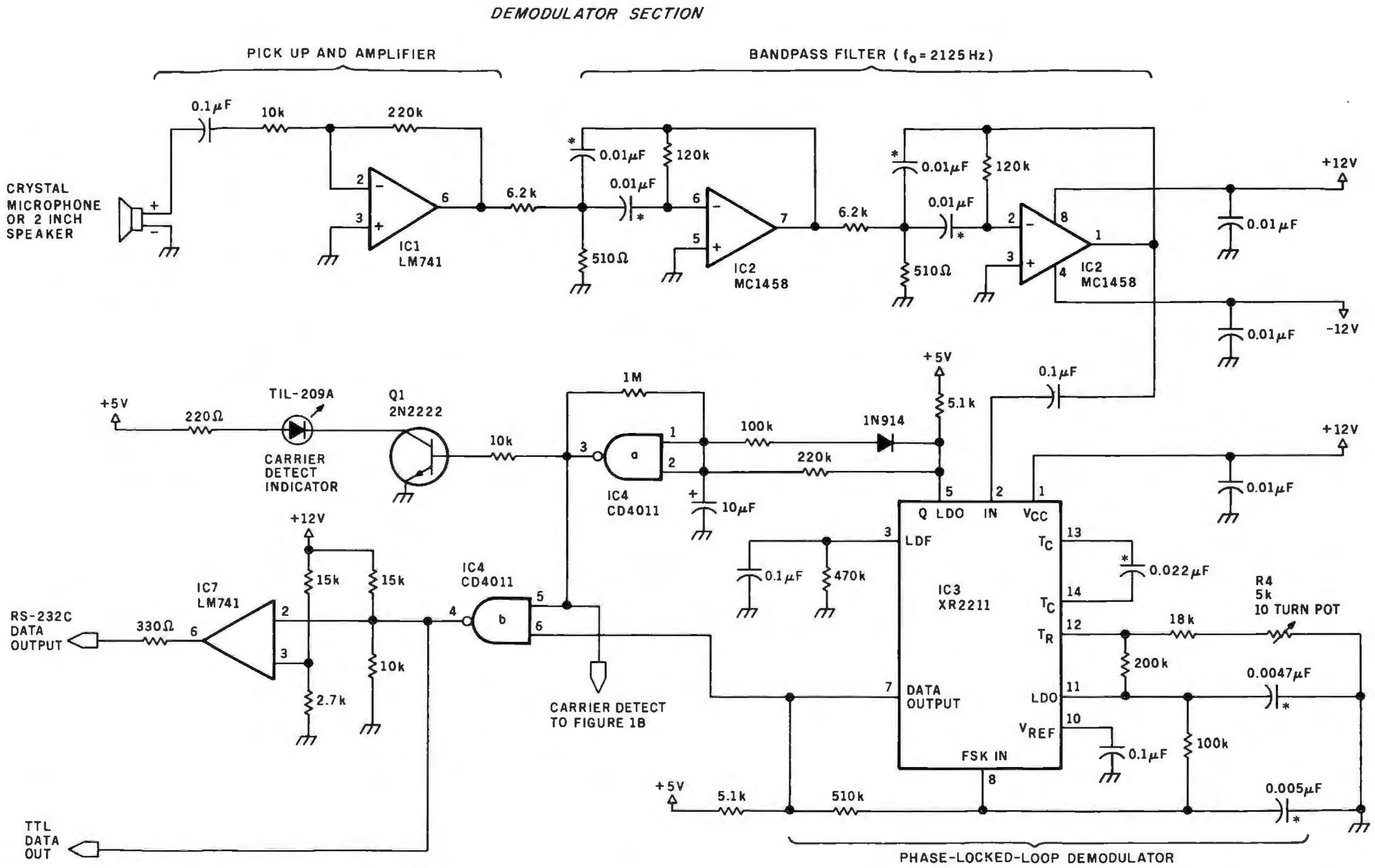

Figure 1a: *Originate-only demodulator section of the modem circuit, shown as a schematic diagram. This circuit features automatic muting and LED indication of carrier detection and will operate at data rates from 0 to 300 bps. The demodulator section is more complex than the modulator (shown in figure 1b) and consists of a preamplifier, a bandpass filter, and the phase-locked-loop demodulator.*

Capacitors marked with asterisks (*) must be Mylar or polystyrene types. If RS-232C compatibility is not needed, the LM741 operational (op) amplifier shown as IC7 can be omitted from the circuit. If a crystal microphone is used, instead of the voice-coil speaker, the op amplifier IC1 might be unnecessary.

Components were chosen to operate from power supplies of +12 V and −12 V. The circuit can be made to work for supplies within the range of ±5 V to ±18 V; however, the resistor network associated with IC7 may have to be changed.

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Number	Type	+5 V	GND	−12 V	+12 V
IC1	LM741			4	7
IC2	MC1458			4	8
IC3	XR2211		4		1
IC4	CD4011	14	7		
IC5	NE567	4	7		
IC6	LM386	6	4		
IC7	LM741			4	7

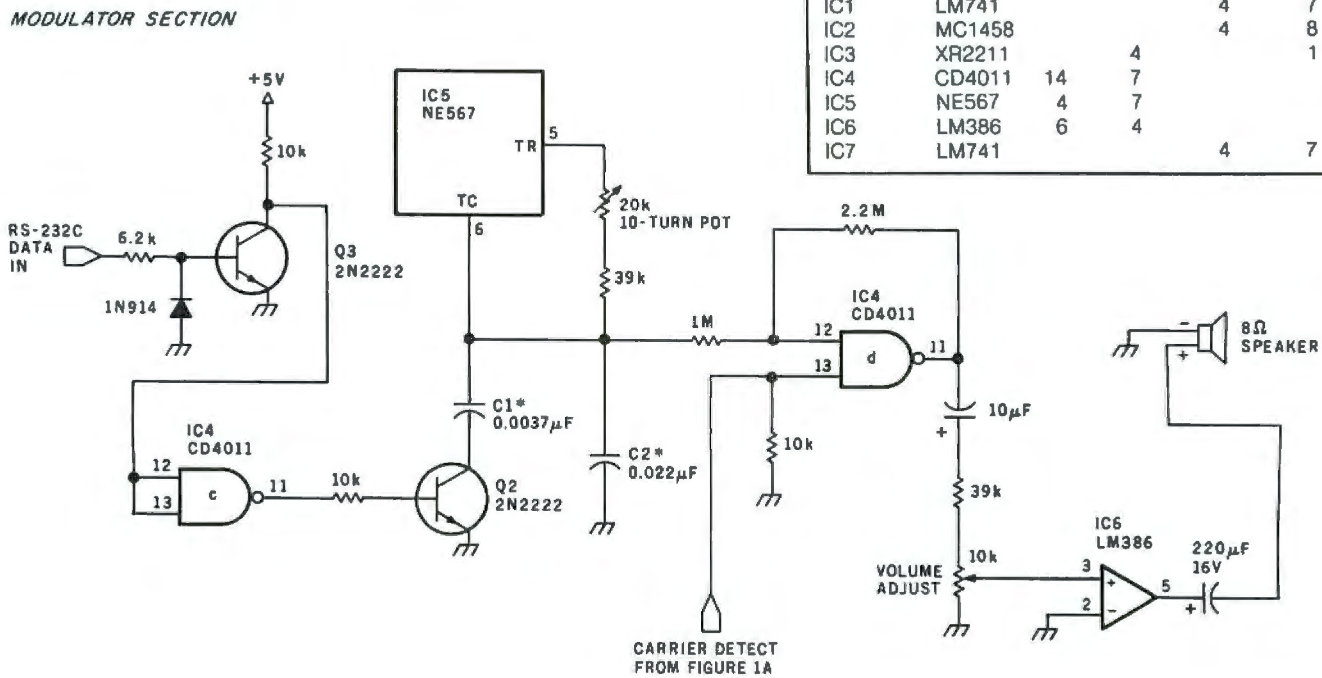


Figure 1b: *Modulator section of the modem circuit in schematic form. The tone frequency for a mark (1270 Hz) is set up by choosing the proper values for capacitor C2 and adjusting the 20 k-ohm potentiometer. When transistor Q2 gates capacitor C1 in parallel with C2, the oscillator frequency changes to 1070 Hz.*

Capacitor C1 (0.0037 µF) may be formed from a parallel combination of two components, a 0.0015 µF and a 0.0022 µF part. For use in the answer mode, the proper value for capacitor C1 is 0.001 µF, and the value for C2 is 0.01 µF.

If RS-232C communication is not a necessity, transistor Q3 may be omitted from the circuit.

Text continued from page 24:
you need in this instance, has a 1070/1270 Hz modulator and a 2025/2225 Hz demodulator. On standard dial-up telephone lines the acceptable speed limit is 300 bits per second (bps).

An answer modem is necessary when someone else calls you and chooses the originate frequencies for himself. In the answer mode, the modulator uses 2025/2225 Hz and the demodulator uses 1070/1270 Hz.

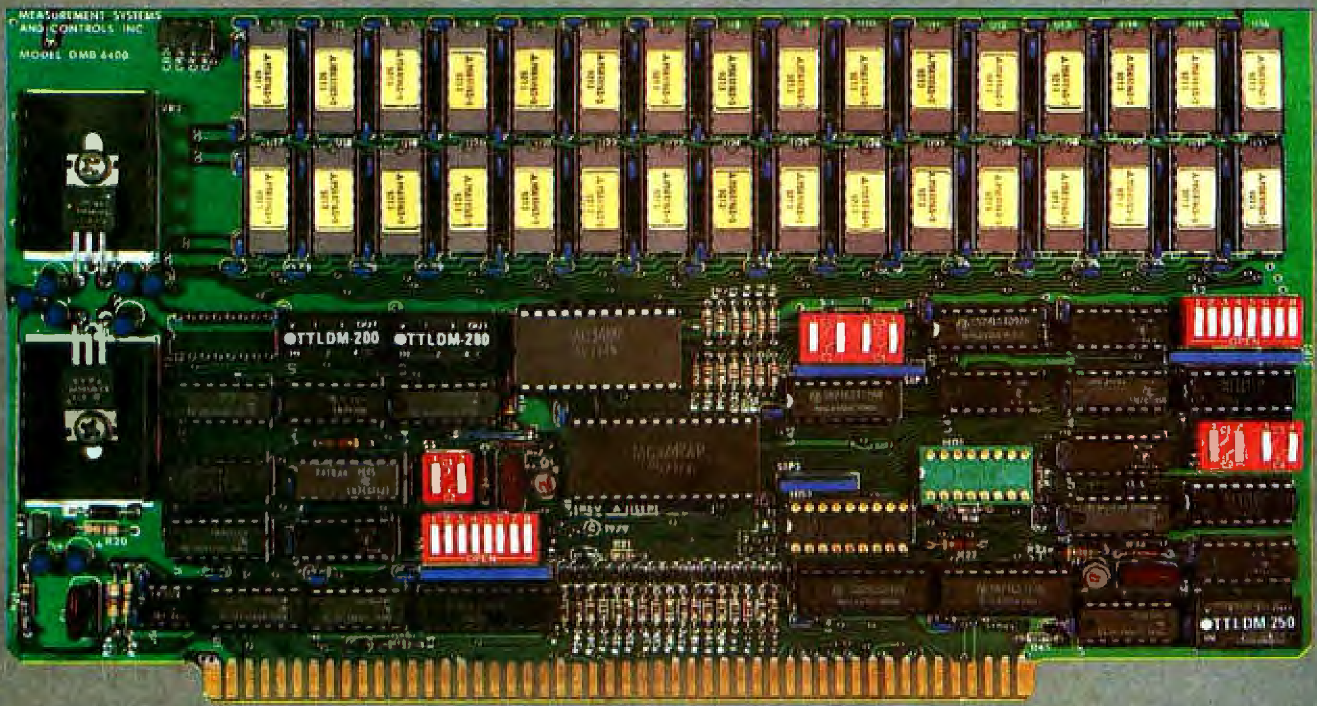
The choice is arbitrary: either modem can use originate mode or answer mode so long as they don't both use the same mode. Owning an originate-only modem is not a handicap as long as someone trying to communicate with you can set his modem to the answer mode to accommodate you.

The modem attaches to the serial input/output (I/O) port on the computer. Most serial ports use the RS-232C protocol, and most commercial modems also use RS-232C. While there are various handshaking requirements listed in the complete RS-232 specification, for the most part handshaking is ignored in simple full-duplex modem applications. Usually the only signals required for operation, beyond the data itself, are Carrier Detect and Data Set Ready.

Photo 4: *Apply rubber cement to the outside of the wedge-shaped piece of pipe insulation.*

Build Your Own Originate Modem

Gaining the capability to dial up a



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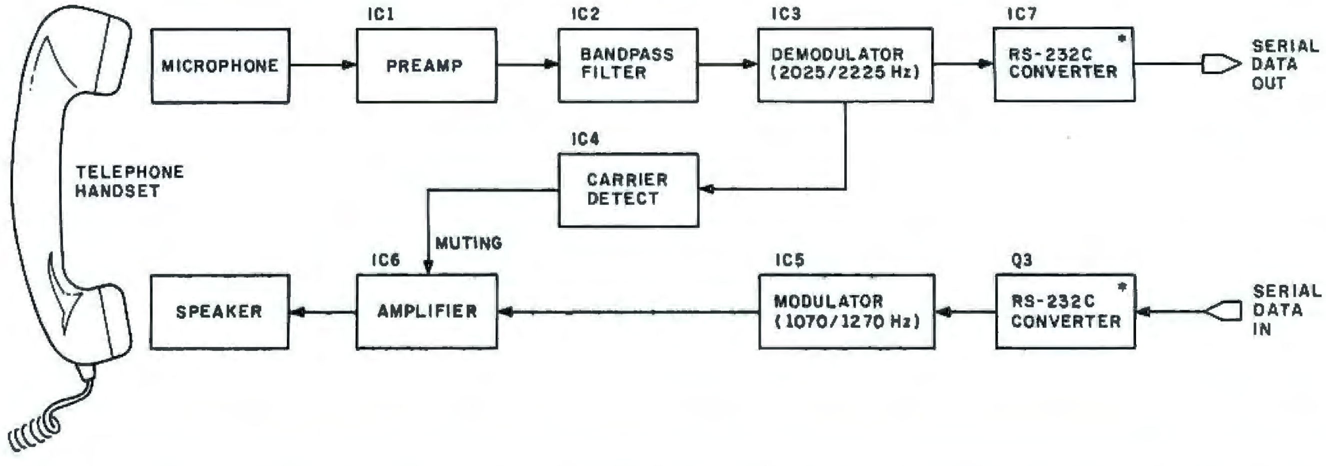

Figure 2: *Block diagram of the originate-only modem presented in this article. The blocks marked with asterisks (*) indicate the components that provide RS-232C compatibility; these may be left out of the circuit if RS-232 communication is not needed.*

national timesharing network or phone any of a hundred computer-information services on your personal computer is a significant milestone. When connected to these systems, you go beyond the hardware limits of the personal computer and instantly add large-computer capabilities. Figure 1 is the schematic diagram of a 0-to-300 bps originate modem which meets all the requirements for communicating with these systems. The prototype is shown in photo 1, mounted under the top cover of the COMM-80 serial/parallel interface.

There are two kinds of modems: direct-connect and acoustic-coupled. The former type requires attachment to the telephone wires through a data-coupler transformer. The latter type, the use of which has fewer legal strings attached, employs an acoustic coupler. This is nothing more than a speaker and microphone that sit under the mouthpiece and earpiece of the telephone handset. The speaker transmits the modem's output tones into the telephone, and the microphone listens for the other terminal's response.

Photo 5: *Adding pliable material to produce a tight fit around the phone handset. I found a plastic placemat at a discount store with a ⅛-inch foam backing that was perfect. Cut a strip 1½ by 8 inches and glue this around the outside of the wedge as shown. Trim to the exact circumference and cover with a strip of fabric adhesive tape. The latter helps hold everything together.*

Modems vary in complexity. Fifteen years ago they were very expensive and contained many discrete, precision components, including many toroidal inductors for the filter circuits. Photo 2 shows, on the right, an old Anderson-Jacobson modem. Newer technology is shown on the left: the Novation Cat, which is probably the most popular acoustic modem around. The reduction in size is accomplished through integrated-circuit technology.

Figure 2 is a block diagram of the modem circuit in figure 1. The design I am presenting takes advantage of advanced technology and uses only six integrated circuits for the complete modem. Two additional RS-232-converter devices can be added if RS-232C interfacing is required.

The modem is divided into two sections: modulator and demodulator. It also features carrier detection and automatic muting. A light emitting diode (LED) lights to signify that the answering modem is on the line and connected when the 2025 Hz tone (the "carrier") is detected on the line. A signal generated upon detection of the carrier automatically enables the modulator output (of the 1070 Hz tone) in response. Without this feature, the 1070 Hz tone would be blaring out of the speaker continuously.

The modulator section of figure 1b is not very difficult to understand. Tone decoder IC5 (an NE567 device)

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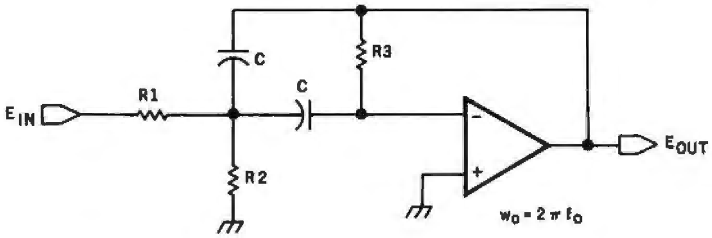
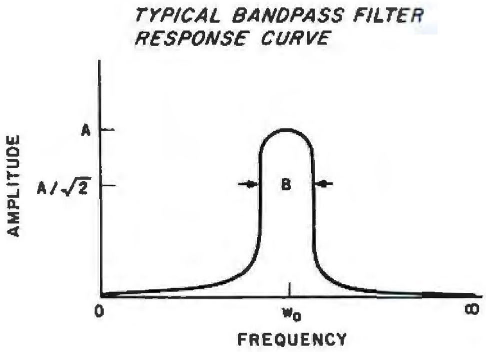




BANDWIDTH $B = 2/R_3C$

GAIN $G = -R_3/2R_1$

Q FACTOR $Q = f_0/B$

CENTER FREQ. $w_0^2 = 1/R_3C^2(1/R_1 + 1/R_2)$

FOR: $R_1 = 6.2k$ $R_2 = 510\Omega$ $R_3 = 120k$ $C = 0.01\mu F$

CALCULATED PARAMETERS:

$B = 265$ Hz
$G = -9.7$
$Q = 8$
$f_0 = 2117$ Hz

FOR AN ANSWER MODEM WITH $f_0 = 1170$ Hz USE:

$R_1 = 11k$
$R_2 = 910\Omega$
$R_3 = 220k$
$C = 0.01\mu F$

Figure 3: *The multiple-feedback, second-order bandpass filter: schematic diagram, response curve, and parameter-value calculation for given center-of-passband frequency.*

is configured as a very stable current-controlled triangular-wave oscillator. The space frequency (1270 Hz) is determined by the setting of the 20 k-ohm 10-turn potentiometer and capacitor C2. In response to a logic 1 input (inverted from logic 0 by IC4c) transistor Q2 gates capacitor C1 in parallel with C2. The oscillator frequency will now be 1070 Hz. This 567 oscillator, while very stable, has a high-impedance output. One section of the CD4011 NAND gate (IC4d) is used as a high-impedance linear amplifier to match the output of IC5 to the 50 k-ohm impedance input of IC6, the LM386 amplifier. Also connected to pin 13 of the CD4011 is the carrier-detect signal, which mutes the tone output when no 2025 Hz carrier is being received.

The demodulator section of figure 1a is more complicated and accounts for the major expense in a modem. In an acoustic demodulator there are three basic sections: preamplifier, bandpass filter, and demodulator. Either a crystal microphone or a standard 8-ohm speaker (the latter of which is really about the same thing as a dynamic microphone) can be used with this circuit.

The output of the speaker/mike is amplified by IC1, an LM741. You may not need the gain provided by this circuit (22×) if you're using a crystal mike. In that case you should eliminate IC1 and the 10 k-ohm and 220 k-ohm resistors, and feed the microphone output directly to the 6.2 k-ohm resistor leading to IC2. In either case, the signals acquired by the mike are sent through a sharp bandpass filter which passes only signals between 2000 Hz and 2250 Hz.

We use an MC1458 operational amplifier (IC2) to construct a multiple-feedback, second-order bandpass filter. IC2 is configured as two such elements, cascaded to improve response. The mathematical calculations behind component selection in this type of filter are outlined in figure 3. The objective is to pro-

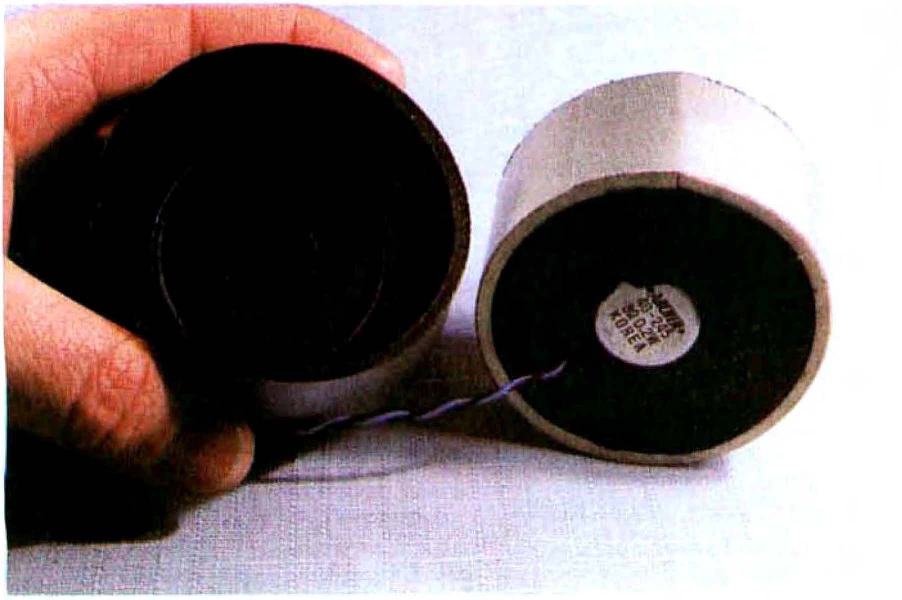
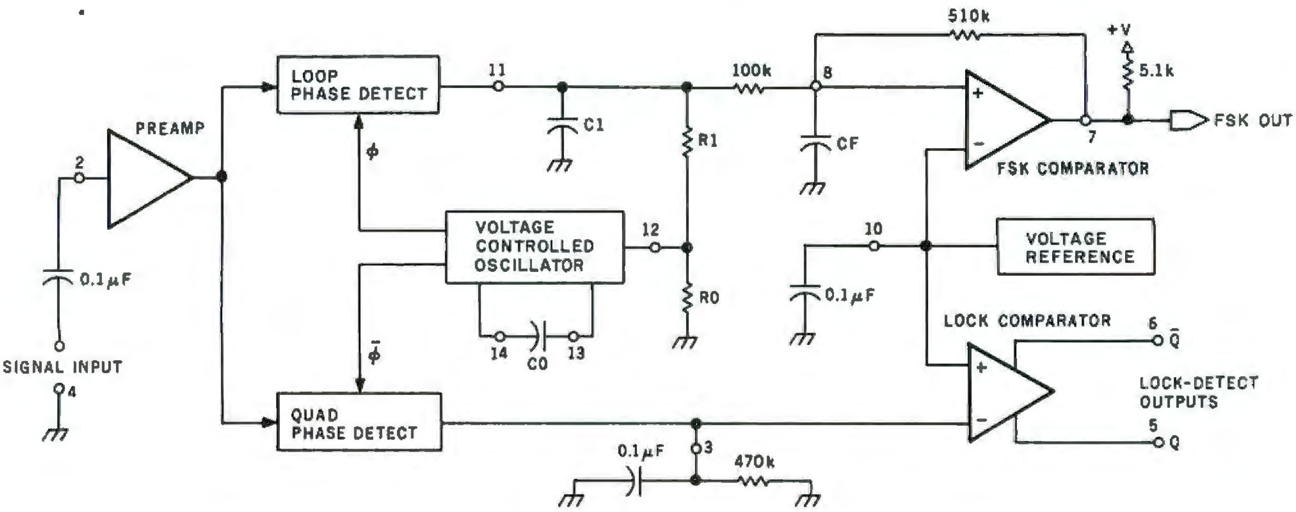


Photo 6: *Insert the speaker into the hole and align it with the angle of the foam wedge. In the unit shown, I used a black broad-tip marker to darken the white surfaces on the inside.*



ORIGINATE MODEM	*ANSWER MODEM*
f_1 = 2025 Hz	f_1 = 1070 Hz
f_2 = 2225 Hz	f_2 = 1270 Hz
R1 = 200k	R1 = 100k
R0 = 18 k	R0 = 18k
C1 = 0.0047μF	C1 = 0.01μF
CF = 0.005μF	CF = 0.005μF
C0 = 0.022μF	C0 = 0.039μF

Figure 4: *Block diagram of the XR2211 phase-locked loop component, which is IC3 in figure 1a. Appropriate component values for the two modem modes are shown.*

duce a filter with a center-of-passband frequency midway between 2025 Hz and 2225 Hz, with a bandwidth wide enough to allow these two frequencies to pass easily but reject everything else. The computed filter has a center frequency of 2117 Hz, a total gain factor of about 95, and a bandwidth of 300 Hz. When the telephone handset is inserted in the coupler, nothing is passed except the tones we want.

The output of the filter is sent to IC3, which is an XR2211 monolithic phase-locked loop (PLL) especially designed for FSK data communication by Exar Integrated Systems. Figure 4 presents a block diagram of this device with pertinent external component selection.

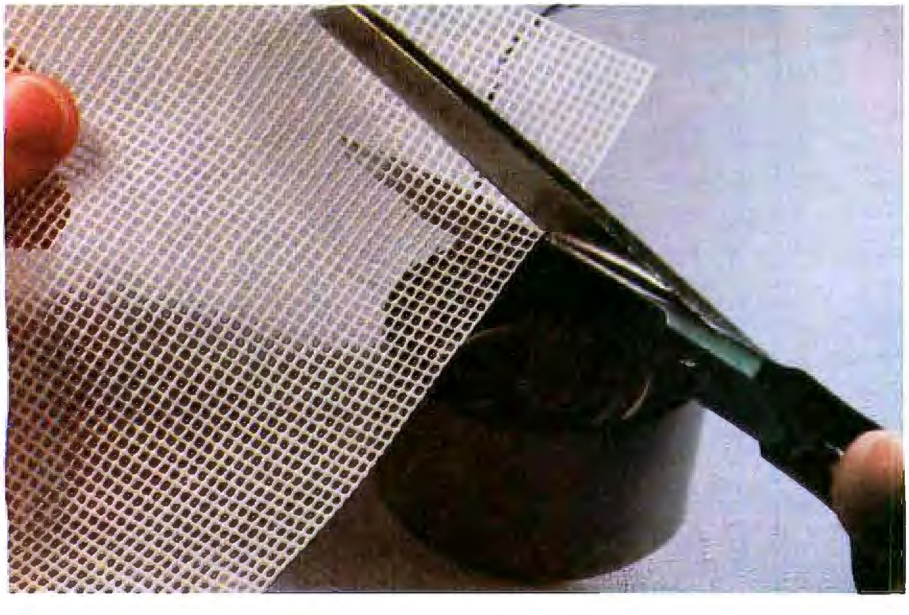


Photo 7: *Cutting the grill cloth. The stiff canvas used for needlepointing is ideal. Cut a circular piece and fit it to cover the speaker.*

A phase-locked loop is basically an electronic servo loop consisting of a phase detector, a low-pass filter, and a voltage-controlled oscillator (VCO). Its function is to synchronize its own oscillator to the incoming signal. If the incoming signal changes, the phase-detector output changes correspondingly to adjust the VCO to track the signal. In the XR2211, if the signal amplitude at the locked frequency is above a minimal value, the FSK comparator signifies this condition with a binary 1 output. The XR2211 can accommodate analog input signals between 2 mV and 3 V.

As shown in figure 1, the components are chosen for originate frequencies, and the XR2211 is powered by +12 V. (The specification says anything between +4.5 V and +20 V is acceptable, but +5 V is marginal in my experience.)

Alignment is simply a case of adjusting the 5 k-ohm potentiometer (R4). With a 2225 Hz signal applied to the microphone input, adjust R4 until pin 7 of IC3 goes low. Changing the input frequency to 2025 Hz

should make this pin go high.

In addition to the FSK output on pin 7, there is a lock-detect output on pin 5, used to denote carrier detection. It is connected to one section of the CD4011. This circuit is a 1-second-on/2-second-off delayed-trigger monostable multivibrator (one-shot). Either tone (considered the carrier in this case) has to be present for at least 1 second to trigger the circuit into operation, allow data to flow from the modem to the terminal, and turn on the modulator amplifier.

Photo 8: *The final assembly can be spray-painted black as I have done, but this is not necessary. Caution: some paints act as solvents on foam and will produce a sticky mess. Test a small sample before spraying the whole unit, and don't spray the speaker cone.*

IC7 and Q3 are added for RS-232C interfacing. If RS-232C communication is not a requirement, then these parts can be eliminated. Using the CD4011 (IC4b), the circuit can directly drive one low-power Schottky (LS) transistor-transistor logic (TTL) input load. A CD4049 inverting buffer or CD4050 buffer can be added to drive more input loads if necessary.

Construction Hints

We are dealing with high impedances and critical capacitances in this modem circuit. Layout should be compact, and Mylar or polystyrene capacitors should be used where indicated. Shielded cable should be used between the microphone and the modem board to reduce electrical-noise interference.

The acoustic coupler can be salvaged from an old modem, such as the Anderson-Jacobson unit

Photo 9: *With the production of two of the speaker assemblies I have described, we are in business. The one wired to the microphone input of the modem should be placed under the earpiece of the phone, and the one designated as the modem output speaker against the telephone mouthpiece. Dial your favorite computer, place the handset in the coupler, and when you see the carrier-detect indicator light, you are ready to go.*

(bought on the surplus market for $20.00), purchased from the source I listed, or you can make one from readily available materials which cost virtually nothing.

Photos 3 thru 9 illustrate the construction of an acoustic coupler. Both the transmitter and receiver use a 2-inch Radio Shack 8-ohm speaker and such "exotic" materials as foam pipe insulation, a plastic placemat, needlepoint canvas, and rubber cement.

When you are through building the coupler, connect it to the modem circuit and dial your favorite timesharing system. When the telephone connection has been made and you hear the tone, place the handset into the coupler. The carrier-detect LED should light, and you'll be in business.

If you succeed in building the modem and use it to call The Source, send me a message describing your effort. My user-identification number is TCE317.

Next Month: *A simple remote data-entry terminal for use in home control applications.* ■

Readers who wish to obtain the modem may order the following:

- *a complete kit of integrated circuits and components as shown in figures 1a and 1b, a printed-circuit board, and directions for assembly—$39.95*
- *two commercially made rubber cushions designed to fit 2-inch speakers, for use in acoustic couplers and two 2-inch speakers—$12.95*
- *this modem is available combined with the COMM-80 serial/parallel interface (June Circuit Cellar) and called the "chatter box." Assembled and tested with software—$259.95*

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Product Review

The Ohio Scientific CA-15 Universal Telephone Interface

Gregg Williams, Editor

Imagine the following scenario: a businessman in San Francisco calls his office in Boston. The phone rings four times, then a metallic voice answers.

"Hello," it says, "this is the message service of Morell Pharmaceuticals. If you wish to leave your number, please type it in using your push-button phone. Thank you."

Since the man calling is John Morell, the owner, he knows he can type in a special access code. He types in 999 on the Touch Tone phone. The computer on the other end of the line recognizes this sequence.

"Business status," the metallic voice answers. "Zones 1 thru 8 secure—no intruders. Zones 1 thru 8 report no fire alarms. Do you wish messages?"

Mr Morell types in 9, which stands for yes.

"You had three calls. Mr Morse called at 6:04 PM. Ms Morell called at 7:40 PM. Unidentified caller, phone 555-1501, called at 7:51 PM. Do you wish controls?"

Mr Morell types in another yes.

"Operation?" the computer asks. Mr Morell presses the buttons for the digits 0 and 2.

"Office lights on. Time to turn off?" the computer asks. Mr Morell presses the buttons 1, 0, 4, and 5, instructing the computer to turn the lights off at 10:45 that night.

"Another command?" Mr Morell types in a 6, which stands for no.

"Thank you. Good night," the computer voice says, then hangs up.

Is this another computer user's fantasy? (After all, we know that computers cannot do useful things like start coffee in the morning or water the lawn.) No, the above scene is entirely possible. In fact, I have seen a scaled-down demonstration similar to the above during a recent trip to Ohio Scientific to see its new CA-15 universal telephone interface (UTI).

Description

The CA-15 universal telephone interface (shown in photo 1) is a one-board peripheral device that will fit in any Model C8P, C2-8P, C2-OEM, or C3-series Ohio Scientific computer. The internal organization of the

Touch Tone is a registered trademark of the Bell Telephone System for its dual-tone, multiple-frequency signaling system.

Photo 1: *The CA-15 universal telephone interface board, shown with its optional Votrax voice synthesis module.*

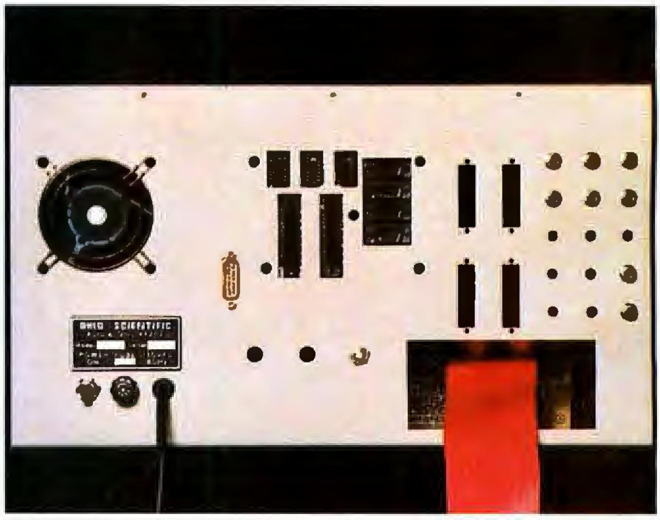

Photo 2: *Rear panel of an Ohio Scientific C8P computer, showing connections from the CA-15 universal telephone interface to outside components. The board connects to a CBT-type data coupler through the DB-15 connector (the small gold-colored connector in the center of the back panel). Other connections are made through the six phono jacks in the upper right-hand corner of the back panel. The jacks, listed in row order from left to right, are: cassette-recorder on/off control, phone-line monitor output, Votrax output (if used), cassette-player on/off control, cassette-player input, and auxiliary input.*

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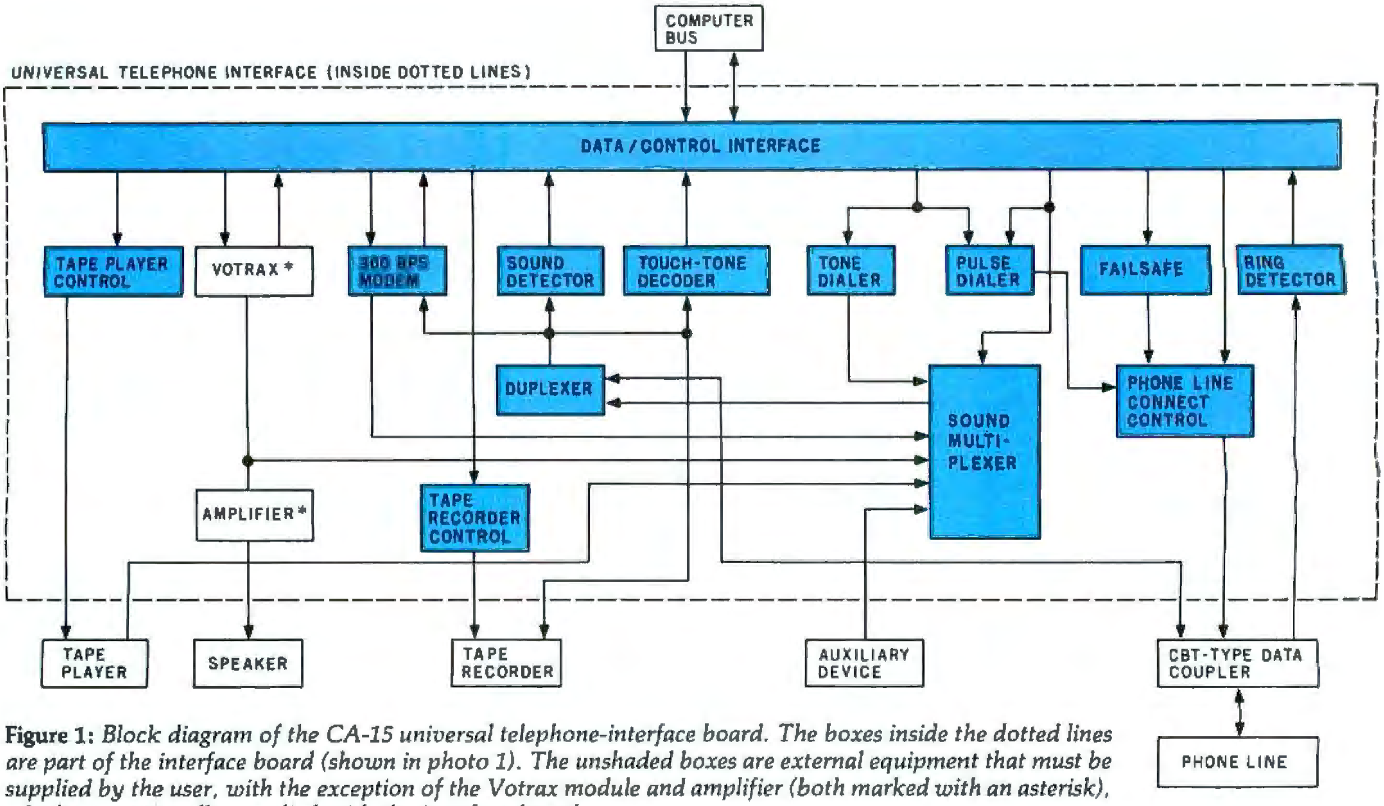


Figure 1: *Block diagram of the CA-15 universal telephone-interface board. The boxes inside the dotted lines are part of the interface board (shown in photo 1). The unshaded boxes are external equipment that must be supplied by the user, with the exception of the Votrax module and amplifier (both marked with an asterisk), which are optionally supplied with the interface board.*

board is shown in figure 1.

The CA-15 interface can:

- Initiate either Touch Tone or rotary pulse dialing of telephone numbers of any length.
- Use Touch Tone dialing to transmit numeric and control data.
- Sense a phone line ringing (on an incoming call) or a busy signal (on an outgoing call).
- Answer incoming calls and disconnect outgoing calls.
- Act as a 300 bits per second (bps) originate-or-answer modem.
- Play a prerecorded message from an external cassette player onto the phone line.
- Record a voice message onto an external cassette recorder.
- Place audio information (eg: computer-generated music from a digital-to-analog converter) on the phone line from an auxiliary input device.
- Optionally, speak using a computer-controlled Votrax speech synthesizer.

The CA-15 interfaces to the outside world via seven output jacks, as shown in photo 2. The board connects to a dedicated (ie: not used for any other purposes) telephone line through a CBT-type data coupler, which can be purchased from Ohio Scientific or rented from the telephone company. The data coupler is necessary to make a reliable, safe, and legal connection between a computer and the telephone line.

The universal telephone-interface board connects to the external data coupler through a DB-15 connector (the small gold connector in the center of the C8P rear panel shown in photo 2). The remaining six connections are made through the two rows of three jacks each in the upper right-hand corner of the computer's backplane. The jacks, listed in row order from left to right, are: cassette-recorder on/off control, phone-line-monitor output, Votrax output (if used), cassette-player on/off control, cassette-player input, and auxiliary input.

In keeping with Ohio Scientific's "hardware-first" orientation, the interface is controlled through examining and writing to (PEEKing and POKEing, in BASIC) certain memory locations. For example, to dial the three digits 6, 0, 3 (after initializing the interface board), we execute the BASIC instructions:

```
POKE 63494,189
POKE 63494,215
POKE 63494,190
```

The documentation supplied with the CA-15 universal telephone interface includes complete instructions that detail manipulation of the interface through reading and writing the appropriate memory locations.

Commentary

Coupled to the security and home-control options available in the Ohio Scientific line of computers, the CA-15 universal telephone interface is the link that extends the influence of a computer beyond its immediate environment. This extended environment includes any point within reach of the existing telephone network. With the Ohio Scientific AC-12P wireless remote-control option, the CA-15 interface can control home appliances

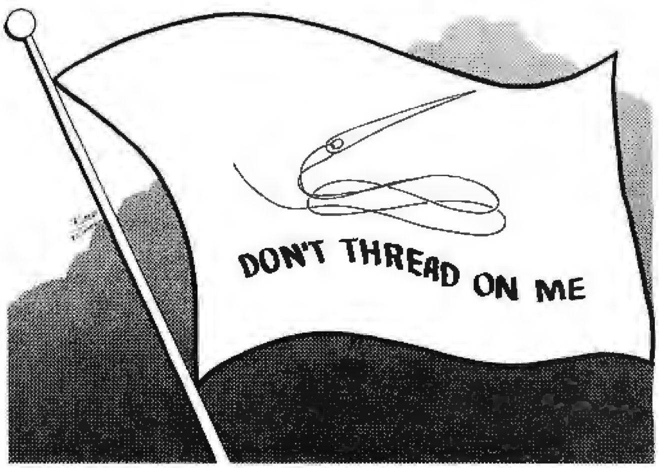
from any Touch Tone telephone. (A dial-type telephone can also be used if the person called has an external device that generates the standard Touch Tones.)

With the AC-17P home-security option, the CA-15 interface allows you to remotely determine whether intrusion, fire, or car alarms have been activated. And, with a sufficiently sophisticated BASIC program running, you can interconnect and control the security and wireless-control options from any telephone.

Other applications that come readily to mind are a sophisticated telephone-answering service (such as the scenario at the beginning of this review) and a stand-alone terminal, which can be used to call up computer bulletin boards, time-sharing services, and other remote devices.

The CA-15 universal telephone interface requires three power-supply voltages (+5 V, +12 V, and −9 V), while the popular model C4P computer (and its predecessor, the C2-4P) supply only +5 V. Other difficulties include the large number of input and output lines the interface requires and the limited number of slots in the C4P and C2-4P. Because of these problems, the interface cannot be used with the above two machines. However, I was told that an area of the CA-15 board has been left blank (see the bottom center of the interface board in photo 1) for a voltage-doubler circuit that would make its use feasible in the C4P and C2-4P. C4P or C2-4P owners interested in this option should express their interest to Eric Davis at Ohio Scientific, 1333 S Chillicothe Rd, Aurora OH 44202.

The CA-15 universal telephone interface is available through Ohio Scientific dealers for $499, or $799 with the Votrax voice module added. A Federal Communications Commission (FCC) approved CBT-type telephone line isolator is available for $199. Finally, a modified disk BASIC called Security BASIC is available for disk-based Ohio Scientific machines only. It is a modified Microsoft 9-digit-precision BASIC with extensions for the wireless remote-control, home-security, and telephone-interface options; these software extensions replace some of the PEEKs and POKEs otherwise used for device control with BASIC-like mnemonic commands. The Security-BASIC language system is available for $99. ■



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Product Review

The Heath H-89 Computer

Mark Dahmke, 1515 Superior St, Apt 15, Lincoln NE 68521

The Heath H-89 is Heath Company's latest in their rapidly expanding line of desk-top computers. The H-89 has a number of unique hardware features, and the same excellent software support and documentation as the original H-8 8080-based system.

Heath Company is promoting the H-89 as the *all-in-one* computer, which it most certainly is. It is based on the Zilog Z80 microprocessor, which makes it upward-compatible with all H-8 8080 software. Not only is the computer based on the Z80, but the video display terminal and keyboard subsystem also contains a Z80.

Photo 1: *The Heath H-89, a Z80-based all-in-one personal computer with built-in 5-inch floppy-disk drive, WH-19 terminal, and 16 K bytes of programmable memory (expandable to 48 K bytes). The price for the assembled unit is $2295.*

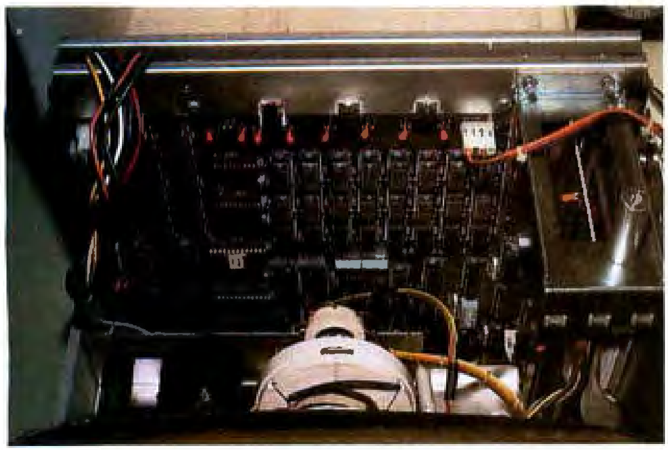

Photo 2: *Interior of the Heath H-89 computer.*

The processor board Z80 runs at 2.048 MHz — slightly faster than an 8080 at 2 MHz, but not at the 4 MHz maximum possible with a Z80. Up to 48 K bytes of main memory may be plugged into sockets directly on the processor board, as well as up to six expansion cards on twenty-five pin connectors. The processor board also has single-step and full interrupt logic, a serial RS-232 port that connects to the terminal board, and sockets for three 2708 EPROMs (erasable programmable read-only memories).

The terminal board consists of a Z80, a 6845 video controller chip, two read-only memories, two 2112-2 programmable memory components, an S740 keyboard encoder circuit, and an 8250 UART (universal asynchronous receiver/transmitter) for RS-232 communications. The terminal has a 12-inch video screen that displays twenty-four lines of eighty 5-by-7 dot-matrix characters. The twenty-fifth line is accessible under software control for special applications. Lowercase descenders and thirty-three 8-by-10 dot graphics characters are also provided.

A full keyboard with repeat key (this repeats any key pressed), eight user-definable function keys (see table 1), and a separate numeric keypad are standard on the H-89.

The special function keys generally send out a series of characters such as ESC H for *cursor home*, ESC E for *erase screen*, and so on. Although Heath has its own set of escape functions, the terminal may be placed in the ANSI (American National Standards Institute) mode for a standardized set of the same functions. The numeric keypad actually has three possible modes: the unshifted numeric mode (normal), the keypad shifted mode, and the alternate keypad mode. Table 2 shows the keycodes for each mode. A complete list of escape sequences is shown in table 3.

The ESC r X sequence allows the user to set the data rate from 110 to 9600 bits per second. For example, ESC r C sets the data rate to 300 bits per second.

Another nice feature is the special twenty-fifth line of the screen. This line is separate from the other twenty-four and will not scroll with the rest of the screen. The line may be enabled by sending ESC x 1 from either the computer or the keyboard. After enabling the twenty-fifth line, the cursor must be positioned somewhere in the line before writing characters using the direct cursor addressing sequence: ESC Y (line number) (column number) where the line and column numbers are sent as two ASCII characters after the ESC Y. In this case, the line number is 25 + 31 (31 must be added to the actual line and column number values) which is equal to 56 or "8" in ASCII codes. The column number (1 to 80) may range from 32 (ie: 1 + 31) to 111. To position the cursor

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Key	Heath Mode	ANSI Mode
F1	ESC S	ESC O S
F2	ESC T	ESC O T
F3	ESC U	ESC O U
F4	ESC V	ESC O V
BLUE	ESC P	ESC O P
RED	ESC Q	ESC O Q
GRAY	ESC R	ESC O R

Table 1: *Special function keys on the Heath H-89 computer.*

Unshifted Key	Shifted Key	Alternate Keypad Mode
0	0	ESC ? p
1	ESC L	ESC ? q
2	ESC B	ESC ? r
3	ESC M	ESC ? s
4	ESC D	ESC ? t
5	ESC H	ESC ? u
6	ESC C	ESC ? v
7	ESC @	ESC ? w
8	ESC A	ESC ? x
9	ESC N	ESC ? y
.	.	ESC ? n
ENTER	RETURN	ESC ? M

Table 2: *H-89 numeric keypad functions.*

in column 1 of line 25, the following sequence would be entered via the keyboard or sent from the computer: ESC "Y" "8" " ". If the sequence is sent from the keyboard, it is necessary to look up the character equivalents for each value (as above), but if the terminal is driven from a program in BASIC, the process is much simpler:

```
PRINT CHR$(27); "Y"; CHR$(56); CHR$(32);
```

Note that the CHR$(27) causes the ASCII "ESCAPE" code to be sent; 56 and 32 are the line and column numbers, added to 31. The CHR$ function converts the decimal code number into the corresponding character.

MTR-88 Monitor Program

The H-89 comes with a monitor program in programmable read-only memory that allows the user to operate at machine level or use the system without disk drives (or tape, for that matter). The MTR-88 cassette I/O functions are compatible with the cassette entry points in the PAM-8 front-panel monitor of the H-8, so software written for the H-8 will execute correctly on the H-89.

The monitor supports the following commands:

Boot	Load HDOS from disk.
Dump	Dump a program to cassette tape.
Go	Execute a program at the given address.
Load	Load a program from cassette tape.
Program Counter	Set the program counter address (prior to entering the Go command).
Substitute	Inspect or change memory locations.

The load and dump commands are set up to work with the H-88-5 cassette interface board. MTR-88 also maintains a tick counter in memory. The counter is a 2-byte field at memory addresses 040.033 and 040.034 (in split octal notation) that is incremented by 1 every 2 ms as long as interrupts are enabled. It is possible to assign interrupt vectors for special applications (as with all Heath software) by changing the addresses in the bottom 64 bytes of memory.

HDOS Disk Operating System

HDOS (Heath Disk Operating System) is a comprehensive disk-management package. HDOS allows the user to create, manipulate, and display the contents of disk files and the disk directory. Other commands allow the user to display disk statistics (ie: usage, remaining space, errors) and to set device options such as console/printer data rate, whether or not a back-space cursor function is available on the terminal in use, uppercase or upper/lowercase mode, tabs, console width, and so on. HDOS provides "device drivers," special subroutines which perform all necessary initialization and housekeeping functions for each peripheral interface — console, line printer, alternate console, and so on. The device drivers may be called by the user's program, saving the user the effort of writing device interface routines.

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All devices on the H-89 have been assigned device names. Table 4 lists all devices. For example, to list a file on the printer, the command

COPY LP:=SY0:FNAME.EXT

is used, where LP: is the destination, and FNAME.EXT is the disk file on device SY0: to be listed.

ESC H	Cursor home
ESC C	Cursor forward (right)
ESC D	Cursor backward (left)
ESC B	Cursor down
ESC A	Cursor up
ESC I	Reverse index
ESC n	Cursor position report
ESC j	Save cursor position
ESC k	Set cursor to previously saved position
ESC Y	Direct cursor addressing
ESC E	Clear display (also shift erase)
ESC b	Erase beginning of display
ESC J	Erase to end of page
ESC l	Erase entire line
ESC o	Erase beginning of line
ESC K	Erase to end of line
ESC L	Insert line
ESC M	Delete line
ESC N	Delete character
ESC @	Enter insert character mode
ESC O	Exit insert character mode
ESC z	Reset to power-up configuration
ESC r *Bn*	Modify data rate (*Bn* is a character to select data rates from 110 to 9600 bps.)
ESC x *Ps*	Set mode: (select *Ps* from:) 1 = Enable twenty-fifth line 2 = No key click 3 = Hold screen mode 4 = Block cursor 5 = Cursor off 6 = Keypad shifted 7 = Alternate keypad mode 8 = Auto line feed on receipt of carriage return 9 = Auto carriage return on receipt of line feed
ESC y *Ps*	Reset mode(s): (same as set modes listed above)
ESC <	Enter ANSI escape-sequence mode
ESC [	Enter hold screen mode
ESC \	Exit hold screen mode
ESC p	Enter reverse video mode
ESC q	Exit reverse video mode
ESC F	Enter graphics mode
ESC G	Exit graphics mode
ESC t	Enter keypad shifted mode
ESC u	Exit keypad shifted mode
ESC =	Enter alternate keypad mode
ESC >	Exit alternate keypad mode
ESC }	Keyboard disabled
ESC {	Keyboard enabled
ESC v	Wrap around at end of line
ESC w	Discard at end of line
ESC Z	Identify as DEC VT52 terminal
ESC]	Transmit twenty-fifth line
ESC #	Transmit page

Table 3: *H-89 escape sequences.*

SY0:	System disk drive #0
SY1:	System disk drive #1 (optional)
TT:	Console device
AT:	Alternate terminal (optional)
LP:	Line printer
ND:	Null device (This eats up characters sent to it.)

Table 4: *H-89 device assignments in HDOS.*

The H-89, Heath's all-in-one computer, has a number of unique hardware features and the same excellent software support and documentation as the original H-8 system.

The two directory-oriented devices are SY0: and SY1: . On these devices (ie: disks), the directory keeps track of what files exist and where they are. Each file can have an eight-character name with a three-character extension. The extension is useful when keeping track of a number of related files. For example:

MYPROG.ASM
MYPROG.LST
MYPROG.ABS

Here the .ASM indicates that the first file is the assembler source of MYPROG entered via the text editor. The .LST file is the listing output of the assembler, and .ABS is the object code resulting from the assembler run.

HDOS Utilities

HDOS also comes with a number of useful utility programs:

PIP	(peripheral interchange program) A generalized disk-file maintenance program.
ONECOPY	A program that allows the user with only one disk drive to copy files from one disk to another.
SET	A very useful program that allows the user to redefine device driver configurations. Table 5 lists all options of the SET command.
STAT	Displays system performance, number of disk errors, etc.
FLAGS	Sets disk-file flags to write-protect a file, to suppress normal listing and copying of a file, and (optionally) to lock the file against further flag changes.

DBUG

The Heath console debug program allows the user to enter and debug machine-language programs from the console. DBUG will perform the following functions:

- Display and alter contents of any memory location.
- Display and alter contents of any 8080 processor register.
- Single step through a program.
- Execute a program.
- Set breakpoints in a program.
- Load or dump user programs to or from a device (eg: tape or disk).

Note that DBUG supports only the 8080 register set, not the extra registers in the Z80. Also, DBUG does not have a disassembler feature.

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The Text Editor

The Heath Text Editor is used to enter and edit assembly and BASIC programs, as well as to create and edit reports, letters, and manuscripts.

EDIT uses all available memory in the system as a text buffer. When the buffer is full, all or part of it may be transferred to a disk file. This allows the user to work on files in size up to the limit that will fit on disk. EDIT has a very unusual command format:

<range> <verb> <qualifier string> <option> <parameters>

Range defines the buffer lines the command is to operate on. Characters to indicate certain lines are as follows:

!	Defines the first line of the buffer.
$	Defines the last line of the buffer.
+	Followed by a decimal number, refers to the *nth* line past the current line pointer.
−	Followed by a decimal number, refers to the *nth* line preceding the current line pointer.
+ *'string'*	The first line in the buffer which contains the 'string' after the current line.
− *'string'*	The first line in the buffer which contains the 'string' preceding the current line pointer.

Multiple line ranges can be specified by using two of the above range expressions in sequence with a comma between them. A blank preceding a verb will cause the command to operate on the entire buffer. An equals sign reuses the range of the last command.

The verb specifies the action to be taken by the editor. Examples are: Print, Replace, Delete, Read, Write, Use, Search, Bye, and so on.

The qualifier string is a further restraint on the range expression and is optional. For example, it is possible to operate on only those lines that contain a phrase or string of characters. If the phrase is entered in single quotes in the qualifier string field, only those lines containing the specified string will be affected.

The option field determines if the current line is to be displayed before it has been modified, after it has been modified, or both. Use of this field is optional.

The parameter field is a special field used to direct disk I/O actions of the editor.

This is the most difficult editor I have ever tried to work with. Even after carefully reading the manual and spending a great deal of time learning how to use it, it is incredibly frustrating. The range and other fields are unconventional and require some getting used to. When writing programs in BASIC, it is far easier to use the line entry and edit commands in the BASIC interpreter. Trying to write assembler programs with this editor is nearly impossible.

Considering all the excellent software and hardware documentation and support of the H-89, and the powerful intelligent terminal features for full-screen editing, it

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SET VER	prints the version number of the SET program.
SET HELP	gives information on the SET command.
SET TT: HELP	gives information on the SET command for a particular device; TT: in this case.
SET TT:	
Option	Description
NOBKS	uses the back-slash character for errors.
BKS	allows back-spacing to correct typing errors.
BKM	causes back-space (control-H) to be treated as a delete.
NOBKM	lets HDOS receive the back-space character.
MLI	maps lowercase input to uppercase.
NOMLI	allows lowercase input to HDOS.
MLO	maps lowercase output to uppercase.
NOMLO	allows lowercase output from HDOS.
NOTAB	HDOS expands TAB (control-I).
TAB	lets terminal expand TABs (faster).
2SB	uses 2 stop bits (universal).
1SB	uses 1 stop bit (normal).
WIDTH n	sets console width to n characters, 80 is default.
FILL c n	sets c as a character that needs n fill characters following it; for slow hardcopy terminals.
SET LP:	
6LPI	sets the H-14 printer for six lines per inch.
8LPI	sets the H-14 printer for eight lines per inch.
PAGE n	sets the number of lines per page to n.
PORT n	sets the port address for LP: to n.
WIDTH m,n	sets the width control switch position
BAUD n	sets the data rate for LP:
SET AT:	same as for TT:
SET SY:	
STEP n	sets the step time between tracks on the disk drive. (The TEST command is used to determine the value of n.)

Table 5: *SET command options.*

REPLACE "fname"	replaces "fname" with current program, if it exists; works like SAVE if the file doesn't exist.
CNTRL iexp1,iexp2	CNTRL 0 sets a GOSUB to line iexp2 when a CTL-B is typed. CNTRL 1 sets iexp2 digits before exponential format is used. CNTRL 2 controls the H-8 front panel. Does nothing on the H-89. CNTRL 3 sets the width of a print zone to iexp2 columns. CNTRL 4 controls the state of the HDOS system overlay. iexp2 = 0, swap overlay. iexp2 = 1, keep overlay in memory.
FREE	displays the amount of memory assigned to tables and program text.
FREEZE "fname"	saves BASIC interpreter, current program, and data values on the file "fname".
UNFREEZE "fname"	reloads the file saved with a FREEZE command.
LOCK	protects the program by preventing execution of BUILD, BYE, CHAIN, UNFREEZE, DELETE, RUN, SCRATCH, and CLEAR commands.
UNLOCK	reverses a LOCK command.
UNSAVE "fname"	deletes the file "fname" from disk.

Table 6: *Extended Benton Harbor BASIC commands not found in other versions of BASIC.*

seems incongruous that this system should have such a difficult editor to work with.

The Assembler

The Heath Assembler is a very straightforward, absolute 8080 assembler (not Z80) with most of the standard assembler directives (ie: DB, DS, DW, END, EQU, ORG, SET, TITLE). The XTEXT directive is used to include whole disk files of assembler text into a program. This is convenient if there are some standard symbols or memory addresses that are to be incorporated into every assembler program, such as HDOS definitions. Also, useful subroutines may be included in this way. This feature may be used as a macro-instruction library facility, because the assembler does not allow macro-

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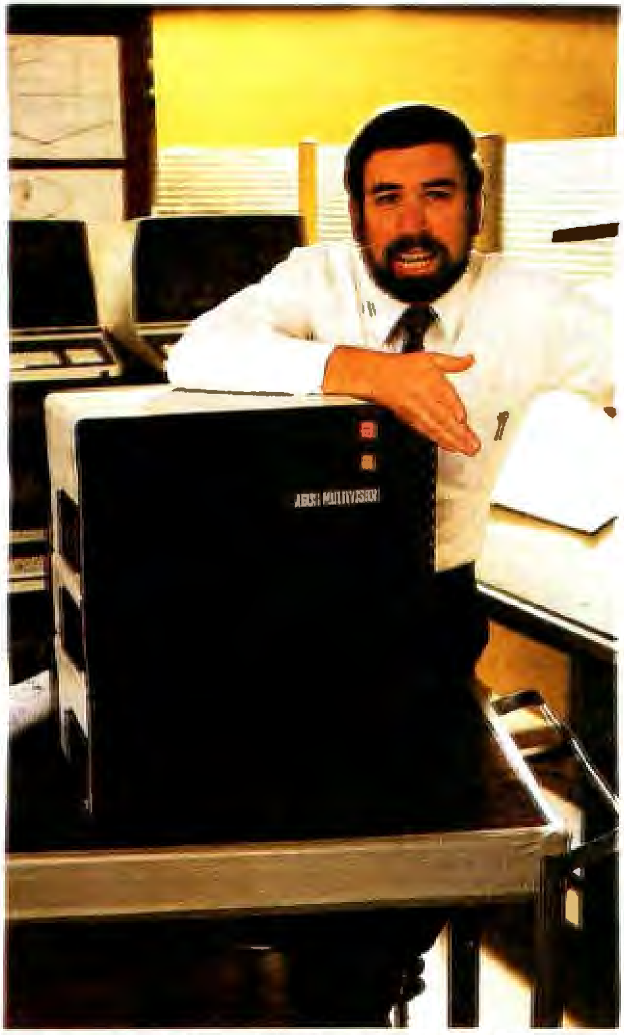

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instruction definitions. A file comes with HDOS called HDOS.ACM. It contains standard HDOS system-call symbols for easily interfacing a user-written program with HDOS and the device drivers.

Extended Benton Harbor BASIC

Extended Benton Harbor BASIC (herein referred to as EBH BASIC) is Heath's own version of BASIC. It is an extension of Dartmouth BASIC with some unique features. One of the first differences I noticed was the command that initiates automatic line numbering while entering programs. In most versions of BASIC it is called AUTO, but in EBH BASIC it is BUILD. The BUILD command works exactly like AUTO. Another important difference is the lack of a RUN "FNAME" command. If the user wishes to execute a program that is on disk as the file "FNAME", the following must be entered:

```
OLD "FNAME"
RUN
```

To clear the machine of program and data, the command is SCRATCH, not NEW as in most versions of BASIC.

EBH BASIC has some unique and useful commands. (Table 6 lists these special commands and their functions.) But it is not without its problems. Even the most insignificant of syntax errors, such as leaving out a comma or right parenthesis, causes EBH BASIC to display a simple SYNTAX ERROR message. Unfortunately since it has to access a disk file called ERRORMSG.SYS to get the text of the error message, the user is forced to wait several seconds to find out what he or she probably already knows. The philosophy of storing error-message text on disk to save space in memory is a useful one, but in this case it severely hampers development of programs. The best approach would be to have the most frequently occurring error messages in memory and then access the disk for the remainder.

Microsoft BASIC

Microsoft BASIC is widely used and is very standardized. I will not spend time describing its features.

The Heath implementation of Microsoft BASIC does have one significant fault; when a program is loaded from disk, the disk read head is raised and lowered for each and every sector of the file. This produces an annoying banging sound that seems to go on forever. It is also bad for the drive mechanism and will contribute to the wear and tear of the unit.

Conclusions

The H-89 has flexibility and does not require the user to understand anything about the hardware to take full advantage of all the features. One important point remains: after all the HDOS operating system utilities are put on a single 5-inch floppy disk, there is very little room for any large user programs. To make the system really useful, a second disk drive is a necessity. If the H-89 were to be used in a business with a really large data base, the data would be a tight fit even with two drives. ■

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The Hard-Disk Explosion

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High-performance, high-quality, and large-capacity hard-disk drives are now a low-cost reality for your personal-computer system. Most hard disks use *Winchester* media, head technology, and other modern techniques to achieve high density and high performance in a small space. One side effect is low power consumption. Some of the drives suitable for personal computers use the older 14-inch standard diameter platters. Many new drives use one of two new small sizes—200 mm (7.87 inch) or 210 mm (8.27 inch) diameter—and one new drive uses 130 mm (5.12 inch) platters. Even so, their data capacities are significantly larger than floppy-disk drives of the same approximate size.

The latest disk drives can be divided into two general categories:

- low-cost, relatively low-performance drives that will eventually replace floppy-disk drives, especially where multiple drives would normally be necessary to obtain enough storage. For example, instead of adding more floppy drives to increase the storage capacity of a system, one set of dual floppy-disk drives might be replaced with an 8-inch hard-disk drive that fits in the same space. This improves the storage capacity and system performance dramatically. These low-end disk products will compete on a cost-per-drive basis.
- high-capacity, top-performance drives that must compete on a cost-per-byte basis. The 8-inch or smaller versions will likely (at least at first) be more costly per byte than the 14-inch models. However, their advantages of small size, light weight, low noise, and low power requirements make them very attractive for desktop and personal computers as well as small business systems.

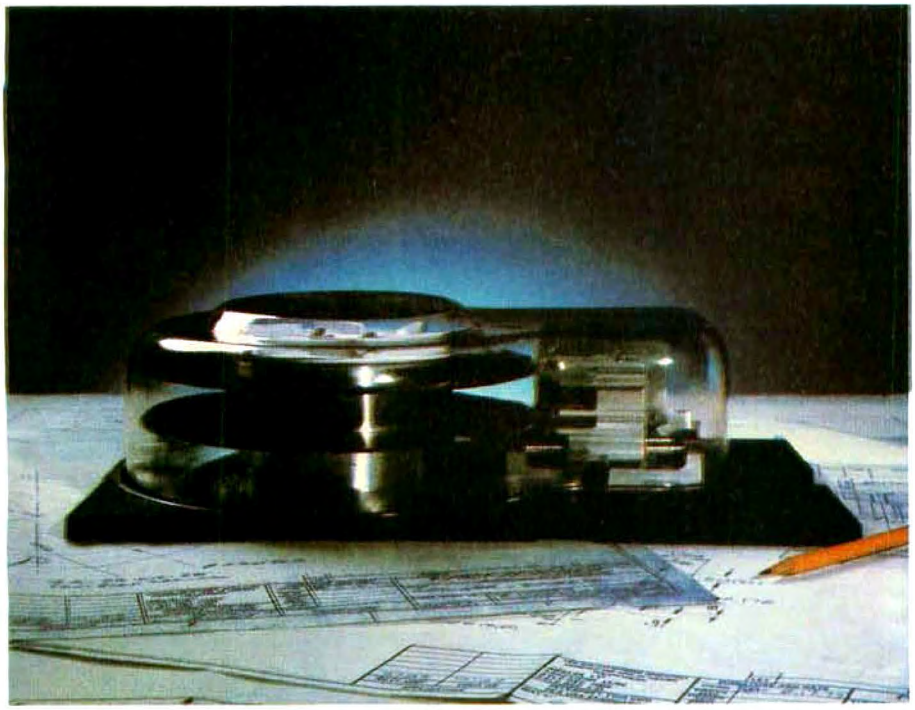

Photo 1: *The Memorex Model 101 hard-disk drive. (Photo courtesy of Memorex.)*

The Winchester disk-drive technology developed by IBM provided expensive, large-capacity, high-performance, and low cost-per-byte disk subsystems (ie: the IBM 3350 and 3370 disk-drive systems) for large, expensive computer systems. This technology and development in other areas of disk-drive performance are now being applied to the development of products suitable for smaller systems. The tremendous growth of microcomputers has created a de-

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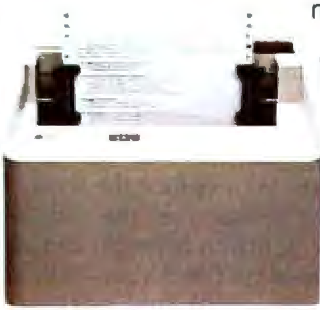

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mand for small, compact disk drives. The industry has responded and is beginning to produce them. A Winchester disk drive for your personal computer is now, or soon will be, a possibility. However, it may still cost you five to ten times the price of your processor to get a complete small hard-disk subsystem with drive, controller, interface, power supply, and packaging.

Photo 2: *Close-up of a Winchester-type read/write head. (Photo courtesy of Kennedy Company.)*

Photo 3: *The remarkable Shugart Technology Model ST506 hard-disk drive, offering 6 megabytes of mass storage in a 3.5-pound package that fits in the same space as a 5-inch floppy-disk drive. (Shugart Technology is a new company located in Scotts Valley, California, and is not affiliated with either Shugart Associates or Xerox. Photo courtesy of Shugart Technology.)*

What Is Winchester Technology?

Three disk technologies have evolved, all pioneered by IBM. Other manufacturers have refined the designs. These technologies are usually referred to by the model numbers of the original IBM product employing the technology: "2314" technology (in the 1960s), "3330" technology (late 1960s, early 1970s), and "Winchester" technology (1973).

Disk storage, being a special type of add-on memory, can directly affect a computer system's performance, throughput, and reliability. Because of this crucial role, the principal design objectives for disks are large capacity, fast access time, absolute reliability, and low cost.

Each of the three advances has brought a significant increase in storage density. One way to increase density is to reduce the flying height of the heads over the disk surface. Each reduction in height allows an increase in tpi (tracks per inch) and bpi (bits per inch) (see figure 1). Advances in head design and positioning mechanisms have also contributed to increases in tpi and bpi.

Head flying heights have evolved as shown in table 1.

Just prior to 1973, disk-drive technology approached some limits. The flying height had been reduced to 31 microinches. Without further reduction, significant improvement in data density was difficult. At lower flying heights, a single smoke particle, whose diameter may be up to ten times the distance between the head and disk surface, can damage the disk and data. Therefore, cleaner conditions were required. Also, the disk platters and magnetic surfaces were inadequate for large increases in track and bit densities.

The 3340 Winchester disk drive, introduced by IBM in 1973, was the first breakthrough. Storage Technology Corporation announced a similar disk drive around the same time: the STC 8800 superdisk.

Winchester Characteristics

Winchester disk drives have the following characteristics:

- sealed disk, head, and positioning assemblies
- new trimaran head design—two outriggers supporting a narrower inner hull containing the read/write head (see photo 2)
- thinner magnetic coating: 44 microinches versus 185 microinches in the 2314 disk drive
- lubricated disk surfaces
- heads resting on disk surface when drive is stopped—they take off and fly low when motion starts (normal take-off and landing are done on an area reserved for that purpose)
- light loading force (10 g) and lighter heads.

These characteristics permit many performance improvements: very low flying heights (19 to 20 microinches), improved reliability, and a dramatic reduction in head crashes are possible because of the clean environment, new head and loading designs, and lubrication. Data densities are increased because of lower flying height and thinner platter coating. The higher densities improve throughput performance directly. More bits per inch allow more data to pass under the heads per unit time. More tracks per inch mean that track-to-track access times are shorter. The lighter heads and head mounts have less inertia and can be positioned faster. Throughput performance can be improved by increasing the rotational speed, up to a point—the aerodynamic characteristics of the flying head put some constraints on the rotational speed. The reliability of the Winchester drives surpassed that of any moving-head disk drive that was previously available.

Improvements and refinements have continued from many manufacturers. The costs of many of the most expensive elements in a disk (the motor, head actuator, and control electronics) are relatively independent of the capacity of the disk platters. It is, therefore, cost-effective to increase the density of the platters and the number of platters. The incentive has been to add capacity by any conceivable means, and trends have been toward more platters per spindle and greater bpi and tpi densities (data density has gone from about 1000 bpi on early 2314s to over 8600 bpi on some of the recent disks, and tpi density has gone from 200 tpi on 2314s to over 600 tpi on new products). Cost effectiveness has also been enhanced by reducing the access time and increasing the data flow; the economic payoff is increased throughput and efficiency of the total

system. In applications where disk storage is a key element, the processor is often disk-I/O-bound. Program execution speed depends on disk speed. Every increase in throughput will improve the total performance.

Other improvements in throughput performance in disk subsystems have come from RPS (rotational postioning sensing), which frees the disk controller and I/O (input/output) channel for other work during seek time (head actuator movement) and during part of the rotational delay time. Improvements have also included new automatic error detection, correction, and recovery capabilities built into disk controllers.

Voice-coil actuators, described in the next section, are common on high-performance disk drives. There are both linear and rotary voice-coil positioners. Rotary voice coils typically take up less space, require less power, and generate less heat than linear voice coils. Stepper motors with band actuators are usually used in lower-performance, lower-cost disk drives. Many of the new small drives use brushless DC (direct current) motors with direct drive on the platters. Designed as part of the spindles, these motors are compact (about 1 inch high), maintain speed more accurately, use less power, and require simpler power supplies than AC (alternating current) motors with belt drives. In many drives, each recording surface is split into inner and outer bands with a head for each band, reducing the average access time by one-half, because twice the amount of data can be read or written without moving the heads.

Photo 4: *BASF Systems' 6170 Series 8-inch, fixed hard-disk drive, available in 8- and 24-megabyte versions. (Photo courtesy of BASF.)*

Comparing the New Hard Disks to Floppy-Disk Drives

The current trends toward multiterminal systems, real-time transaction oriented systems, small business systems, and more powerful personal computers for a great variety of applications have created a demand for more on-line data storage. Floppy-disk drives and tape cassettes often do not have the required performance (access times, throughput, etc), reliability, or capacities. Thus, the need for secondary storage is being filled by new, inexpensive, high-performance, highly reliable small-disk drives with capacities, speeds, and reliability close to the very expensive drives. These new drives are physically much smaller and more reliable than 14-inch cartridge or disk-pack drives. They are aimed initially at a gap between floppy drives and 14-inch drives (eg: Winchester, 5440 cartridges and 3330 type packs). They are designed for use on small business systems, distributed-processing systems, word-processing systems, and advanced personal computer systems.

The new drives offer a lower cost per unit than 14-inch drives, and lower cost per byte than floppy-disk drives. They provide the advantages in capacity and performance of hard disks in a package the same size as an

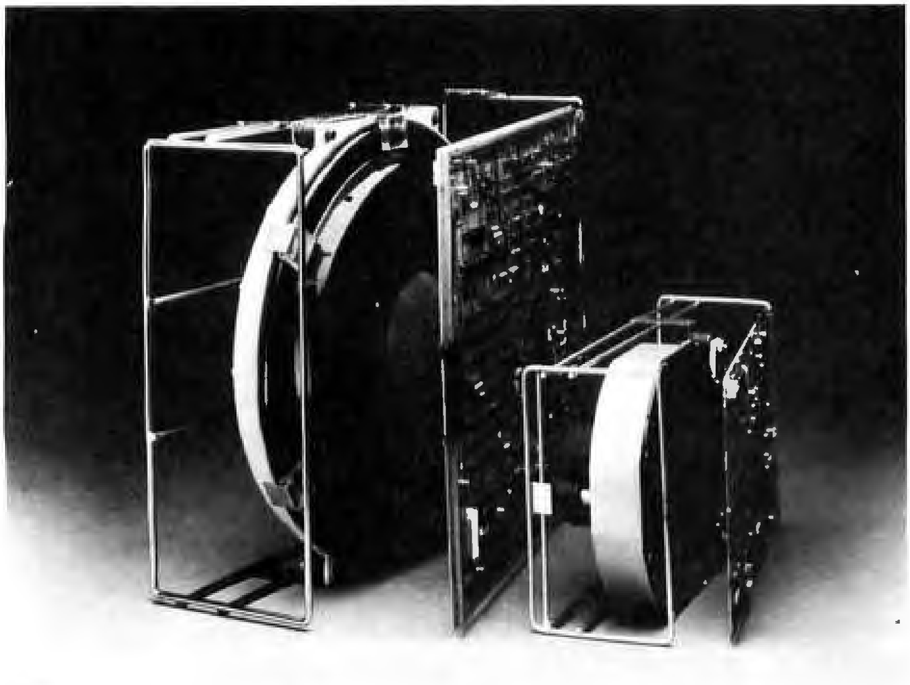


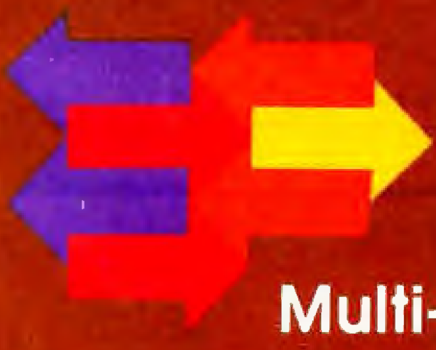
Photo 5: *Priam 14-inch (at left) and 8-inch Winchester hard-disk drives. (Photo courtesy of Priam.)*

Photo 6: *Kennedy Series 7000 8-inch hard-disk drive. (Photo courtesy of Kennedy Company.)*

UniFLEX™

Multi-User

UniFLEX is the first full capability multi-user operating system available for microprocessors. Designed for the 6809 and 68000, it offers its users a very friendly computing environment. After a user 'logs-in' with his user name and password, any of the system programs may be run at will. One user may run the text editor while another runs BASIC and still another runs the C compiler. Each user operates in his own system environment, unaware of other user activity. The total number of users is only restricted by the resources and efficiency of the hardware in use.



Multi-Tasking

UniFLEX is a true multi-tasking operating system. Not only may several users run different programs, but one user may run several programs at a time. For example, a compilation of one file could be initiated while simultaneously making changes to another file using the text editor. New tasks are generated in the system by the 'fork' operation. Tasks may be run in the background or 'locked' in main *memory* to assist critical response times. Inter-task communication is also supported through the 'pipe' mechanism.

Support

The design of UniFLEX, with its hierarchical file system and device independent I/O, allows the creation of a variety of complex support programs. There is currently a wide variety of software available and under development. Included in this list is a Text Processing System for word processing functions, BASIC interpreter and precompiler for general programming and educational use, native C and Pascal compilers for more advanced programming, sort/merge for business applications, and a variety of debug packages. The standard system includes a text editor, assembler, and about forty utility programs. UniFLEX for 6809 is sold with a single CPU license and one years maintenance for $450.00. Additional yearly maintenance is available for $100.00. OEM licenses are also available.

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8-inch or even a 5-inch floppy-disk drive—many will actually fit the panel openings for floppy-disk drives. Reliability will be better than with floppy and cartridge drives, and power consumption will be significantly lower than that of the 14-inch drives.

Systems based on 16-bit processors or microcomputers often require much more and much faster secondary storage than floppy disks can provide. The more sophisticated multiprogramming and file-management software currently being added to small computer systems requires so much continuous use of mass storage that the high performance and durability of hard disks may soon be a necessity.

The new 8-inch and 5-inch disk drives offer several advantages over both floppy and 14-inch hard drives:

- They have five to sixty times the storage capacity of a floppy-disk drive in the same space.
- They access data four times faster than the floppy-disk drive.
- They weigh less, take up less space, and use less power than 14-inch drives.
- They are only three to five times more expensive than floppy-disk drives, with cost reductions likely.

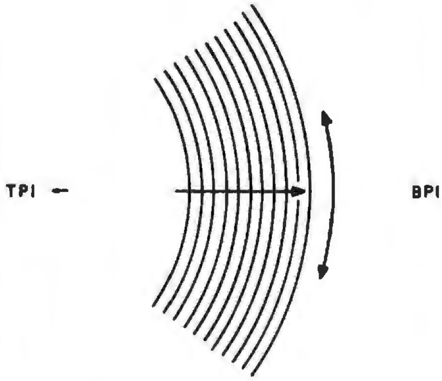

Figure 1: *Detail of hard-disk surface, illustrating the ideas of tpi and bpi.*

The availability of low-cost-per-function hard disks has long been awaited by the small system marketplace. The wait is all but over. This summer a score of products are scheduled to be available, at least in sample or evaluation quantities.

Though many of the new small disk products are advertised as fitting the same 4.6 by 8.5-inch opening as the standard floppy-disk drive (Shugart Technology's 5-inch Micro Winchester fits a 5-inch floppy-drive opening, see photo 3), a floppy-disk drive cannot literally be pulled out and replaced by the hard drive. To begin with, the packages contain different electronics. Most of the drives

	2314	3330	Winchester
Head flying height (in microinches)	100 to 120	31 to 45	19 to 20

Table 1: *Evolution of head flying heights in hard-disk drives.*

	Floppy-Disk Drives	Hard-Disk Drives, Cartridges and Disk Packs
Standard platter diameters	8-inch 5-inch	14-inch, 8-inch, and 5-inch
Capacity	100 K bytes to 1 megabyte	2 megabytes to 300+ megabytes
Average Access Time	0.1 to 1 second	25 to 70 ms
Rotational Speed	300 rpm	2400 to 4700 rpm
Reliability and Useful Life Relative to Floppy-Disk Drives	1	2+

Table 2: *Technical comparisons between floppy-disk drives and hard-disk drives, cartridges, and disk packs.*

	Memorex Corporation Santa Clara CA	New World Computer Co Inc Costa Mesa CA	Shugart Associates Sunnyvale CA	Shugart Technology Scotts Valley CA
Model	101	211	SA1002/SA1004	ST506
Unformatted Capacity (millions of bytes)	11.7	2.1	5.33/10.67	6.38
Platter Size millimeters and (inches)	200 (7.87)	8 inch	200 (7.87)	130 (5.12)
Number of Platters	2	1	1 or 2	2
Average Access Time	70 ms	18.825 ms	70 ms	170 ms
Maximum Data Transfer Rate (K bytes per second)	—	756	543	625
Average Latency	10.1 ms	8.825 ms	9.6 ms	8.3 ms
Rotational Speed	2964 rpm	3600 rpm	3125 rpm	3600 rpm
Motor Type	DC	—	AC	brushless DC
Spindle Drive	direct drive	—	belt drive	direct drive
Actuator Type	high speed band	simplified band	band	band
Positioning Mechanism	open loop stepper motor	stepper motor	stepper motor	open loop stepper motor
Density bpi	6100	8000	6270	7690
Density tpi	195	100	172	254
Physical Size (inches)	4.38 by 8.55 by 14	2 by 9.5 by 9.5	4.62 by 8.55 by14.25	3.25 by 5.75 by 8
Weight (pounds)	10	8	17	3.5
Single Quantity Price	—	$4,500	$1,600/$1,980	$1,500
OEM Discount Price	$1,200[1]	$1,250	$1,140/$1,400	$925
Cost Per Thousand Bytes (OEM Discount)	$.103	$.595	$.214/$.131	$.145
Comments	[1] Includes a data separator	20 heads, 8 tracks per head. Low-end only in capacity, not in performance.		First micro Winchester Drive. Fits 5-inch floppy space

Table 3: *Specifications and characteristics of low-end, 5-inch and 8-inch hard-disk drives.*

have the basic drive electronics, signal amplifiers, read/write electronics, and motor and servo control circuitry integrated into the package. Some have room to add optional, separately priced controllers to do error-checking and correction, data formatting, and interfacing to the computers.

Stepper-motor actuators are a technique borrowed from floppy drives for use in hard-disk drives. This idea allowed lower prices for Winchester-technology units such as the 14-inch Shugart SA4000 and Century Data Systems Marksman, but at a cost of greater access time and reduced storage capacities when compared with voice-coil actuator-based units.

A voice-coil actuator is a cylindrical, permanent magnet with a hole machined from pole to pole. A coil rides on bearings within the magnet and moves back and forth. The read/write positioning mechanism with electromagnetic heads is attached to the coil. A voice-coil actuator is positioned by servo-control with servo tracks written on one platter's surface at the factory.

Voice-coil actuators allow increases in data-storage capacity because their accuracy in small movements allows high tpi densities. Since the distance between tracks is smaller, access time is reduced. Also, voice-coil actuators do not impose the additional penalty of settling time.

One disadvantage of a voice-coil actuator is the magnetic field produced by the coil: the coil's magnetic field must not get too close to the disk platters or it could erase them. Efficient design can keep the magnetic field intensity at a safe level near the recording surfaces. Table 2 gives a partial technical comparison between floppy-disk drives and hard disks.

Future Technological Progress

Some of the more recent developments in heads (such as thin film heads) and disks (thin-film-plated disks) mean that data densities will probably advance from the presently attainable 8 to 10 megabytes per 8-inch surface to 50 or more megabytes per surface as track densities of 1000 tpi and bit densities of 10,000 bpi are achieved. A small, relatively inexpensive disk drive could then store 100 megabytes or more of data with an additional 100 megabytes added for nominal cost. Thin-film

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technology may be the next breakthrough in mass-storage techniques.

Secondary storage and storage backup are currently being supplied by a wide variety of devices, including

- cassette tapes
- 8-inch floppy-disk drives
- 5-inch floppy-disk drives
- reel-to-reel magnetic tapes
- cartridge magnetic tapes
- cartridge-disk drives
- disk-pack drives
- fixed storage Winchester drives
- combinations: fixed Winchester-disk/cartridge-disk drive or fixed Winchester/magnetic-tape cartridge
- streaming-tape drives
- bubble memories
- nonvolatile semiconductor programmable memory
- videocassette recorders
- video disks

The last three or four types are more for the future than now. Bubble memories and nonvolatile integrated circuits will have the great advantage of no moving parts and the potential convenience of plug-in modules; but they are still quite expensive. At least one interface and controller for American and European standard VCRs (videocassette recorders) is available to provide removable backup for high-capacity disks on small systems (the Corvus Mirror, manufactured by Corvus Systems Inc, San Jose, California). It stores up to 100 megabytes on one videocassette and has a transfer rate of 15 K bytes/second. Video disks have the potential to offer extremely high data-storage capacity and fast access rates (up to 1250 megabytes per 12-inch disk, equal to approximately four times the contents of the Encyclopaedia Britannica).

Small vs Large Hard-Disk Drives

Hard-disk drives for small systems fall roughly into two size categories: up to 12 megabytes and over 12 megabytes; and two performance categories: slow, with stepping-motor positioning, and fast, with voice-coil positioning. Those with stepping-motor positioning have average access times of 70 ms and capacities of under 12 megabytes. The drives with fast voice-coil positioning have average access times ranging from 25 ms to 50 ms, with models that fall into both size categories. The less expensive units are aimed at replacing floppy-disk drives directly. Examples of this type of product are the Memorex 101, the Shugart Associates SA-1000 series, and the Shugart Technology ST 506. The high end is led by IBM with the Piccolo drive, which is integrated into the System 34, and is an add-on peripheral for the Series 1. It features a rotary voice coil, 17 ms average access time, and up to 64.5 megabytes of storage capacity. Other contenders in this category offer high performance in a wide range of sizes (eg: the BASF Systems 6170 Series, IMI (International Memories, Inc) 7700 Series, Kennedy Company 7000 Series, Microcomputer Systems MSC-8000, Micropolis Corporation Micro Disk 1200 Series, Pertec Computer Corporation D-8000, and Priam Diskos 2050/3450).

The disk capacity and the performance you need depend on your particular application, which in turn has a significant impact on the cost of a system. Small-system applications, as

mentioned before, can be placed in two major classes: *single-user, single task* and *multi-user, multi-task*.

- Single-user, single-task systems are usually stand-alone workstations, intelligent terminals, or personal computers. Their chief use of magnetic storage, in general, is for program storage and data storage. The amount of storage required is often less than 10 megabytes. Because the speed need only match one human operator's response time, there is no benefit to be derived from disks with extremely fast access times. An average access time of 70 ms is usually sufficient in such applications. This class of application is cost-per-unit-oriented, since the storage device is dedicated to one user. It is price-oriented, and performance is not a vital factor. The low-end, small hard-disk drives fill this need splendidly.
- Multi-user, multi-task systems require that more than one, sometimes many, users have access to a common data base. They typically require from 30 to 100 megabytes of magnetic storage, usually on one spindle. Some require less storage and some will require multiple spindles. The cost per byte of storage is a more important consideration than the cost per drive unit, because the basic device cost is spread over many users.

Multi-user, multi-task systems require an average access time of 50 ms or less because multiple users must contend for the common storage device. The main purpose of these applications is usually not to share the processing power, but rather to share the data. These systems are often "disk-bound" rather than "computer-bound." Disk performance becomes a critical factor in system performance. Even when the disk capacity required might be relatively small (8 to 10 megabytes), the fast performance of the high end mini-disks will be required.

With their faster access times, higher capacities, greater reliability and OEM (original equipment manufacturer) quantity prices ranging from $1000 to $5000 (some may soon drop below $1000), both classes of the new hard-disk drives should be attractive to personal-computer systems builders who want additional capacity and performance, but not the traditional 14-inch disk size and price per unit. Some complete packages of drives, controllers, interfaces, and power supplies are available for about $5000. Even though they cost five to ten times as much as the processor, these units are still cheaper per drive than 14-inch drives. They are also applicable where more capacity and performance than a floppy disk can supply are needed, but the space or the cost of a 14-inch disk drive is prohibitive. Tables 3, 4, and 5 list some of the current disk-drive products for small systems. The reliability and maintainability of these products are essentially high and are consistent across the board. (See table 6.)

Controllers and Interfaces

One of the problems with the new 8-inch hard-disk drives is the variety of interface systems to choose from. Such variety is inevitable at this stage because of the many personal computers already on the market, and the diversity of interface requirements. In the absence of a comprehensive interface standard, many of the drive suppliers have designed their own. A similar situation has developed in the audio industry. Consider the many types of noncompatible audio recording standards including: the LP (long-playing) record, 45 rpm records, open reel tapes, cassettes, and eight-track cartridges. This kind of variety at the outset of new products is not necessarily bad—there is much freedom for innovation.

In August of 1979 an ANSI (American National Standards Institute) Subcommittee (number X3T9.3) began to standardize an interface for 8-inch hard disks. If a standard interface is widely accepted by the industry, users may soon be able to interface drives from several vendors.

Types of Interfaces

There are two main categories of disk-drive interfaces, *device level* and *host level*. The main characteristics for the device level are:

- serial data transfer
- formatting/de-formatting external to drive

Text continued on page 138

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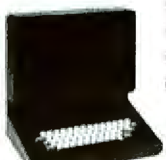

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Programming Quickies

Self-Reproducing Programs

John Burger, David Brill, Filip Machi,
System Development Corporation, 2500 Colorado Ave,
Santa Monica CA 90406

Listing 1 is a C program that duplicates itself. When the program is run it produces (on the standard output) a file containing an exact copy of its own source code. This program runs under the UNIX operating system and uses the American Standard Code for Information Interchange (ASCII) character set. If this program is compiled on a system using a different character set, the octal values of "q" and "n" must be changed to the numbers representing that system's codes for the quote and newline (or linefeed) characters, respectively.

Why We Wrote a Self-Reproducing Program

A while back, *Pascal News* contained a listing of a Pascal program called PRINTME that performs this feat. (See reference.) The Pascal listing took 46 lines of code.

We are currently writing a large system in the C language. We considered the Pascal program to be an unstated challenge, and in response we wrote a C version of the PRINTME program that works pretty much the same way as the Pascal version. This version is shown in listing 2.

This version is more elegant than the Pascal version and is 12 lines shorter. It takes a total of decimal 1313 bytes to store the source code. Then, one of us who once had done a lot of LISP programming wrote a LISP function that evaluates to itself. This function takes exactly 279 bytes of memory in which to store the print image of the code. The LISP function is shown in listing 3.

A week or so after the LISP function had been written, we were all discussing the similarities of LISP and C. From this discussion, we developed the C program of listing 1. It works like the LISP function and takes 126 bytes in the source code file.

For purists, though, a still shorter C version can be written. The C compiler, like a LISP compiler, sees all programs as a stream of bytes, and linefeed characters are parsed as spaces. Thus a C program *could* be written all on one line. The program in listing 4 is written on a single line in order to remove the necessity of printing linefeeds in the internal print.

Note that the octal ASCII values for the quote and linefeed characters have been replaced by decimal values (gaining one byte per number) and that all linefeeds except the last have been removed. Our C compiler seems to require at least one linefeed at the end of the file. The source code for this program is only 101 bytes long! ■

Listing 1: *Four-line C program which duplicates itself without any user input. If a non-ASCII character set is used on your system, the values of "q" and "n" must be changed to the values representing that system's quote and newline (linefeed) characters.*

```
main(){
char q=042,n=012,
*a="main(){%cchar q=042,n=012,%c*a=%c%s%c;%cprintf(a,n,n,q,a,q,n,n);}%c";
printf(a,n,n,q,a,q,n,n);}
```

Listing 2: *Original self-duplicating C program.*

```
char *text [] = {
        "char *text [] = {",
        "0 };",
        "main () {",
        "       char newline = 012, quote = 042, escape = 0134, *p, **pp;",
        "       printf (\"%s%c\", *text, newline);",
        "       for (pp = text; *pp; pp++) {",
        "               printf (\"        %c\", quote);",
        "               for (p = *pp; *p; p++) {",
        "                       if (*p == quote)",
        "                               putchar (escape);",
        "                       putchar (*p);",
        "               }",
        "               printf (\"%c,%c\", quote, newline);",
        "       }",
        "       for (pp = text + 1; *pp; pp++)",
        "               printf (\"%s%c\", *pp, newline);",
        "}",
0 };
main () {
        char newline = 012, quote = 042, escape = 0134, *p, **pp;
        printf ("%s%c", *text, newline);
        for (pp = text; *pp; pp++) {
                printf ("        %c", quote);
                for (p = *pp; *p; p++) {
                        if (*p == quote)
                                putchar (escape);
                        putchar (*p);
                }
                printf ("%c,%c", quote, newline);
        }
        for (pp = text + 1; *pp; pp++)
                printf ("%s%c", *pp, newline);
```

Listing 3: *Self-duplicating LISP function which inspired the C program in listing 1.*

```
(PRINTME (LAMBDA NIL (PROG (A B)
   (SETQ A (QUOTE (PRINTME (LAMBDA NIL (PROG (A B)
        (SETQ A (QUOTE FOO))
        (SETQ B (COPY A))
        (RPLACA (CDADDR (CADDAR (CDDADR B))) A)
        (RETURN B))))))
   (SETQ B (COPY A))
   (RPLACA (CDADDR (CADDAR (CDDADR B))) A)
   (RETURN B))))
```

Listing 4: *Final one-line, self-duplicating C program. This program is written on a single line to remove the necessity for code to generate linefeeds. However, the program is too long to display here without breaking the line. The program shown is to be written and compiled as a single line of source code.*

```
main(){char q=34,n=10,*a="main(){char q=34,n=10,
*a=%c%s%c;printf(a,q,a,q,n);}%c";printf(a,q,a,q,n);}
```

Reference

Pascal News, Pascal Users' Group, number 12, June 1978. (Pascal Users' Group, c/o Andy Mickel, University Computer Center: 227 EX, 208 SE Union St, University of Minnesota, Minneapolis MN 55455.)

The Evolution of FORTH, an Unusual Language

Charles H Moore
FORTH Inc
2309 Pacific Coast Hwy
Hermosa Beach CA 90254

Introduction

When I invented FORTH about 10 years ago, my goal was simply to make myself a more productive programmer. When I first worked with computers at MIT and Stanford in the early 1960s, I figured that in 40 years a very good programmer could write forty programs. And I wanted to write *more* programs than that. There were things out in the world to be done, and I wanted a tool to help me do them. As I worked on programs that ranged from satellite orbits to chromatography to business systems, I developed FORTH in line with my overall goal. For several years now, I have been able to work at ten times my original rate.

As I began thinking of rather drastic improvements to programs, I think I was arrogant. I wanted to do things my way. I was not convinced that I should not be permitted to, and I was a bit hard to get along with. The arrogance was necessary because I felt insecure. I was promoting ideas that everyone said were wrong and that I thought were right. But, if I were right, that meant that all the other people would have been wrong, and there were many more of them than me. And it took a lot of arrogance to persist in the face of massive disinterest.

FORTH is a polarizing concept. There are people who love it and people who hate it. It's just like religion and politics. If you want to start an argument, say, "Boy, FORTH's really a great language."

This is partly because FORTH is an amplifier. A good programmer can do a fantastic job with FORTH; a bad programmer can do a disastrous job. I have seen very bad FORTH code and have been unable to explain to the author exactly why it was bad. There are some visible characteristics of good FORTH, such as very short definitions (many of them). Bad FORTH often takes the form of one definition per block—big, long, and dense. It is quite apparent, but difficult to explain, why or how a FORTH program is bad.

BASIC and FORTRAN are less sensitive to the quality of the programmer. I was a good FORTRAN programmer; I thought that I was doing the best job possible with FORTRAN, but it was not much better than what everybody else was doing. In this sense, FORTH is an elitist language.

On the other hand, I think that FORTH is a language that a grade school child can learn to use quite effectively, if it is presented in bite-size pieces with the proper motivation.

FORTH is the first language that has come up from the grass roots. It is the first language that has been honed against the rock of experience before being standardized. I hesitate to say it is perfect; I will say that if you take anything away from FORTH, it is not FORTH any longer—the basic components are all essential to the viability of the language.

History

What might be called the prehistory of the FORTH language goes back much further than 10 years. The first element of FORTH to exist was the text interpreter, shown in listing 1. This early version, programmed in ALGOL at the Stanford Linear Accelerator Center in the early 1960s, was part of a program called TRANSPORT, which designed electron-beam transport systems. Besides the text interpreter, this printout also shows an early version of the dictionary. The influence of LISP is evident in the indivisible entity (which in FORTH is called a *word*) named ATOM. As the interpreter reads a word from a punched card, it executes the associated routine, as for DRIFT in this example. The style resembles that of modern FORTH: there is no limit on the length of a word, as you can see by the length of the word SOLENOID, but only the

About the Author
Charles H Moore is Chairman of the Board of FORTH Inc, a firm created in 1973 to provide application programming services and packaged FORTH systems. This article is adapted from a speech delivered at the FORTH Convention held in San Francisco in October 1979.

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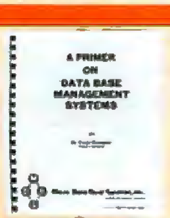

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first characters are significant and words are separated by spaces.

Other very early concepts have either changed in form or have evolved dramatically. In listing 2, the word that has become { : } (colon) in modern FORTH is called DEFINE , while END has become { ; } (semicolon). This listing also shows stack operators being defined. As an example of a concept that has evolved, consider the dictionary being sealed by the word SEAL and broken by the word BREAK . Such sealing and breaking has since been replaced by the idea of vocabularies.

Listing 3 shows another prototype in ALGOL, this time of a FORTH text editor. Here ATOM has become W and I am looking up plus, minus, and the commands T, R, A, and I, to edit a deck program.

Another method of implementing a dictionary is shown in listing 4. I am looking up the words in a conditional statement and setting NEXT, the key routine of modern FORTH's address interpreter, to the index.

Listing 5 shows an early implementation of a stack. Since it is written in BALGOL, which allows assignment statements inside other statements, I could replace STACK[J] with [J+1] in order to push items onto the stack. I did this so that I could manipulate parameters that were interpreted from the card deck as arguments to the routines. When I wanted, for instance, to convert angular measure from one unit to another, this added the ability to use arithmetic operators.

From Stanford I moved to the East Coast, where I programmed on a free-lance basis for several years. Some of you probably remember that, in the 1960s, a programmer at a typical computer center needed to learn about nineteen languages in order to function adequately: JCL (Job Control Language); languages to control utilities and facilities, such as the linking loader; assembly language and the assembler's control language; plus several high-level languages and the methods for controlling their compilers.

Listing 6 shows two of these languages, a PL/I program and the JCL necessary to run it. Note the obvious difference in syntaxes. FORTH developed in response to such conditions. In terms of modern FORTH, the importance of this example lies in the use of NEXT as a procedure that goes off to get the next word and do something with it.

Listing 7 shows a version of FORTH coded for the IBM System/360 with the routines PUSH and POP, which executed in about 15 μs. They include stack limit checking, which doubled the cost and was one of the things that led me to believe that execution-time stack checking is not desirable. This was coded in a macroassembler that did not have stack operations, which led to the deck full of statements like L19

Listing 1: *An early version of the FORTH text interpreter (written in ALGOL).*

```
IF ATOM="DRIFT" THEN DRIFT
ELSE IF ATOM="QUAD" THEN QUAD
ELSE IF ATOM="BEND" THEN BEND
ELSE IF ATOM="FACE" THEN FACE(-1)
ELSE IF ATOM="ROTATE" THEN ROTATE
ELSE IF ATOM="SOLENO" THEN SOLENOID
ELSE IF ATOM="SEX" THEN SEX
ELSE IF ATOM="ACC" THEN ACC

ELSE IF ATOM="MATRIX" THEN BEGIN IF NOT FITTING THEN BEGIN
   REAL A;
   WRITE1(3,0,0,CORE[S]); LINE(-(8+42×(ORDER-1)));
   FOR J←1 STEP 1 UNTIL 6 DO BEGIN
      FOR K←1 STEP 1 UNTIL 6 DO WRITE1(2,8,R1[J,K]×UNIT[K]/UNIT[J],2);
      LINE(0) END;
   IF ORDER=2 THEN FOR C←1 STEP 1 UNTIL 6 DO BEGIN
```

Listing 2: *An early version of the FORTH words { : } (called DEFINE here) and { ; } (called END here).*

```
"- "OPEN DEFINE   MINUS +    END
SEAL    "< "OPEN DEFINE    - <    END BREAK
"NOT "OPEN DEFINE   MINUS 1+    END
"> "OPEN DEFINE   •<    END
"AND "OPEN DEFINE    ×    END
"OR "OPEN DEFINE   NOT •NOT AND NOT    END
  "T 1 1 "REAL DECLARE
"= "OPEN DEFINE   T← ; DUP T< • T> OR NOT    END
"≠ "OPEN DEFINE   = NOT    END
"≤ "OPEN DEFINE   > NOT    END
"≥ "OPEN DEFINE   < NOT    END
"DUMP "OPEN DEFINE   NAME 10 "ALPHA WRITE; 3 10 "REAL WRITE 0 LINE END
```

Listing 3: *Another prototype of the FORTH text editor, again in ALGOL. In this listing, the word ATOM (the predecessor of the basic unit in FORTH, the word) has been replaced by the word W .*

```
CYCLE; FILL OUTPUT WITH BUFFER[1],BUFFER[2];
WHILE WORD NEQ "END     " DO
IF W=GM1 THEN REPLY("OK     ")
ELSE IF NUMERIC THEN L:=MIN(W-1,$OF)
ELSE IF W="+         " THEN L:=MIN(L+WORD,EOF)
ELSE IF W="-         " THEN L:=MAX(L-WORD,0)
ELSE IF W="T        " THEN BEGIN
   IF WORD=GM1 THEN W:=1; W:=MIN(L+W-1,EOF);
   FOR L:=L STEP 1 UNTIL W DO BEGIN
      POSITION; TYPE END; L:=L-1 END
ELSE IF W="R        " THEN BEGIN
   POSITION; REPLACE END
ELSE IF W="A        " THEN BEGIN
   L:=EOF:=EOF+1; REPLACE END
ELSE IF W="I        " OR W="D         " THEN BEGIN
   IF NOT RECOPY THEN BEGIN
      RECOPY:=TRUE; REWIND(CARD) END;
   POSITION; IF W="I         " THEN BEGIN
      PLACE; REPLACE END
   ELSE BEGIN EMPTY:=TRUE; IF WORD NEQ GM1 THEN BEGIN
         L:=MIN(L+W-1,EOF); SPACE(CARD,L-L0+1); L0:=L+1
            END END END
```

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Listing 4: *An early version of the FORTH dictionary.*

```
PROCEDURE RELEVANCE; BEGIN REAL T,K0;
J:=0; I:=-1; WHILE WORD NEQ "END      " DO
IF W="=        " THEN NEXT:=3
ELSE IF W="GT      " THEN NEXT:=4
ELSE IF W="LT      " THEN NEXT:=5
ELSE IF W="NOT     " THEN NEXT:=6
ELSE IF W="AND     " THEN NEXT:=7
ELSE IF W="OR      " THEN NEXT:=8
ELSE IF W="+       " THEN NEXT:=9
ELSE IF W="-       " THEN NEXT:=10
ELSE IF W="*       " THEN NEXT:=11
ELSE IF W="/       " THEN NEXT:=12
ELSE IF K0:=SEARCH1(W) GEQ 0 THEN BEGIN
   NEXT:=1; NEXT:=K:=K0 END
ELSE BEGIN
   NEXT:=2;
   IF BASE[K]=" " THEN NEXT:=WORDS[0]
   ELSE NEXT:=W END;
NEXT:=0 END;
```

Listing 5: *An early implementation of the FORTH stack, written in BALGOL.*

```
BOOLEAN PROCEDURE RELEVANT; BEGIN
I:=J:=-1; STACK[0]:=1; DO CASE NEXT OF BEGIN
   J:=-1;
   STACK[J:=J+1]:=CONTENT;
   STACK[J:=J+1]:=NEXT;
   STACK[J:=J-1]:=REAL(STACK[J]=STACK[J+1]);
   STACK[J:=J-1]:=REAL(STACK[J] GTR STACK[J+1]);
   STACK[J:=J-1]:=REAL(STACK[J] LSS STACK[J+1]);
   STACK[J]:=REAL(NOT BOOLEAN(STACK[J]));
   STACK[J:=J-1]:=REAL(BOOLEAN(STACK[J]) AND BOOLEAN(STACK[J+1]));
   STACK[J:=J-1]:=REAL(BOOLEAN(STACK[J]) OR BOOLEAN(STACK[J+1]));
   STACK[J:=J-1]:=STACK[J]+STACK[J+1];
   STACK[J:=J-1]:=STACK[J]-STACK[J+1];
   STACK[J:=J-1]:=STACK[J]×STACK[J+1];
   STACK[J:=J-1]:=STACK[J]/STACK[J+1];
   END UNTIL J LSS 0;
RELEVANT:=BOOLEAN(STACK[0]) END;
```

DC AL2(*-L18), which gave me a link from L19 to the previous label. It worked but it was not pleasant.

Listing 8 shows a similar routine, this time coded in COBOL. I am setting up a table of identified words that will be interpreted from an input stream. Since COBOL does not allow parameters for subroutines, it is awkward to do anything meaningful.

New Concepts

About this time, I began to think of defining a word that would define other words; and at that time, this idea was staggering. For example, { ;CODE } was a very esoteric word. I explained it to people, but I could not express the potential I thought it had.

It took time to find out exactly what { ;CODE } should do (it specified the code to be executed for a previously defined word). I do not have the records, but I think the initial code for { ;CODE } was three or four lines long; to simplify that code was one of the driving forces behind the address interpreter—to make it possible to code { ;CODE } cleanly. This had implications as to what registers should be available.

The fact that W should be saved in a register for defining words led to *indirect*, rather than direct, threaded code. That was the most complicated concept I had coded in this evolving program—probably deserving of a patent in its own right.

A little bit later, it seemed that there ought to be an analog of {;CODE } that specified the code to be *interpreted* when you executed a word. It seemed the natural balance, but when the idea first arose, I did not have the foggiest notion of what to do or what the implementation should be. The first definition of this analog, called { ;: } (semicolon-colon), required three or four lines of code. It had to do what { ;CODE } did, and then more.

Out of that came the distinction between compile-time action and


C
IDRIS
PASCAL

execute-time action. It was convenient for words to be coded to act this way, but it was expensive. It required not only the address of the code to be executed, but the address of the code to be interpreted, as well as the parameter to be supplied to the code being interpreted so you could do something useful.

Late in the 1960s I went to work for Mohasco Industries, where I put something strongly resembling FORTH on a Burroughs 5500, cross-compiled to the 5500 from an IBM 1130. (There is no assembler on the 5500; there is a dialect of ALGOL called SBOL that Burroughs used to compile operating systems, not available to users.) Listing 9 shows the code definitions of stack operations on the 5500, which was a stack-oriented processor at a time when stack machines were not popular. The names of some FORTH stack operators stem from that machine's operations; see, for example, DUP . The symbol ¢ stands for CODE and distinguishes the assembler's OR from the FORTH OR . (Vocabularies were not yet available.)

Listing 10 gives an example of FIND (a dictionary search routine) coded for the 5500. Notice the word SCRAMBLE , a colon definition making a hashed search. Apparently I had eight threads to the dictionary here, a concept we added back to FORTH when we developed polyFORTH last year.

Listing 6: *The NEXT procedure in PL/I and its associated JCL (Job Control Language) statements (lines 1 thru 8).*

```
 1 //UTILITY   JOB  SYSTEM,OVERHEAD
 2 //          EXEC PGM=IEBUPDTE,PARM=NEW
 3 //SYSPRINT  DD   SYSOUT=A
 4 //SYSUT2    DD   DSNAME=OUTLIB,UNIT=2314,DISP=(NEW,KEEP),
 5 //               VOLUME=SER=MOORE,SPACE=(TRK,(100,,10)),
 6 //               DCB=(RECFM=F,LRECL=80,BLKSIZE=80)
 7 //SYSIN     DD   DATA
 8 ./         ADD   NAME=WORD,LEVEL=00,SOURCE=0,LIST=ALL
 9     DECLARE KEYBOARD STREAM INPUT,PRINTER STREAM OUTPUT PRINT;
10     NEXT: PROCEDURE CHARACTER(4);
 1     DECLARE (1 TEXT CHARACTER(81) INITIAL((81)" "),
 2        2 C(81) CHARACTER(1), I INITIAL(81),W CHARACTER(4),
 3        WORD CHARACTER(32) VARYING BASED(P),P,NUMERIC BIT(1)) EXTERNAL;
 4     DO WHILE C(I)=" "; I=I+1;
 5        IF I=82 THEN BEGIN; I=1;
 6           READ FILE(KEYBOARD) INTO(TEXT); END; END;
 7     P=ADDR(C(I));
 8     IF C(I)="-" OR C(I)="." OR "0" LE C(I) THEN BEGIN; NUMERIC="1"B;
 9        IF C(I) NOT="." THEN DO I=I+1 BY 1 WHILE "0" LE C(I); END;
20        IF C(I)="." THEN DO I=I+1 BY 1 WHILE "0"  LE C(I); END; END;
 1 ELSE DO; NUMERIC="0"B;
 2       IF "A" LE C(I) THEN DO I=I+1 BY 1 WHILE "A" LE C(I) OR C(I)="-";
 3       END; ELSE I=I+1; END;
 4     W=WORD; RETURN(W);
```

Listing 7: *The FORTH words PUSH and POP written in IBM 360 assembly language.*

```
0056                          830 L18 DC AL2(*-L17)
                              831     NAME 3,X'445550',0    DUP
03445550                      832+           DC    AL1(3),X'445550'
00                            833+           DC    X'0'
                              834+           ORG   *-2-V0
                              835+           DS    0H
                              836+           ORG   *+V0+1
400004                        837+           DC    AL1(0*X'40'+X'40'),AL2(4)
5AC0 6014            00014    838 PUSH A SP,MFOUR   COSTS 15 US
5040 C000            00000    839     ST T,0(,SP)
19CB                          840     CR SP,DP
0729                          841     BCR 2,NEXT   BHR
47F0 667C            0067C    842        B ABORT
001A                          843 L19 DC AL2(*-L18)
0444D2CF50400008              844     DC AL1(4),X'44D2CF50',X'40',AL2(8)   DROP
41C0 C004            00004    845     LA SP,4(,SP)
5840 C004            00004    846 POP L T,4(,SP)   COSTS 21 US
41C0 C004            00004    847     LA SP,4(,SP)
59C0 602C            0002C    848     C SP, SP00
07C9                          849     BCR 12,NEXT   BNHR
47F0 667C            0067C    850        B ABORT
```

FORTH and the IBM 1130

At Mohasco I also worked directly on an IBM 1130 interfaced with an IBM 2250 graphics display. The 1130 was a very important computer; it had the first cartridge disk, as well as a card reader, a card punch (as backup for the disk), and a console typewriter. The 1130 let the programmer, for the first time, totally control the computer interactively.

FORTH first appeared as an entity on that 1130. It was called F-O-R-T-H, a five-letter abbreviation of FOURTH, standing for fourth-generation computer language. That was the day, you may remember, of third-generation computers and I was going to leapfrog. But because FORTH ran on the 1130 (which permitted only five-character identifiers), the name was shortened.

What came out of the 1130 was a cross-assembler that assembled the instructions, which were then to be executed by the 2250. I think the 2250 had its own memory, and these things had to be programmed carefully. What I accomplished was that the 1130 in FORTRAN in 32 K bytes could draw pictures on the 2250, fairly slowly; and FORTH, in 8 K bytes, could draw three-dimensional moving pictures on the 2250—but it could do that only if every cycle was accounted for and if the utmost was squeezed out. That is why FORTRAN had to go—I required an assembler and could not do an impressive enough job with FORTRAN.

But high-level or colon definitions were not yet compiled—the compiler came much later. The text was stored in the body of the definition, and the text interpreter reinterpreted the text in order to discover what it was to do. This contradicts the efficiency of the language, but I had big words that put up pictures and I did not have to interpret too much. The cleverness was limited to squeezing out extraneous blanks as a compression medium. I am told that this is the way that BASIC acts today in many instances.

This machine had a disk drive, and I am almost certain that the word BLOCK existed in order to access

records off the disk. I do remember that I had to use the FORTRAN I/O (input/output) package and that it would not put the blocks where I wanted them; it put the blocks where *it* wanted them, and I had to pick them up and move them into my buffers.

At Mohasco I also implemented FORTH on a Univac 1108, interfacing it with their COBOL compiler. Listing 11 displays a set of record descriptions in a Dun and Bradstreet reference file (for looking up bad debts). The layout shows named fields followed by the number of bytes allocated.

The Mohasco programs mark the transition point between something that could be called FORTH and something that could not. All the essential features except the compiler were present by 1968.

Listing 8: *A structured table routine, in COBOL.*

```
MOVE "CONFIGURATION" TO IDENTIFY(4);
MOVE "DATA" TO IDENTIFY(5);
MOVE "FILE" TO IDENTIFY(6);
MOVE "FD" TO IDENTIFY(7);
MOVE "MD" TO IDENTIFY(8);
MOVE "SD" TO IDENTIFY(9);
MOVE "WORKING-STORAGE" TO IDENTIFY(10);
MOVE "CONSTANT" TO IDENTIFY(11);
MOVE "PROCEDURE" TO IDENTIFY(12);
MOVE "INPUT-OUTPUT" TO IDENTIFY(13);
```

Listing 9: *Code definitions of FORTH stack operations on the Burroughs 5500, written in SBOL.*

```
LIST
( 'PRIMITIVES'  26 LAST  =  30 SIZE=)
¢ = __S  RETURN
¢ @ <SD  RETURN
¢ + V 241,  RETURN

¢ OR  ¢OR  RETURN
¢ AND  ¢AND  RETURN
¢ NOT  115,  RETURN
¢ DUP  ¢DUP  RETURN
¢ SWAP  ¢SWAP  RETURN
¢ DROP  ¢DROP  RETURN
¢ +  +1  RETURN
¢ -  -1  RETURN
¢ MINUS  ¢MINUS  RETURN
¢ *  *1  RETURN
¢ /  /1  RETURN
¢ MOD  ¢MOD  RETURN
```

Listing 10: *A dictionary search routine, FIND , written for the Burroughs 5500.*

```
¢SM ¢FIND  SCRAMBLE  <SD  ¢DUP
 41 >A  41 >B  ¢BEGIN  V <U  1771, ¢IF
    ¢BEGIN  V0 <U  1771, ¢IF
        1 <L  RESULT
      ¢THEN  __ADDR  ¢DUP  1 <L  <S
      0S WORD <U  ¢EQUAL ¢IF
        V1 __U  0S  RESULT
       ¢THEN  ¢DUP <SD  ¢BACK
  ¢THEN  GET  ¢BACK
: FIND TOP  ¢FIND ¢IF  UR <UD ¢B  ¢THEN;
```

Listing 11: *Prototype of a file layout, running under FORTH on a Univac 1108. This version of FORTH was written in COBOL.*

```
DBI   DBI/MOORE 33 33
   DUNS 8  NAME 24  STREET 19  CITY 15  STATE 4  ZIP 5
   PHONE 10  BORN 3  PRODUCT 19  OFFICER 24  SIC 4  SIC1 4  SIC2 4
   SIC3 4  SIC4 4  SIC5 4  TOTAL 5.0 EMPL 5.0 WORTH 9.0 SALES 9.0 MFG 1
   SUBS 1  HDQ 1  HEAD 8  PARENT 8  MAIL 19  CITY1 15  STATE1 4
   NAME1 19
END
```

The First Modern FORTHs

The first modern FORTH was coded in FORTRAN. Shortly thereafter it was recoded in assembler. Much later it was coded in FORTH. It took a long time before I thought that FORTH was complete enough to code itself. The first thing to be added to what had already existed was the return stack. That was an important development; the recognition that there had to be exactly two stacks, no more, no less.

The next thing to be added was even more important—*the full-fledged dictionary*, that is, the dictionary in the form of a linked list. Up until then, flags had been set or computed GO TOs had been executed to provide some mechanism for associating a subroutine with a word. The replacement of all that by a code file containing the address of the routine made an incredibly fast way of implementing a word once it was identified.

The first use of modern FORTH occurred when it was written for a Honeywell H316 at the NRAO (National Radio Astronomy Observatory). In 1971 I was hired by George Conant to write a radio-telescope data-acquisition program: that led to the next step, the compiler. This meant the recognition that, rather than reinterpret a string of text, words could be compiled and an average of 5 characters per word could be replaced by 2 bytes per word. This gave a compression factor of 2 or 3, not drastic but appreciable. But execution speed would be much faster. Again I asked myself, as I had done when I first began modifying programs: if it was that easy, why hadn't anyone else done it? It took me a long time to convince myself that you could compile anything and everything.

Interrupts came around this time. It was important to utilize the interrupt capability of the computer, but it had not been done by me before that—I did not know anything about interrupts. I/O, however, was not yet interrupt-driven. Interrupts were available for the application if it wanted them—FORTH did not bother.

The multiprogrammer came along

Circle 55 on inquiry card.

a couple of years later when we developed an improved version of the system for NRAO's telescope at Kitt Peak. This computer was a PDP-11; the multiprogrammer had four tasks. Input was still not interrupt-driven, which was unfortunate.

The Second FORTH Programmer

Ten years ago there was one FORTH programmer, me. The second FORTH programmer, Elizabeth Rather, came along in 1971. That is quite a quantum jump, from one to two; the next step was four (the next two came out of Kitt Peak National Observatory); the growth can be traced from there to the several thousand today.

The first FORTH user was Ned Conklin, head of the NRAO station at Kitt Peak, Arizona. NRAO runs a millimeter-wave radio telescope that is in great demand by observers, in part because it is responsible over the last 10 years for discovering half of the interstellar molecules that are known to exist. FORTH is still running on that telescope at Kitt Peak and on a lot of other telescopes.

Given interest from other astronomers, a few believers split off from NRAO in 1973 and formed FORTH Inc. We were deluged by requests for FORTH systems from astronomers and went into business to try to exploit that market. It would still be our principal line of business today except that there are so few new telescopes in the world that you cannot support a company on that market.

We developed miniFORTH™ (FORTH on minicomputers) with the idea of having a programming tool. An important implementation of the tool came when we put an LSI-11 and FORTH into a suitcase. I think I became the first computer-aided programmer—computer-aided in that I had my computer and took it around with me. I talked to my computer, my computer talked to your computer, and we could communicate much more efficiently than I could communicate directly with your computer before it could run FORTH. Using this tool, we have put FORTH on many computers.

We added the feature of interrupt-driven I/O when FORTH Inc produced its first multiterminal system. It did not speed things up particularly from the user's point of view, but it *did* prevent any loss of characters when several people were typing at the same time. You did not have to look quickly to get the character before the next one came along. They were all buffered and waiting for you, which is an important distinction for multiprogrammed systems.

Data-base management came along at this time. It has been extensively changed, just as FORTH has. But fundamentally, nothing has changed. The concept of files, records, fields, and relational pointers that polyFORTH™ offers dates back from 1974 or so—years and years ago. Listing 12 shows a recent application of the FORTH Inc data-base management system.

With microFORTH™ in 1976 came the first version of our current target compilers. They are very complex things, much more so than I expected them to be. At about the same time, we worked out the current implementation of DOES> .

This new form of { ;: } does not require the address of the code to be interpreted. Since that is supplied by a different mechanism, the parameter can occupy the parameter field as it is supposed to. You can "tick" it and change its value, which is nice. [*The FORTH word* { ' } *(called "tick" above) places the address of the word that follows it onto the stack....*GW] But we save 2 bytes for every DOES> word, 2 bytes for very common words—and for 3 years, we did

Listing 12: *Field and record layouts for a recent FORTH Inc data-base management system.*

```
64 LIST

  0  ( GLOSSARY FILE)
  1 2  ( LINK)   12 BYTES WORD   12 BYTES VOC
  2  NUMBER SOURCE   NUMBER STACKS   70 BYTES PHRASE
  3  210 FILLER ( 4 LINES)   32 FILLER ( 340 B/R, 3/BLOCK) DROP
  4 2   24 BYTES WORD+VOC   DROP
```

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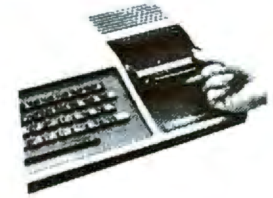

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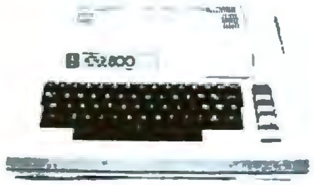

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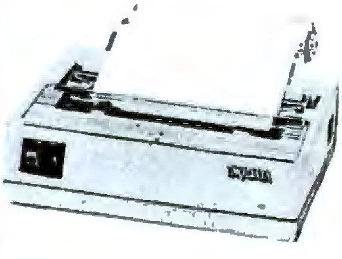

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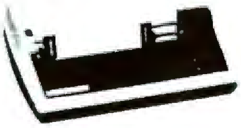

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I know no way of speeding this process from initial thought to development, except to let a certain amount of time pass. We could sit, we did sit and debate this thing endlessly, and we missed the obvious.

I think that completes the capabilities that I think of as FORTH today. You see how they dribbled in—at no point did I sit down to design a programming language. I solved the problems as they arose. When demands for improved performance came along, I would sit and worry and come up with a way of providing improved performance.

polyFORTH is a condensation of everything that we at FORTH Inc have learned in the last 10 years of developing FORTH. I think it is a very good package. I foresee no fundamental changes in the design of the language except for accommodation to FORTH standards, which are becoming increasingly important.

Implementations of FORTH

I would like to review the implementations of FORTH of which I am aware. It is actually a tour through the history of computers and it is fascinating that this could all have happened in 10 years.

FORTH has been programmed in FORTRAN, ALGOL, PL/I, COBOL, assembler, and FORTH; and I am sure some of you can come up with other languages with the same history. My list is strictly personal.

FORTH has been implemented on the Burroughs 5500; the IBM 1130; the Univac 1108; the Honeywell 316; the IBM 360; the Data General Nova; the HP 2100 (not by me but by Paul Scott at Kitt Peak); the PDP-10 and PDP-11 (by Marty Ewing at the California Institute of Technology); the PDP-11 (by FORTH Inc); the Varian 620; the Mod-Comp II; the GA SPC-16; the CDC-6400 (by Kitt Peak); the PDP-8; the IV-Phase; the Computer Automation LSI-4; the RCA 1802; the Honeywell Level 6; the IBM Series 1; the Interdata; the 6800; the 8080; the 8086; the TI-9900; and soon the 68000, the Z8000, the 6809, and a Child Inc computer. Some independent groups have 6502s, ILLIAC, and others running FORTH. I raise the question—is it the case that FORTH has been put on every computer that exists?

Some people think FORTH ought to be machine independent, but that premise is wrong. The equivalence is FORTH—each machine requires meticulous attention to its individual characteristics. You must use all the hardware capabilities of each machine and must then work to force it into the mold specified by FORTH's virtual machine.

For example, we put a subset of FORTH on an SMS-300 microcomputer. It had only eight instructions. The internal characteristics of every machine can and must be exploited. You do not need any particular number of registers or stacks or anything. All can be simulated, but if you neglect the abilities of the machine, you can end up a factor of 2 down in performance from where you might otherwise be.

At no point did I sit down to design a programming language. I solved the problems as they arose.

FORTH-in-Hardware Computers

The first FORTH computer I know of was built at Jodrell Bank in England around 1973. It is a redesign of an English Ferranti computer that went out of production. The observatory at Jodrell Bank was going to build their own bit-slice version; they discovered FORTH about the same time, modified the instruction set to accommodate FORTH, and built what I am told is a very fast FORTH computer. I have never seen it, but have talked to its competent designer, John Davies, who is one of the early FORTH enthusiasts.

In 1973, before Dean Sanderson came to FORTH Inc to develop microFORTH, he had a FORTH computer at a company called General Logic. It qualifies as a FORTH computer because it has a FORTH instruction. And there is a story there. Dean showed me his instruction set, and there was this funny instruction that I could not see any reason for—I figured it was some kind of no-op or catchall or something; it had the weirdest properties, and it could not possibly be useful. It was NEXT. It was a one-instruction NEXT which was beautiful. And it was a very *simple* modification (this was a bit-slice computer) to the instruction set—a few wires here and there—and that is the first time I saw a FORTH computer, if you will. I call it a FORTH computer because it had the ability to change itself from an ordinary computer into a FORTH computer.

I think that hardware today is in the same shape as software was 20 years ago. No offense, but it is time that the hardware people learned something about software. There is an order or two of magnitude improvement in performance possible with existing technology. We do not need picosecond computers to make really substantial improvements in execution speed. Faced with that realization, there is no point in trying to optimize the software any further until we have taken the first crack at the hardware. The hardware redesign has to be as complete as the software redesign was. The standard microprocessors did not have FORTH in mind. Those minicomputers that can be microprogrammed cannot be microprogrammed well enough to even be worth doing. The improvements available are much greater than you can achieve by these half measures.

I have built a small FORTH computer. The design changes as fast as the chips can be plugged into the board. But it is not difficult to do. Here are the characteristics of a FORTH computer:

- It does not need a lot of memory (16 K bytes is about right—half programmable read-only memory, half user programmable memory, maybe).
- It does not need a lot of I/O ports; in fact, it does not need any I/O ports except for the application requirements.
- A serial line and interface to a disk drive are useful but not required.

We have put FORTH on an 8080-based machine with a virtual disk in memory, enough memory to hold eight blocks. The system is quite viable and has no particular problem with system crashes. Bubble

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memories are coming. A FORTH computer does not need much mass storage; 100 K bytes are adequate, and 250 K bytes are plenty. The fact that FORTH can exist quite happily on a machine that is very small by contemporary standards should be exploited.

Organizations

Finally, I would like to run through the history of the organizations that have been involved with FORTH. They have formed another thread of the tapestry. It began with Mohasco, of course, followed by NRAO and Kitt Peak National Observatory: then came FORTH Inc.

The next step was probably DECUS (Digital Equipment Computer Users' Group). Marty Ewing gave his PDP-11 FORTH system to DECUS. FORTH Inc was not sure whether free FORTHs floating around was a good idea at the time. But it turned out that a lot of people were exposed to FORTH who otherwise would not have been.

Cybek came along and provided an entry into the business-systems market. Art Gravina, the president of Cybek, is the person who designed our data-base management system. He provided us the opportunity to do commercial systems and the ability to handle ten times as many terminals as he could with the BASIC program that preceded it.

In about 1976, a committee of the International Astronomical Union met and adopted FORTH as a standard language. That was a boost in the world of astronomy, although the world of astronomy was no longer the major driving force in the popularity of FORTH.

I think EFUG (the European FORTH Users' Group) came along about that time (1976). It turned out to our surprise that Europe was a hotbed of FORTH activity that we were largely unaware of (and perhaps still are, in that we are not involved in that world and do not appreciate the level of interest). An international FORTH Standards Team probably grew from their first meetings. A couple of years later, the FORTH Interest Group started. Now we have FORML—FORTH Modification Laboratory, an idea-generating organization.

Conclusion

The tendency seems to be for people to organize themselves in groups. Some of these groups are companies, others are associations. It looks like FORTH is going to be a communal activity in that sense—that it will grow from the work of unstructured clusterings of like-minded people. The suggestion is that this whole world of FORTH is going to be quite disorganized, uncentralized, and uncontrollable. It's not bad, perhaps it's good.

My view of the future is more unsettled today than it has been for years: promising, confusing, perplexing. The implications are perhaps as staggering now as they were 20 years ago. The promise of realization is much higher. My original goal was to write more than forty programs in my life. I think I have increased my throughput by a factor of 10. I do not think that that throughput is program-language limited any longer. So I have accomplished what I set out to do: I have a tool that is very effective in my hands. It seems it is very effective in others' hands as well. I am happy and proud that this is true.

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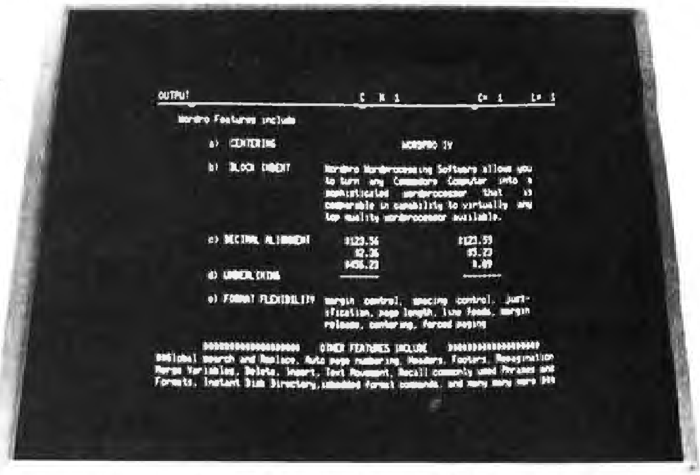

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Components of FORTH

FORTH is characterized by five major elements: dictionary, stack, interpreters, assembler, and virtual memory. Although not one of these is unique to FORTH, their interaction in FORTH produces a synergistic effect that creates a programming system of unexpected power and flexibility.

- Dictionary: *The resident FORTH system is organized into a dictionary that occupies almost all of program memory. The dictionary is a threaded list of variable-length items, each of which defines a word of the vocabulary. The actual content of each definition depends on the type of word: noun, verb, etc. The dictionary is extensible, growing toward high memory. In a multiterminal system, terminal tasks may have private dictionaries that are connected in a hierarchical tree structure.*
- Stack: *Two push-down stacks (last-in, first-out, or LIFO, lists) are maintained for each multiprogrammed task in the system. These provide the primary communication between routines as well as an efficient mechanism for controlling logical flow. A stack normally contains items one computer word long, which may be addresses, numbers, or other objects. Stacks, which are of indefinite size, grow toward low memory.*
- Interpreters: *FORTH is fundamentally an interpretive system, meaning that program execution is controlled by data items rather than by machine code. It is a common assumption that interpreters are severely wasteful of processor time; this is avoided in FORTH by maintaining two levels of interpretation.*

The first of these is the text interpreter, also known as the outer interpreter. *It works in a conventional manner, parsing text strings that come from terminals or mass storage and looking up each word in the dictionary. When a word is found in the dictionary, it is executed (unless the task is in compile mode) by invoking the address interpreter.*

The address interpreter (also known as the inner interpreter) *interprets strings of absolute memory addresses by executing the definition pointed to by each. Most dictionary definitions contain addresses of previously defined words that are to be executed by this interpreter. This level of interpretation requires no dictionary search since these words have already been compiled by the text interpreter, which generated the absolute addresses.*

The address interpreter has several important properties. First, it is fast. *Indeed, on some computers it executes only one instruction for each word, in addition to the code implied by the word itself. Second, it interprets compact* definitions. *Each word referenced in a definition compiles a single memory location. Finally, the definitions are* machine independent *because the definition of one word in terms of others does not depend upon the computer that interprets the definitions.*

- Assembler: *FORTH includes a resident assembler, which allows the programmer to define words that will cause specified machine instructions to be executed. This type of definition is necessary to perform device-dependent input and output operations, to implement elementary operations, and to do highly time-critical processing.*
- Virtual memory: *The final key element of FORTH is its blocks: fixed-length segments of disk space that may contain program text or data. A number of buffers are provided in memory; blocks are read into them automatically when referenced. If a block is modified in memory, it is automatically replaced on disk. Explicit read and write operations, therefore, are not required; programmers may presume that program text or data is in memory whenever it is referenced.*

[The above paragraphs present a concise overview of FORTH as a language; the following paragraphs describe features of a FORTH Inc product, polyFORTH...GW]

The standard polyFORTH system utilities include the following:

Text editor:	*Facilitates editing program source text, both by line and by character.*
Source listings:	*Prints program source listings and indexes.*
Disk copy:	*Provides for disk-to-disk copying of data file and program source files for backup purposes.*
Disk diagnostic:	*Produces a simple, read-only disk diagnostic that may be run at any time without disturbing other users. (More extensive hardware diagnostics are optional.)*

Each polyFORTH system also contains a Target Compiler™ *capability; this allows the user to develop, for run-time applications only, a computer system that does not require the entire operating system. Since FORTH is an interpretive language, an interpreter must always be present; but the target compilation process creates the minimum dictionary necessary, thus allowing a program to be run with a minimum of memory overhead. Typically, this overhead is less than 1000 bytes.*

Full data-base management support is available in an optional Extended File Management package. Included within its structure are the essential features of the CODASYL standard along with the characteristic speed, compactness, and flexibility of the FORTH language. Facilities include commands for file definition and formatting and for field and record descriptions, as well as several file-accessing techniques, operators for accessing individual fields by name and fields within specified files, and such utility functions as a report generator and an optional key-sort routine. ■

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NEWS AND SPECULATION ABOUT PERSONAL COMPUTING

Conducted by Sol Libes

Personal Computer Prices Increasing: Both Texas Instruments (TI) and Atari recently announced price increases for their personal computer systems. Radio Shack, Commodore, and Apple are holding the line, at least for the present.

Atari increased the price of its Model 400 from $550 to $630 and the Model 800 from $1000 to $1080. The company attributed the increase to rising component costs, particularly components that incorporate precious metals.

TI, on the other hand, has subtly unbundled the 99/4 system. Previously, a purchaser bought the keyboard/processor console and a 13-inch color video monitor for $1150. Now he can buy the console for $950 and the monitor for $450, a total of $1400. Or, he can buy the console and an RF (radio-frequency) modulator ($75) and hook it up to a standard color television set. This combination costs $1025, which is only $125 less than the old complete system price.

Although Radio Shack, Commodore, and Apple have not raised the prices of their basic systems, certain peripheral devices and add-ons have increased in price. Furthermore, when the Federal Communications Commission (FCC) RF-radiation standards go into effect on January 1, 1981, there may be significant price increases.

Most personal-computer marketing experts agree that for personal computing to become a true mass market, prices must decrease, not increase. The experts are therefore disturbed over what they feel will be a real damper to personal-computing sales.

Software Piracy: Over the years, software vendors have complained many times about hobbyists copying software from one another instead of buying it. One supplier even has gone so far as to offer a $10,000 reward for information leading to the conviction of anyone found copying its software. I am not aware that this plan has had any positive results. It has, however, raised the ire of many hobbyists, and there may have been a negative effect on this particular supplier's software sales, because he sells cassette software mostly to hobbyists.

Although copying by hobbyists remains a problem for software vendors, a much greater problem has developed: software piracy for commercial purposes, by pirate vendors who are marketing copies in much the same way as audio- and videocassette pirates do.

For example, Nestar Systems of Palo Alto, California, has charged that its read-only-memory-based "Basic Programmer's Toolkit" (for the Commodore PET) is being distributed in Europe in both cassette and floppy-disk format. The pirating distributor is alleged to have changed the code (relocating it into user memory) and to have changed the copyright notice. Nestar is taking action in this case.

This type of software piracy will have a more serious financial impact on the software vendor than hobbyist copying. Here, the vendor is actually losing dealer sales, since many dealers are purchasing the software from the pirate at a much lower cost—and probably marking it up more—than if the dealer purchased it from the legitimate vendor. In most instances, end users are not aware that they have purchased a pirated copy until they try to get software support from the rightful vendor.

Tektronix Sets Up Handicapped Person's Hot Line: Physically handicapped persons, or people wanting information on special electronic equipment for coping with physical impairments, can get answers to questions by calling the Tektronix Special Interest Group on Computers and the Physically Handicapped in Beaverton, Oregon, at (503) 357-4354.

Intel Releases Data on 32-Bit Microprocessor: Intel, the recognized leader in microprocessor development, has "leaked" advanced information on three new forthcoming 16- and 32-bit microprocessors. Intel is now playing the game of trying to scoop its competition by announcing products long before they will be available in production. This will, no doubt, have an impact on sales of the Zilog Z8000 and Motorola MC68000, as purchasers may now wait for a more powerful product.

The 32-bit microprocessor will be known as the iAPX-432, and will be a 3-chip set with a brand-new architecture and instruction set. Intel claims that it will provide the power of a medium-scale IBM 370 system. It will directly execute Ada code. Ada is an upward extension of Pascal, and it is the language designed for and to be used by the US Department of Defense. It is interesting to note that at this time there is no Ada compiler up and running.

The two new 16-bit microprocessors are essentially 8086s with integrated functions and higher speed to improve performance. They are intended for multiprogram and multiuser systems.

Intel promises that all three new microprocessors will be available in 1981, with the 32-bit microprocessor becoming available first.

Xerox Opens Computer Stores: The Xerox Corporation recently opened retail stores in Dallas, Texas, and Denver, Colorado. Apparently these are the first links in a chain of retail computer stores across the country. The store is selling Xerox 510 small-business computers, Apple II com-

New, Exciting

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APPLE WORLD

By Paul Lutus

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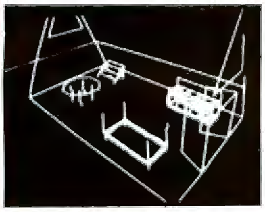

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By Ken Germann

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An 87 page manual fully documents **KRAM** 2.0 detailing **KRAM** functions and illustrating with programming samples. **KRAM** architecture is fully explained and a sample mailing list application program is included.

PET & Apple Requirements

KRAM is designed to work with both Apple's Disk II, or Corvus Systems 10 Megabyte Winchester Disk, and Commodores 2040, 3040, and 8050 Disk units. **KRAM 2.0** requires an integer Apple or Apple Plus with integer card and at least one disk drive. **KRAM** works on any 40/80 column 16K/32K PET.

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Baseball	9.95
Super Startrek	14.95
PET Music Box	29.95

puters, Centronics printers, Hewlett-Packard calculators, and ADT security systems. Xerox plans to open at least 200 such outlets in at least 50 cities within 2 years.

Apple Foundation Awards Grants To Schools: The Apple Education Foundation, chartered by Apple Computer Inc, has awarded $120,000 worth of equipment to schools and individuals to expand the use of microcomputers in education. The foundation plans to donate another $250,000 worth of equipment to support programs at all educational levels. Current recipients include Iowa State University; Bowditch Middle School in Foster City, California; North Texas State University; Educational Services Management Corporation in Raleigh, North Carolina; Children's Hospital in Philadelphia; the National Science Foundation; Dr Robert N Noyce, vice president of Intel Corporation; and others.

Other participating contributors include the Bell & Howell Company, Heuristics Inc, and Integral Data Systems Inc.

For more information, contact the Apple Education Foundation, 20605 Lazaneo Dr, Cupertino CA 95014.

5¼-Inch Mini-Winchester Disk Introduced: Shugart Technology of Scotts Valley, California (*not to* be confused with Shugart Associates) has introduced a 5¼-inch Winchester-type hard-disk drive with a 6.38-megabyte unformatted capacity. It is the same size and uses the same power-supply voltages as a standard 5¼-inch floppy-disk drive. [*See Tom Manuel's article, "The Hard Disk Explosion," on page 58 of this issue for more details*....**CM**]

Lobo Drives, Goleta, California, plans to make available a low-cost controller which interfaces the 5¼-inch hard-disk drive and floppy-disk drives to several personal-computer systems. These products should become available in 1981.

Random News Bits: Votrax (Division of Federal Screw Works, 500 Stephenson Hwy, Troy MI 48084) has announced a new voice synthesizer with an unlimited vocabulary in seven languages and controllable inflection. The Model VSB, built on a single printed-circuit card, is intended to interface with terminals, electronic typewriters, word processors, and other equipment. The unit is controlled by 8-bit input commands that select phonemes and inflection. Original equipment manufacturer price is $280....A national FORTH language group is in operation. They publish a newsletter, distribute software, and conduct meetings. For information contact: Jim Flounoy, 17370 Hawkins Ln, Morgan Hill CA 95037....Radio Shack has released a software package for its TRS-80 Model I which enables users to originate Mailgram messages. Users must have a Western Union (WU) Electronic Mail account, and if so, users are billed monthly by WU for messages sent....Matsushita Electric, Osaka, Japan, has introduced a single-component voice synthesizer that generates either 10 seconds of high-quality speech or up to 30 seconds of low-quality speech. The integrated circuit uses only 28 pins and operates from +5 V. The device will probably be used in consumer appliances, cars, etc....National Semiconductor, Santa Clara, California, has introduced a microprocessor that includes a read-only-memory-resident BASIC interpreter and 64 bytes of user memory. The single-chip computer keeps getting closer and closer to reality....CompuServe, the company that provides the MicroNet information utility, has been negotiating with H & R Block about a corporate merger, with intent to become a subsidiary of the income-tax firm.

Random Rumors: A semiconductor manufacturer will soon introduce two integrated circuits that together will handle all interfacing requirements for the S-100 bus, thereby reducing the number of components required by S-100 master and slave boards. The two devices will provide all the necessary bus buffering, control signals, and address decoding and will meet IEEE S-100 specifications....Hewlett-Packard (HP) is rumored to be working on a hand-held calculator that is programmable in BASIC (maybe they should call it a computer). Rumor is that they, and several others, will introduce such units by year end. A few have already been introduced in Japan....Texas Instruments (TI), which has been working on a disk-drive system of its own, is now negotiating with a number of outside suppliers for 8-inch Winchester-type hard-disk drives to be included in a new small-business/word-processor system to be introduced next year. TI, however, is still pursuing in-house designs. TI is also negotiating with several tape-drive suppliers for a backup storage system....The rumor is that Tandon Magnetics, Chatsworth, California, is about to announce a 2-megabyte quad-density 5-inch floppy-disk drive with a $375 original equipment manufacturer price tag....Look for Integral Data Systems to introduce a $1500 letter-quality dot-matrix printer. It will use overlapping dot-matrix printing. To be called "Paper Tiger Plus," it will print at 120 cps, with proof copies at over 200 cps.

Too Good To Be True? A rumor recently heard at BYTE says that a major manufacturer will shortly introduce a 5-inch floppy-disk drive with a tenfold increase in density. This sounds too good to be true. Will standard media support such an extension?...**CH**

Microminis and Micromaxis: Two new words have been coined to describe the newer microprocessors. If an 8-bit processor is called a "micro," then a 16-bit microprocessor must be a "micromini." That is the conclusion of many in the industry, particularly since many of these new 16-bit microminis will be competing head-on with applications that were previously the exclusive domain of the 16-bit minicomputers.

It therefore follows that the 32-bit microprocessors, which are expected within three years, should be called "micromaxis," since they will most likely compete for applications previously handled by large mainframe computers. At least that is what many industry watchers think.

Well now...my question is: what do we call a 4-bit microprocessor? Is it a "minimicro"?

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

Sol Libes
Amateur Computer Group of New Jersey (ACG-NJ)
1776 Raritan Rd
Scotch Plains NJ 07076

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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	●	●	□	■	●

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We set the standard.

This selected list of FORTH vendors is meant to be an overview only. For complete details contact the vendors. Many of the products, listed as fig-FORTH versions, are implementations of the FORTH Interest Group software customized for a given machine and available in machine-readable (as opposed to printed) form.

When purchasing a version of FORTH, check to see what source the version is based upon. All good versions of FORTH are based on either the FORTH Inc or the FORTH Interest Group versions. Some existing implementations use nonstandard shortcuts that limit the usability of the product; these should be avoided.

Literature on FORTH is scarce, so be prepared to puzzle through cryptic documentation. Miller Microcomputer Services offers a wide selection of books on FORTH (the only selection we know of). Particularly suitable are microFORTH Primer *(supplied with the purchase of MMSFORTH) and* Using FORTH, *both written by FORTH Inc.*

*STOIC is a FORTH-like language available from the CP/M Users' Group and is listed because of its low price. N/A refers to information unavailable at the time this table was compiled....*GW *and* CHF

Selected FORTH Vendors

Manufacturer	Product Name(s)	Machine Requirements	Format	Cost	Notes
Acropolis Software 17453 Via Valencia San Lorenzo CA 94580 (415) 276-6050	A-FORTH (based on fig-FORTH)	Any machine running Micropolis disks and MDOS operating system	Floppy disk	$150	Includes 8085 assembler, double-precision fixed-point math, enhanced disk access, other features.
Cap'n Software POB 575 San Francisco CA 94101 (415) 540-0202	fig-FORTH	Apple II with disk	5-inch floppy disk	$140	FORTH hot line available for questions. Extra packages (Apple high-resolution graphics, floating point) available at extra cost.
CP/M Users Group 1651 Third Ave New York NY 10028	STOIC (*not* FORTH, but a FORTH variant)	Any CP/M machine.	8-inch floppy disk	$20	See editorial for further details.
FORTH Inc 2309 Pacific Coast Hwy Hermosa Beach CA 90254 (213) 372-8493	FORTH, polyFORTH, microFORTH, picoFORTH	Versions for various machines: 8080, 8086, 6800, 1802, LSI-11; also handles versions for minicomputers and mainframes	Varies with machine.	$2500 up ($495 for picoFORTH)	These are the inventors of the language; they supply custom packages and extensive support; picoFORTH (for 8080 or 1802) can be directly upgraded to polyFORTH.
FORTH Interest Group POB 1105 San Carlos CA 94070	fig-FORTH	Various machines with 16 K bytes or more: 8080, 6502, 6800, LSI-11, 9900, PACE; disk preferable	Printed listings; must be customized by user.	$20	$20 includes installation manual and assembly language source for one processor (8080, etc); requires some work by user to install; quality product at a low price.
FORTH Power 17390 Hawkins Ln Morgan Hill CA 95037 (415) 471-1762	fig-FORTH	Heath WH-89 or 6800 EXORciser	N/A	N/A	
Forthright Enterprises POB 50911 Palo Alto CA 94303 (415) 856-0450	fig-FORTH	CP/M machine, 16 K bytes	8-inch CP/M floppy disk	$30	Includes all source code.
John James POB 348 Berkeley CA 94701 (415) 526-8815	fig-FORTH	PDP-11, all models; stand-alone or running under RT-11 or RSX-11M; 24 K bytes or more	8-inch floppy disk	$140	Package includes all documentation and source code; also offers a book of FORTH reprints.
M&B Design 820 Sweetbay Dr Sunnyvale CA 94086 (408) 243-0834	polyFORTH-CP/M	8080 CP/M system	8-inch CP/M floppy disk	$4000	Multitasking version of FORTH running on CP/M system with 32 K bytes or more; includes utility programs and interface to CP/M; system uses CP/M I/O drivers only.
Miller Microcomputer Services 61 Lake Shore Rd Natick MA 01760	MMSFORTH (based on FORTH Inc microFORTH)	TRS-80 Model I, with Level II BASIC, 16 K bytes or more	Cassette or 5-inch floppy disk	$59.95, cassette $79.95, disk	Offers support of product, consultation, newsletter, additional FORTH products, and a wide selection of FORTH books.
The Stackworks 321 E Kirkwood Ave Bloomington IN 47401 (812) 336-1600	SL5 (FORTH under a different name)	Any CP/M machine, 8080 or Z80	8-inch CP/M floppy disk	$150 (noncommercial use), $1500 (commercial use)	This language is essentially an implementation of the 1977 FORTH Standard; SL5 includes a debug package and packages that allow the generation of condensed, stand-alone programs as either CP/M, COM files, or as programs to be placed in read-only memory.
Talbot Microsystems 7209 Stella Link Suite 112 Houston TX 77025 (713) 666-7588	fig-FORTH	Minimum 12 K bytes (20 K better for FLEX 9.0) 6809 SwTPC FLEX 9.0	5-inch floppy disk soft-sectored	$39.95	Offers telephone support of product.

What Is FORTH? A Tutorial Introduction

John S James
POB 348
Berkeley CA 94701

FORTH is a programming language with a small but fast-growing and enthusiastic user community. Though easy to learn at a terminal, it is difficult to explain abstractly because it is so different from other languages. Even advocates do not agree why it is good or how it should be used.

FORTH was developed for control applications (using a computer to run other machinery), data bases, and general business. It is least useful for big number-crunching jobs (eg: writing a matrix inversion routine), although it can link to subroutine packages written in other languages to incorporate such functions. Unlike Pascal, FORTH gives the user complete access to the machine and does not try to guard the programmer against mistakes. But its modularity and other forms of error control allow production of remarkably bug-free application programs—perhaps more than any other language in common use. The compiler uses much less memory than Pascal does, and its programs run about equally fast. FORTH is much more interactive than most conventional implementations of Pascal. FORTH is available on most common personal computers (eg: Apple, TRS-80) and all major microprocessors (eg: 8080, 6800, 6809, 6502, PACE, LSI-11, and 9900). An international FORTH Standards Team exists, and standard systems are virtually identical among all different machines.

This article will describe what it is like to program in FORTH. A group of annotated terminal sessions, shown in listings 1 thru 10, will provide more details on the language itself.

Acknowledgments and Availability

Listings 1 thru 7 were run on a FORTH system for the Apple II provided by Cap'n Software, POB 575, San Francisco CA 94101. The PDP-11 examples were run on a system written and distributed by the author. The 8080 example was provided by John Cassady of the Forth Interest Group, POB 1105, San Carlos CA 94070; a similar 8080 FORTH system is available from Forthright Enterprises, POB 50911, Palo Alto CA 94303. Other members of the Forth Interest Group contributed helpful suggestions. And of course we are indebted to the inventor of FORTH, Charles Moore of FORTH Inc, 2309 Pacific Coast Hwy, Hermosa Beach CA 90254, who started it all.

The Philosophy of FORTH

FORTH reduces the cost of a subroutine to very little, and the whole language is built on functions that are like subroutine calls. The programmer keeps defining new words (new functions) from old ones until, finally, one of them is the whole job. Most programmers keep each definition short, usually one to three lines not counting comments. The definitions are compiled as entered and are immediately ready to run.

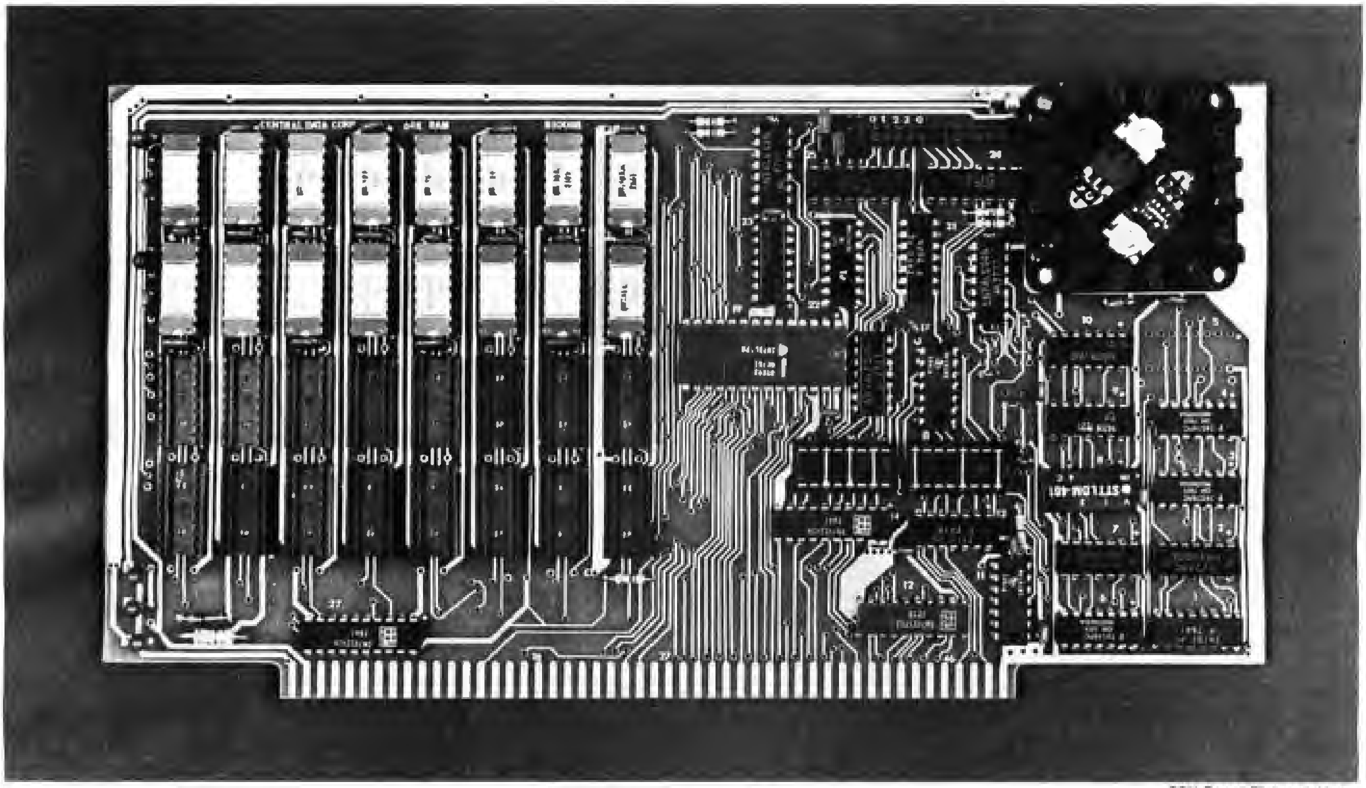
Because FORTH definitions are short, all possible execution paths of the definition can be tested easily. Since most functions work exactly the same when executed as commands from the terminal or when used as components in further definitions, they can be tested immediately from the terminal. And the functions are so general that there is no sharp distinction between program and data.

Since programmers define their own operations, special application libraries of FORTH words can be developed. The new routines are integrally part of the language, so they do not need any special calling sequences, and they are immediately ready to run. Even the original words supplied with the system (there are about one hundred of them), can be redefined if desired, adapting the language for special circumstances. Also, programmers can create their own data types or operation types (eg: their own kinds of arrays or other data structures, or new classes of operations). This flexibility allows unprecedented "customization" of a language to the requirements of a particular installation or application. The finished programs are easily modifiable when requirements change because they are composed of pretested building blocks specially designed for that kind of program.

Stack and Postfix Notation

A smaller convenience of FORTH is that you do not have to do much coding when you start a new program. As soon as the system comes up, all your previous work is ready to go, just as if it were originally part of the language.

A feature that some people do not like is FORTH's use of a stack (explained below) and its *postfix notation* (also called *reverse Polish*



32K Board Pictured Above

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48K	$500	$530
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Most FORTH operations communicate only through a stack.

STACK						7			
			5		6	6	13		
		4	4	9	9	9	9	117	117
	—	—	—	—	—	—	—	—	—
	—	—	—	—	—	—	—	—	—
OPERATION JUST PERFORMED	(BEGIN)	4	5	+	6	7	+	*	(END)

Figure 1: *Evaluation of the postfix-notation expression,* { 4 5 + 6 7 + * }. *Numbers are pushed onto the stack at the top. Operators (here, + and *) pop the top two entries off the stack and push the result of that operation back on the stack. For example, the first plus sign (column 4) replaces the 4 and 5 on the stack with 9, the result of the addition operation.*

notation or *RPN*). In postfix notation (a system used on most Hewlett-Packard calculators), arithmetic formulas are written with the operations after their arguments, not between them. For example, "2+3" becomes { 2 3 + } in FORTH or other postfix systems; "(4+5)*(6+7)" becomes { 4 5 + 6 7 + * }. (See explanation below.) No parentheses are needed in postfix.

Some programmers do not like postfix, and they ask, "Why doesn't someone write an algebraic-to-postfix translator for FORTH? That would be easy to do." The reason is that postfix has benefits far more important than the compiler-writer's convenience. It greatly simplifies linkage to subroutines. With postfix, you do not need any CALL statement or argument list, or any formal parameters in the subroutine. While arithmetic-formula operations (add, subtract, etc) must take either one or two arguments and return exactly one result, postfix functions can have any number of arguments or results.

In FORTH, most operations communicate only through a stack. The stack, perhaps the most important data structure in programming, is used in almost all languages, but most languages hide it from the user. In FORTH, the user controls the stack directly.

A *stack* is a pile of numbers where the last ones put in are the first ones taken out; that is, you can only remove the number that is on top of the stack. It is like a stack of trays in a restaurant; trays are conveniently added and removed only at the top. (Unfortunately, computer-science texts do not agree on terminology, and a few call the top of the stack "the bottom.")

To see how a stack works in computation, consider the expression { 2 3 + } above. In FORTH, numbers are compiled as operations which place their values onto the stack. So when the 2 is executed, it is placed on top of the stack, which then looks as follows:

```
2
—
—
```

where the dashes represent whatever data may have been on the stack before. Then after the 3 has been encountered, the stack becomes:

```
3
2
—
—
```

Then the + is executed. The 1-character word + takes two arguments from the stack (destroying them), performs the addition, and leaves the result on the stack. So the stack finally is:

```
5
—
—
```

The reader can verify that when the formula { 4 5 + 6 7 + * } is executed, the stack goes through the sequence shown in figure 1.

Now we can see why FORTH is not the best language for big number-crunching jobs. Numbers to be operated on must be moved to the stack in addition to whatever operations are to be carried out, and this extra movement slows FORTH down for this kind of computation. Once on the stack, however, arithmetic is fast (for example, single instruction execution for addition on some 16-bit machines, more for 8-bit machines). Also, FORTH can link the useful instructions of one routine and those of another in as little as one or two instruction executions (depending on machine architecture). This makes FORTH programs much faster than BASIC, usually ten times faster or more (assuming an interactive BASIC, that is—FORTH is always interactive). But a good FORTRAN compiler's code may do number-crunching several times faster still.

Characteristics of FORTH Code

FORTH is a structured language (as is Pascal) in that it has no GOTO or statement labels in the language. Discussion of structured programming is outside the scope of this article, but its importance for program correctness and maintainability is recognized.

FORTH object code (ie: a compiled program) is extremely compact, even more so than machine language. The reason is that no matter how much work an operation performs, each invocation of it takes the same space in the object program—two bytes. The bigger the program, the greater the memory advantage, since the hierarchical structure of programs allows increasingly powerful and application-targeted operations to be built up. But FORTH has a relatively large run-time memory overhead, so small programs can take less total space in other languages.

*[The reason that a FORTH call can be shorter than a normal machine-language subroutine call (usually three bytes) is that a FORTH program is interpreted by a FORTH interpreter (also part of the FORTH language) in much the same way that a BASIC program is interpreted by a BASIC interpreter. The "relatively large run-time memory overhead" mentioned above is the FORTH interpreter plus a core of FORTH words defined in machine language. When a FORTH program is very large, it saves enough memory in FORTH calls to make up for run-time memory overhead.... **GW**]*

The complete FORTH system (itself largely written in FORTH) takes about 7 K bytes, and this whole system including the compiler is com-

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MICRO PERIPHERALS, INC./2099 WEST 2200 SOUTH/SALT LAKE CITY, UTAH 84119/(801) 973-6053 monly left in memory as a run-time package. Therefore, 16 K bytes and a floppy disk for storing source programs are sufficient hardware for an excellent FORTH system (compare this with the memory requirements of Pascal, 48 K bytes or more). When compactness is especially important, as when programs are burned into read-only memory and embedded in machinery, FORTH's compiler, terminal handler, and operation names—anything not needed to run—can be stripped out of the application program, leaving a run-time package of about 800 bytes, instead of the usual 7 K bytes.

FORTH programming is *reentrant*; this means that different users can share the same copy of a program in memory while running at the same time. FORTH easily handles multitasking, including multiple terminals used for program development. (At present, however, most of the low-cost systems on the market are still single-user.) FORTH is *recursive*, meaning that routines can invoke themselves.

Suppose you want to link your high-level-language program to a machine-language subroutine (eg: you may be controlling a high-speed device and need the full speed of the computer to keep up). Many languages make this linkage difficult or impossible. In FORTH, however, it is very convenient. You can type in or load from disk a machine-language routine, using a FORTH assembler, and the new routine can be executed immediately. Listing 9 shows examples for PDP-11 and for 8080.

The word CODE invokes the FORTH assembler and begins the definition of a machine-language routine. Mnemonic instructions and address-mode symbols are understood by this assembler, and the whole power of FORTH is available for address arithmetic at assembly time. FORTH assemblers use postfix notation, so op codes come *after* their addresses, not before as in conventional assemblers.

The machine-language code is generated as the definition is being entered. The completed operation works just like any other FORTH word, so the user does not need to use any special calling sequence, or even need to know which operations are defined in code and which are not. (In fact, about fifty FORTH words are written in machine language—all other words in FORTH are ultimately defined in terms of these fifty words.)

The FORTH assembler allows structured conditionals and loops at the machine-code level; it can also assemble unstructured code if desired. Users can define their own macro-instructions, use custom-made data types, etc.

In other words, the FORTH assembler allows structured programming even in machine code, and it links the resulting machine-language subroutines into the system immediately. No separate assembly and linking-loader passes are needed, and the associated file management overhead is avoided.

Some More Advantages

FORTH programs are highly transportable between different computers. Any assembly-language routines used by the program must be rewritten, but most applications do not need any assembly, and very few need more than a handful of short, critical routines. When FORTH systems have been designed for compatibility, large applications can be moved among very different

machines, with little or no change. For example, it can be practical to down-load program development from a PDP-11 to a TRS-80 or an Apple II. It is even possible to write the software for a product before a hardware commitment is final.

Another advantage is that FORTH is a self-contained operating system. The 7 K bytes include terminal and disk handlers and a rudimentary file system. No other software is needed anywhere in the computer. Yet, if a monitor in read-only memory is available, FORTH can use it; and FORTH can run as a task under some other operating system (eg: CP/M) when that is wanted. FORTH can link together otherwise incompatible pieces of systems: software in read-only memory, operating systems, subroutine packages, and hardware. It provides a user interface that enables subroutine packages normally used by batch (ie: noninteractive) programs, mostly on older, larger computers, to be used interactively.

FORTH puts you in charge of your computer. You can understand everything happening in your software or in any desired parts of it, and you can change it. This means no more "black box" systems that only the manufacturer's specialists can understand, no more dependence on someone else for upgrades, fixes, or documentation, and no more question of who is responsible if software does not work. The whole system is written in FORTH, right down to the bits—your application programs, the compiler, the operating system, the I/O drivers, etc. You do not have to learn some other language or be a systems specialist to modify it.

Disadvantages

Few FORTH systems used today have floating-point arithmetic. This is not a fault of the language; rather, it reflects its history in microcomputer control applications, where integer arithmetic is often needed for speed. Now there is more pressure for floating point, and it is becoming available.

A more fundamental limitation of FORTH is that it is not a typed language (unlike Pascal). For example, if an integer operation is performed on a floating-point quantity, no message is printed either at compile time or at run time to warn of this error. (However, the user *can* add type checking and other error-preventing operations into any FORTH word.)

It may seem that unreliable code would result from the untyped nature of FORTH, but, in fact, FORTH code is remarkably solid and bug-free. The modularity and excellent testing environment aid error control; and type mismatches are less dangerous than most other mistakes because they are easy to detect.

Another criticism of FORTH is its lack of a directory file structure. Again, this is historical and is not a characteristic of the language, which can be developed to use any kind of files.

The traditional FORTH file system is primitive, but in practice it has worked very well. The entire disk (or disks) is a single virtual array of blocks numbered from 1, with the block size standardized at 1024 bytes regardless of physical disk sector size. The blocks (called *screens* because they can be displayed as sixteen 64-character lines on a terminal) are automatically buffered so that they are physically read and written only when necessary. A LOAD command will read a given screen and treat the information exactly as if it had been typed in a terminal session, thereby compiling source code or executing commands (depending on the contents of the screen). The LOAD instruction can be executed within a screen; in this way, a single LOAD command can control the compilation of large source programs.

This disk-based file system allows any part of the disk to be read or written with a single access. Load screens or data areas can be saved by name, and portions of the disk can be protected by redefining the names of a few input and output operations so that they check before writing and/or reading.

The disadvantage of this system is that there is no directory; when a new disk is inserted, the user or the program must know the block numbers for load screens and data files. Also, FORTH source programs are traditionally stored without tabs or truncation of blank lines, making white-space (ie: unused area on a line) and

space for comments costly in disk space and load time, discouraging good program layout. For these reasons, there is increasing interest in changing to a directory file system. Perhaps it will be written on top of the screen system currently in use.

The most important criticism of FORTH is that its source programs are difficult to read. Some of this impression results from unfamiliarity with a language different from others in common use. However, much of it results from its historical development in systems work and in read-only-memory-based machine control, where very tight programming that sacrifices clarity for memory economy can be justified. Today's trend is strongly toward adequate commenting and design for readability.

FORTH benefits most from a new, different programming style; techniques blindly carried over from other environments can produce cumbersome results. Most FORTH programmers seldom use named variables; they use the stack instead so that the implicit commenting normally available through choice of variable names is only provided through comments and user-defined operation names. Single definitions that would have more than about three unrelated numbers on the stack at any one time are best split into two or more operations; most programmers learn to keep their definitions short.

FORTH enforces extreme modularity, so the decomposition of each task into component parts is critical. Top-down design is especially important. Large jobs should be written as application-oriented libraries of operations to make teamwork and maintenance easier. A much larger fraction of the total programming effort is spent on design, with less on coding and debugging. For these and other reasons, FORTH creates its own issues of style, which are only beginning to be explored.

A Taste of FORTH

FORTH is an interactive language best explained by example. Because of this, a series of listings (listings 1 thru 10) with fairly detailed explanations make up the rest of this article. In the listings that follow, underlining denotes user keyboard input.

FORTH uses punctuation in some of its words, which makes representing them in text a difficult problem. For example, one FORTH word is ("), which could be taken to mean one of several character combinations. (For your information, the word has three characters and is made from a left parenthesis followed by a double quote mark and a right parenthesis.)

To decrease the chance of confusion while trying not to clutter text unnecessarily, we will sparingly use braces, { }, to isolate the character string within as a FORTH word or phrase. (For example, the above word would be written { (") } .) Braces will be used only under the following situations:

- when the material being quoted is a phrase of FORTH words (eg: { 26 LOAD } or { 3 5 + })
- with the FORTH words { . } (period), { , } (comma), { : } (colon), { ; } (semicolon), { ? } (question mark), { ! } (exclamation point), { ' } (single quote mark), and { " } (double quote mark)
- with any word using the above punctuation marks (eg: { $. } or { ." }).

All other FORTH words will be set apart by a space on either side of the word. So, in this and other FORTH articles in this issue, braces will always signal a FORTH word or phrase. The braces are not part of the word or phrase, and FORTH words will never use braces within the body of a figure or listing....GW

On the Necessity of Using Camera-Ready Copy

Examination of listings 1 thru 10 will reveal a variety of typefaces used. This variety is present because each listing was created by the printer of the system producing the listing. Such listings are called camera-ready copy, *which means that we can reproduce them in BYTE without inadvertently adding the errors that creep in with the retyping of a listing. Contributors to BYTE and* onComputing *are strongly encouraged to submit camera-ready listings made with a fresh ribbon, since this helps us to improve the accuracy of the article.*

Listing 1: *FORTH as a calculator. FORTH is easy to approach because it can be used as a calculator. Here, the programmer has not defined any new operation but has used addition, multiplication, and print (the dot means print). These are three of about one hundred operations that are available when FORTH first comes up. Programming consists of defining new operations which can be custom designed for a particular task or a particular industry.*

FORTH uses postfix *(also called* RPN *or* reverse Polish notation*) arithmetic, which is best known from its use in Hewlett-Packard calculators. In postfix notation, the operations are written after their arguments, not between them. The text of this article shows how postfix notation works, using a data structure called the* stack, *and it explains the formulas in this example.*

Postfix notation, which does not use parentheses, is more general than ordinary arithmetic notation. Its biggest advantage is that it greatly simplifies the writing and calling of subroutines.

In these examples, underlining indicates what the user has typed on the terminal. FORTH does not process the line until you type a carriage return. The OK prompt means that the system has completed its work and is ready for new input from the user.

```
2 3 + . 5 OK
4 5 + 6 7 + * . 117 OK
```

Listing 2: *Changing number bases. FORTH can work in different number bases and can change any time, so it serves as an octal/hexadecimal/binary/decimal calculator within the limits of 16-bit numbers (or 32 bits for double precision). The FORTH word HEX converts FORTH into a hexadecimal machine, and all numbers are printed in*

Listing 2 continued on page 112

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Listing 2 continued:
hexadecimal until some other operation changes the base again. FORTH always begins a session in decimal radix.

The operations DECIMAL and HEX are built into the system; OCTAL , BINARY , and TRINARY (base 3) are not. So when OCTAL was first used, the error message { OCTAL ? } indicated an undefined word; that is, the system did not recognize the word OCTAL . In the next line, the user defined OCTAL (line 6). This example illustrates FORTH's extensibility; users can extend the language to include new operators.

Incidentally, the second error message { 12885 ? } in line 12 resulted because the system was in binary (from the line above), and, in binary, numbers must contain only the digits 0 and 1 , so 12885 was not recognized as a number. It was treated as a word, and, because there was no operation named 12885 , the error message was generated.

OCTAL and the other number-base operations work by giving a new value to BASE , a variable used by the system. Defining new operations is more fully explained in listing 3. The { ! } operation (store) is explained later.

Number bases only affect input and output. All internal computation is in binary, so there is no speed penalty for using nondecimal numeric bases.

```
HEX  OK
3BE8 C8 + . 3CB0  OK
25 2F * . 6CB  OK
DECIMAL 1348 HEX . 544  OK
DECIMAL 1348 OCTAL . OCTAL  ?
: OCTAL 8 BASE ! ;  OK
DECIMAL 1348 OCTAL . 2504  OK
DECIMAL  OK
: BINARY 2 BASE ! ;  OK
: TRINARY 3 BASE ! ;  OK
12885 BINARY . 11001001010101  OK
12885 BINARY . 12885  ?
DECIMAL 12885 BINARY . 11001001010101  OK
DECIMAL 12885 OCTAL . 31125  OK
DECIMAL 12885 HEX . 3255  OK
DECIMAL 12885 TRINARY . 122200020  OK
DECIMAL -12885 TRINARY . -122200020  OK
DECIMAL  OK
```

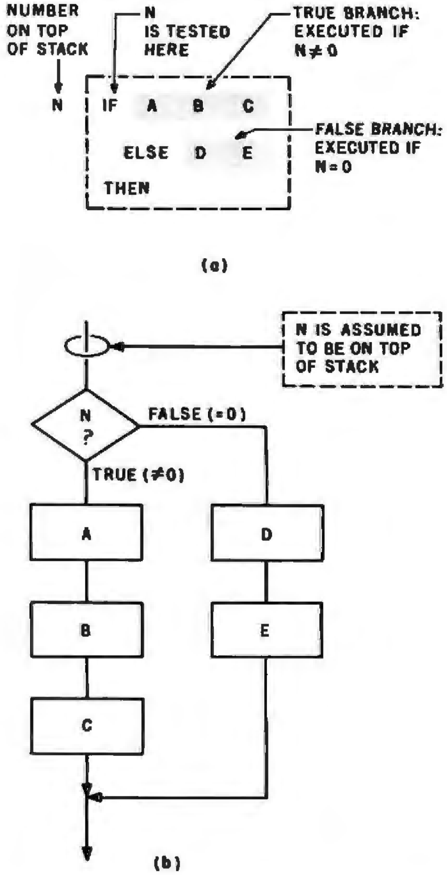

Figure 2: *An explanation of the IF ... ELSE ... THEN construct. (See listing 4.) As shown in figure 2a, the portion of code executed depends on the value of the number on top of the stack when the word IF is encountered. If we call this number N and say that the number has a boolean value of true if its numeric value is nonzero and false if 0, then figure 2b gives the equivalent construct to figure 2a in conventional flowchart notation. Here and in figures 3 thru 5, the dotted box indicates the boundaries of the construct (as opposed to values assumed to be on the stack).*

Listing 3: *Defining new operations. Here, a new operation CUBE is created. CUBE replaces whatever number is on top of the stack with the cube of that number. The statements within the parentheses are comments.*

The colon, { : }, begins a FORTH word definition; the word following it is the name being defined. Semicolon, { ; }, ends the definition.

*The new word CUBE will first execute DUP, which duplicates the number on top of the stack, making a second copy. The second DUP leaves three copies. The first * causes the top two copies to be replaced by the square of the number; the next * computes the cube, and then all three copies of the original number are gone, leaving the cube of the number on top of the stack.*

This colon definition shows one of several ways to create new words in FORTH. Most words that appear inside the definition are compiled and not executed immediately.

All words and numbers in FORTH are separated by one or more blanks (and/or carriage returns). FORTH operation names can be up to thirty-one characters long and can consist of letters, numbers, or any other characters. For example, an operation name could be a number, or it could be nonprinting characters only. In practice such names are rarely used, but they illustrate the flexibility that is available.

Listing 3 continued on page 114

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Listing 3 continued:

This listing shows CUBE being executed from the terminal. It can also be used as a component in further definitions. A fundamental property of FORTH is that operations defined by users are indistinguishable from those which were originally part of the system.

```
: CUBE   ( N -> N.  CUBE A NUMBER)
   DUP DUP   ( NOW THERE ARE THREE COPIES)
   * *       ( GET THE CUBE)
   ;  OK
5 CUBE . 125  OK
-28 CUBE . -21952  OK
HEX 17 CUBE BINARY . DECIMAL 1011111000111  OK
```

Listing 4: *Conditional branching. The IF ... THEN is for conditional execution. IF takes one argument off of the stack; this argument is interpreted as a boolean or truth value, with 0 meaning false and any nonzero value meaning true. If true, any statements between the IF and THEN are executed. In either case, execution continues after the THEN , which terminates the conditional. There is also an optional ELSE clause that is executed only if the argument is false. (See figure 2.)*

Here, the true-clause contains only one word, MINUS , but it could contain almost any FORTH statements, including other conditionals and loops nested to any practical depth. These statements run fast because they are compiled into a form of object program called threaded code.

Incidentally, the FORTH word 0< returns a boolean value indicating whether its argument (the number on top of the stack) is less than zero. The DUP is necessary because 0< follows the FORTH convention that operations should destroy their arguments on the stack. MINUS reverses the sign of its argument (the top stack number).

Items in parentheses are comments. The comment "N -> N" in the first line is to show that this operation takes one number off of the stack and returns one number to it. Perhaps the most important information to put in the comments accompanying each new operation is what arguments it takes off of the stack and what results it returns to the stack.

```
: ABSOLUTE-VALUE   ( N -> N.  ABSOLUTE VALUE)
   DUP 0<   ( GET BOOLEAN, TRUE IF NEGATIVE)
   IF MINUS THEN   ( NEGATE THE NUMBER IF TRUE)
   ;  OK
10 ABSOLUTE-VALUE . 10  OK
-5 ABSOLUTE-VALUE . 5  OK
```

Listing 5: *The DO ... LOOP, a structured loop with a counting index. DO takes two arguments from the stack, the initial value of the index (on top) and the final value plus 1. (See figure 3.) These indices are written in reverse order from most other languages, making the loop terminating value (which is more often passed as an argument) more accessible on the stack.*

CR simply performs a carriage return. In this example, the index values are literals (10 and 0), but they can also come from variables or from computations of any complexity; anything that gets the indices onto the stack is legitimate.

This listing also shows a timing benchmark; the word TIME-TEST does 30,000 empty loops. On an Apple II running FORTH, TIME-TEST executes in less than 4 seconds. In Apple Integer BASIC (which is a fast BASIC), 30,000 empty loops take 40 seconds.

```
: 10CUBES   ( ->.  PRINT A TABLE OF CUBES OF 0-9)
   10 0   ( INDICES OF LOOP)
   DO     ( START LOOP)
      CR I . I CUBE .   ( PRINT A NUMBER AND ITS CUBE)
   LOOP   ( END OF LOOP)
   ;  OK
10CUBES
0 0
1 1
2 8
3 27
4 64
5 125
6 216
7 343
8 512
9 729  OK
: TIME-TEST 30000 0 DO LOOP ;  OK
TIME-TEST  OK
```

Listing 6: *The BEGIN ... UNTIL loop. This loop takes one argument, a truth value, usually computed within the loop, at the end. If it is false (0), control branches back to the corresponding BEGIN ; if the value is true (nonzero), the loop ends, and control transfers to the next word in the program. (See figure 4.)*

Note that the test of the value on top of the stack occurs at the end of the body of the loop; this guarantees that the body of the loop will be executed at least once.

The word = removes the top two numbers from the stack and returns a truth value of 1 if they are equal, 0 otherwise. In this example, the index stays on the stack and is duplicated before each use. The DROP at the end throws away the top stack value; this prevents the used index from cluttering the stack.

The warning message "10CUBES ISN'T UNIQUE" notifies us that the same name has already been defined. The only penalty for reusing a name is that the former definition becomes inaccessible for the rest of the program. Therefore, you do not have to remember a list of reserved words in FORTH; if you do not know about a name or have forgotten about it, you probably were not planning to use it anyway. But, in case of a mistake, the bad definition can be deleted with a FORGET operation, or the source code can be changed on disk.

*[Some versions of FORTH use BEGIN ... END instead of BEGIN ... UNTIL .... **GW**]*

```
: 10CUBES    ( ->.  SAME, USING 'UNTIL' LOOP) 10CUBES ISN'T UNIQUE
  0          ( INITIAL VALUE OF INDEX)
  BEGIN      ( START LOOP)
     CR DUP . DUP CUBE .     ( PRINT A # AND ITS CUBE)
     1 +     ( INCREMENT)
     DUP 10 =     ( TEST FOR INDEX=10)
  UNTIL    ( END OF LOOP)
  DROP    ( THROW AWAY USED INDEX)
  ;  OK
10CUBES
0 0
1 1
2 8
3 27
4 64
5 125
6 216
7 343
8 512
9 729  OK
```

Listing 7: *The BEGIN ... WHILE ... REPEAT loop. This looping structure tests the value on top of the stack at the beginning of the loop; because of this, this loop can execute 0 times. REPEAT causes an unconditional branch back to BEGIN , and WHILE branches out of the loop (just beyond REPEAT) if the truth-value which it finds on top of the stack is false (ie: 0); see figure 5.*

All of these looping and conditional branching structures can be nested within each other to any practical depth. Any mismatching can be detected at compile time. Most FORTH systems allow these structures only inside colon definitions; they cannot be executed directly from the terminal.

[Some versions of FORTH use: BEGIN ... IF ... WHILE or WHILE ... PERFORM ... PEND instead of *BEGIN ... WHILE ... REPEAT .... **GW**]*

```
: 10CUBES    ( ->.  SAME, USING 'WHILE' LOOP) 10CUBES ISN'T UNIQUE
  0          ( INITIAL VALUE OF INDEX)
  BEGIN
     DUP 10 <    ( LOOP TEST)
  WHILE
     CR DUP . DUP CUBE .     ( PRINT A # AND ITS CUBE)
     1 +     ( INCREMENT)
  REPEAT
  DROP    ( THROW AWAY USED INDEX)
  ;  OK
10CUBES
0 0
1 1
2 8
3 27
4 64
5 125
6 216
7 343
8 512
9 729  OK
```

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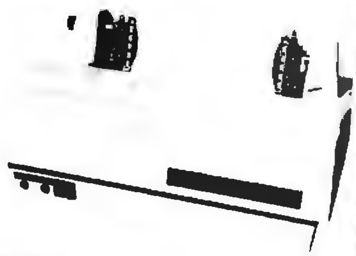

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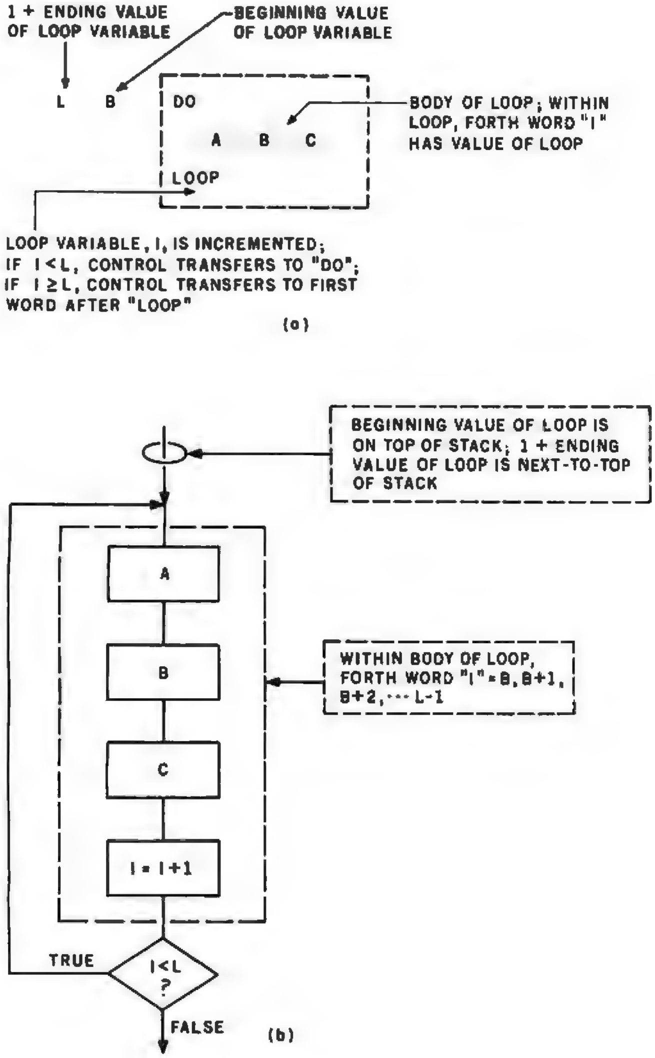

Figure 3: *An explanation of the DO ... LOOP construct. As shown in figure 3a, the top number on the stack is taken to be the lower limit of the loop variable, I, and the next-to-top number on the stack is the upper limit of the loop variable + 1. The body of the loop is shaded, and the loop variable is incremented and tested after the body of the loop is executed. Figure 3b gives the equivalent construct in conventional flowchart notation.*

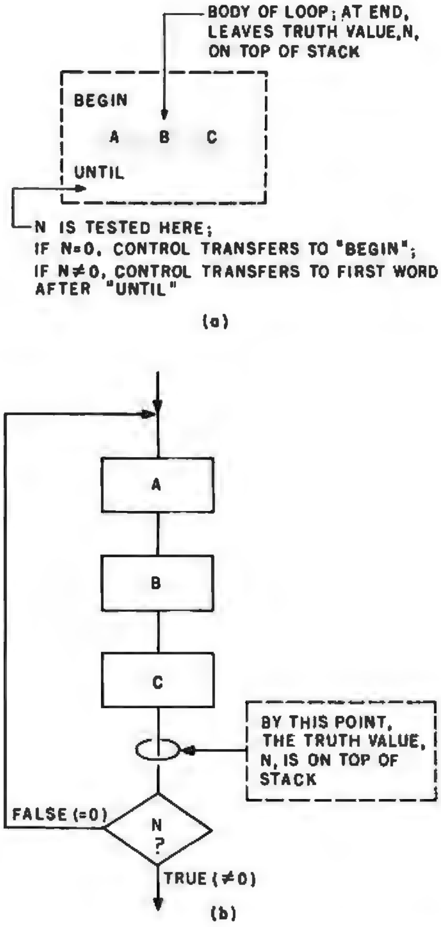

Figure 4: *An explanation of the BEGIN ... UNTIL construct. As shown in figure 4a, the body of the loop (shaded) is repeated only if the value on top of the stack when the word UNTIL is reached is false. Figure 4b gives the equivalent construct in conventional flowchart notation.*

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Listing 8: *An example of FORTH looping. A practical use of FORTH's structured looping is this terminal output handler. This example is for a PDP-11; an example for other computers would be similar. Address 177564 (octal) is the* output status register of the *console terminal; bit 7 of this address is set when the device is ready to receive a character. The ASCII code for the output character can then be placed in address 177566 (the* data buffer register*).*

The FORTH word @ (pronounced fetch) does the work of PEEK in BASIC; it treats the number on top of the stack as an address and replaces it with the contents of that address word. AND does a "bitwise" boolean AND operation. So { 177564 @ 200 AND } indicates true (nonzero) only if bit 7 of the status register is set. Until then, the BEGIN ... UNTIL loop does a waiting loop ending on the above condition. When the device is ready, the argument that was given to TERMINAL-OUT (the ASCII character to be written) is still on top of the stack. { ! } (pronounced store) stores the word that is second on the stack into the address that is on top of the stack; so { 177566 ! } transmits the character to the terminal data buffer register, from which it will be written onto the terminal by the hardware of the PDP-11 system.

The FORTH word ASCII-TEST was written to test the TERMINAL-OUT word. It transmits ASCII values for all of the printable character set.

Listing 9 shows the same device handler, only written in machine-language code with a FORTH assembler.

```
 OK
OCTAL  OK
: TERMINAL-OUT   ( CHAR -> .  TERMINAL OUTPUT HANDLER; PDP-11)
   BEGIN 177564 @ 200 AND UNTIL   ( WAIT TILL PORT READY)
   177566 !   ( TRANSMIT THE CHARACTER)
   ;  OK
: ASCII-TEST   ( -> .  TEST HANDLER - PRINT CHARACTER SET)
   177 40   ( TRANSMIT ASCII BLANK THROUGH '~')
   DO I TERMINAL-OUT LOOP   ( OUTPUT THE CHARACTERS)
   ;  OK
DECIMAL  OK
ASCII-TEST  !"#$%&'()*+,-./0123456789:;<=>?@ABCDEFGHIJKLMNOPQRSTUVWXYZ[\]^_`abcd
efghijklmnopqrstuvwxyz{|}~ OK
```

Listing 9: *FORTH words defined by machine-language subroutines, for PDP-11 and for 8080 processors. The operation TERMINAL-OUT-2 behaves exactly the same as TERMINAL-OUT defined in listing 8, but it is written in assembly language. FORTH assemblers use postfix notation, so address-mode symbols and operation codes (instruction mnemonics) follow their operands, unlike conventional assemblers. In the PDP-11 example (listing 9a), { 177564 200 # BIT, } in line 2 assembles a "bit test" instruction that does a logical AND between address 177564 and the literal 200 (# indicates literal), setting condition codes. { UNTIL, } assembles a conditional branch back to the corresponding { BEGIN, }. The commas are part of the operation names, not punctuation. The word NE tells the { UNTIL, } what kind of conditional branch to assemble. There are also { IF, }...{ THEN, } and { IF, }...{ ELSE, }...{ THEN, } operations; all these code-level structures can be nested.*

In the 8080 example (listing 9b), the machine-language subroutine sets up a call to the character-output routine in the North Star disk operating system. In contrast, the PDP-11 example outputs directly to the hardware without using any software outside of FORTH. Either approach could be used on either machine, of course, and each has its own advantages.

The word CODE , like { : } (colon, introduced in listing 3), creates a new definition in FORTH's dictionary for the word following it. CODE also sets the number base (to octal for PDP-11 and to hexadecimal for 8080), saving the original number base, which is later restored by { C; }. CODE also changes the vocabulary, which allows the same names to have different meanings in the assembler and in the rest of FORTH without confusion. Users can create their own vocabularies and subvocabularies to keep different application libraries separate.

Many FORTH programmers never need to write machine-language subroutines, so they do not need to use an assembler. FORTH assemblers have an unfamiliar postfix notation, but they have the advantage of giving immediate feedback. You know right away whether an operation works, with no wait for assembly passes, linking passes, and file handling. This interactive assembly greatly speeds program development and allows more thorough testing.

Listing 9 continued on page 122

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Listing 9 continued:

Collectively, { : } and CODE are called defining words *because they are used to create new FORTH words. There are several other such functions in FORTH, and users can also define their own types of defining words, creating new data types or operation types; see listing 10.*

```
CODE TERMINAL-OUT-2   ( CHAR -> .  TERMINAL OUTPUT HANDLER, PDP-11)  OK
   BEGIN,   177564 200 # BIT,   NE UNTIL,   ( WAIT TILL PORT READY)  OK
   $ )+ 177566 MOV,   ( POP FORTH STACK INTO DATA REGISTER)  OK
   NEXT,   ( A 2-INSTRUCTION MACRO TO CONTINUE FORTH EXECUTION)  OK
   C;   ( GET OUT OF THE FORTH ASSEMBLER)  OK
OCTAL  OK
: ASCII-TEST-2   ( -> .  PRINT ASCII CHARACTER SET)
   177 40   ( ASCII BLANK THROUGH '~')
   DO I TERMINAL-OUT-2 LOOP   ( OUTPUT THE CHARACTERS)
   ;  OK
DECIMAL  OK
ASCII-TEST-2  !"#$%&'()*+,-./0123456789:;<=>?@ABCDEFGHIJKLMNOPQRSTUVWXYZ[\]^_`ab
cdefghijklmnopqrstuvwxyz{|}~ OK
ASCII-TEST  !"#$%&'()*+,-./0123456789:;<=>?@ABCDEFGHIJKLMNOPQRSTUVWXYZ[\]^_`abcd
efghijklmnopqrstuvwxyz{|}~ OK
```

```
0 CONSTANT DEV ( DEVICE NO FOR NORTHSTAR DOS ) OK
200D CONSTANT COUT ( NORTHSTAR DOS CHAR OUT JUMP POINT ) OK
CODE TERMINAL-OUT-2 ( CHAR->. 8080 WITH NORTHSTAR DOS ) OK
   H POP ( CHARACTER IS ON STACK, POP TO HL ) OK
   B PUSH ( BC IS INSTRUCTION POINTER, SAVE IT ) OK
   L B MOV ( DOS EXPECTS CHAR IN B REGISTER ) OK
   DEV A MVI ( AND DEVICE NUMBER IN ACCUMULATOR ) OK
   COUT CALL  B POP  NEXT JMP  C; ( DO IT AND CONTINUE ) OK
```

Listing 10: *User-defined data types. Because this example is longer, it was not typed in directly like the others, but was stored on disk with an editor (the editor session is not shown here). This example is contained in two disk screens, each of which is a virtual block of 1024 bytes (see text). The commands { 58 LIST } and { 59 LIST } print these screens. The line numbers (0 thru 15) are not part of the program and are used only by the editor.*

This example creates table-lookup sine and cosine routines for integer-degree arguments. The results are accurate enough for most graphics applications, making this situation an example of the versatility of FORTH, even without floating-point routines.

The definition of TABLE creates a new data type. When TABLE is executed, it creates a new table of numbers taken from the stack; the number on top of the stack tells how many items there are in the table. In this case, { 91 TABLE SINTABLE } creates a table called SINTABLE with ninety-one entries; these entries are the values of the sine of 0° thru 90°, multiplied by 10,000 so that they can be expressed as integers. SINTABLE gives the sine (scaled by 10,000) of 0° thru 90° degrees; SIN does the same, except that its argument can be any number of degrees (from −32,768 to 32,767).

Incidentally, few FORTH programs use as much depth of stack as this one. The system used for listings 1 thru 7 limits the stack depth in order to use "page 0" memory for speed, so this example would have to be modified to run on it.

The <BUILDS ... DOES> construct, which creates the new data type, is one of the most advanced concepts of FORTH. Briefly, the <BUILDS part is executed when SINTABLE is defined; that is, it creates the table. The DOES> part defines what happens when SINTABLE is executed. Once TABLE has been defined, any number of tables of varying length can be declared using the word. Similar definitions can create special-purpose arrays such as word, byte, or bit arrays, user-defined record structures or other data objects, or user-defined classes of operations. [An excellent explanation of the words *<BUILDS* and *DOES>* is given in Kim Harris' article "FORTH Extensibility," also in this issue....GW]

```
OK
58 LIST
SCR # 58
  0 ( TRIG LOOKUP ROUTINES - WITH SINE *10000 TABLE)
  1 : TABLE  ( ... N -> .  CREATE 'TABLE' DATA TYPE.)
  2    <BUILDS 0 DO , LOOP   ( COMPILE N ELEMENTS)
  3    DOES> SWAP 2 * + @    ( EXECUTE TABLE LOOKUP)
  4    ;
```

Listing 10 continued on page 124

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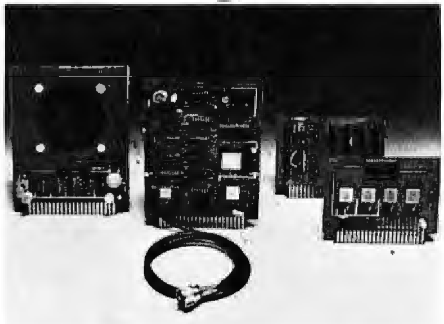

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Listing 10 continued

```
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 9848 9816 9781 9744 9703 9659 9613 9563 9511 9455
 9397 9336 9272 9205 9135 9063 8988 8910 8829 8746
 8660 8572 8480 8387 8290 8192 8090 7986 7880 7771
 7660 7547 7431 7314 7193 7071 6947 6820 6691 6561
 6428 6293 6157 6018 5878 5736 5592 5446 5299 5150
 5000 4848 4695 4540 4384 4226 4067 3907 3746 3584
 3420 3256 3090 2924 2756 2588 2419 2250 2079 1908
 1736 1564 1392 1219 1045 0872 0698 0523 0349 0175
 0000      ( 91 ELEMENTS OF TABLE PLACED ON STACK)
91 TABLE SINTABLE   ( RETURNS SINE, 0-90 DEGREES ONLY)
OK
```

```
SCR # 59
( SINE AND COSINE TABLE-LOOPUP ROUTINES)
: S180 ( N -> N .  RETURNS SINE, 0-180 DEGREES)
  DUP 90 >   ( IF GREATER THAN 90 DEGREES,)
  IF 180 SWAP - ENDIF    ( SUBTRACT FROM 180)
  SINTABLE   ( THEN TAKE SINE)
  ;
: SIN ( N -> SINE.  RETURN SINE OF ANY NUMBER OF DEGREES)
  360 MOD    ( BRING WITHIN + OR - 360)
  DUP 0< IF 360 + ENDIF   ( IF NEGATIVE, ADD 360)
  DUP 180 >   ( TEST IF GREATER THAN 180)
  IF 180 - S180 MINUS   ( IF SO, SUBTRACT 180, NEGATE SINE)
  ELSE S180 ENDIF   ( OTHERWISE, STRAIGHTFORWARD)
  ;
: COS ( N -> COSINE.)
  360 MOD   ( PREVENT OVERFLOW NEAR 32,767)
  90 + SIN ;    ( COSINE IS SINE WITH 90 DEGREES PHASE SHIFT)
OK
```

```
 OK
58 LOAD 59 LOAD  OK
0 SIN . 0  OK
0 COS . 10000  OK
90 SIN . 10000  OK
45 SIN . 7071  OK
1 SIN . 175  OK
361 SIN . 175  OK
1000 SIN . -9848  OK
10000 SIN . -9848  OK
10000 COS . 1736  OK
-25281 COS . 1564  OK
32767 SIN . 1219  OK
32767 COS . 9925  OK
-1 SIN . -175  OK
: SINSCALE   ( N DEGREES -> N .  SCALE BY SINE)
  SIN 10000 */   ( MULTIPLY, THEN DIVIDE; 32 BITS INTERMEDIATE)
  ;  OK
100 45 SINSCALE . 70  OK
10000 45 SINSCALE . 7071  OK
30000 -5 SINSCALE . -2616  OK
```

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The Netronics ASCII/BAUDOT Computer Terminal Kit is a microprocessor-controlled, stand alone keyboard/terminal requring 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.

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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—*

!"#$%&'()*+,-./0123456789:;<=>?
@ABCDEFGHIJKLMNOPQRSTUVWXYZ[\]^_
`abcdefghijklmnopqrstuvwxyz{|}~

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 $ # ( ) . , 9 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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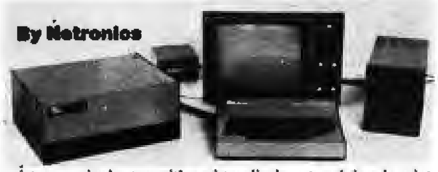
Level "A" at $129.95 is a complete operating system, perfect for beginners, hobbiests, or industrial controller use.

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

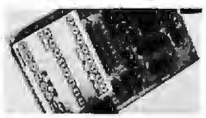
System Monitor (Terminal Version): 2k bytes of deluxe system monitor ROM located at F000 leaving 0000 free for user RAM/ROM. Features include tape load with labeling ...tape dump with labeling...examine/change contents of memory ...insert data...warm start...examine and change all registers...single step with register display at each break point, a debugging/training feature...go to execution address... move blocks of memory from one location to another...fill blocks of memory with a constant...display blocks of memory ...automatic baud rate selection...variable display line length control (1-255 characters/line)...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. Level "A" in the *Hex Version* makes a perfect controller for industrial applications and can be programmed using the Netronics Hex Keypad/Display.

By Netronics



Hex Keypad/Display Specifications



Hex Keypad/Display.

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.

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

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Explorer/85 with Level "C" card cage.

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).

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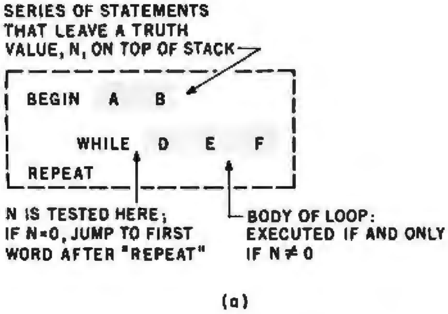

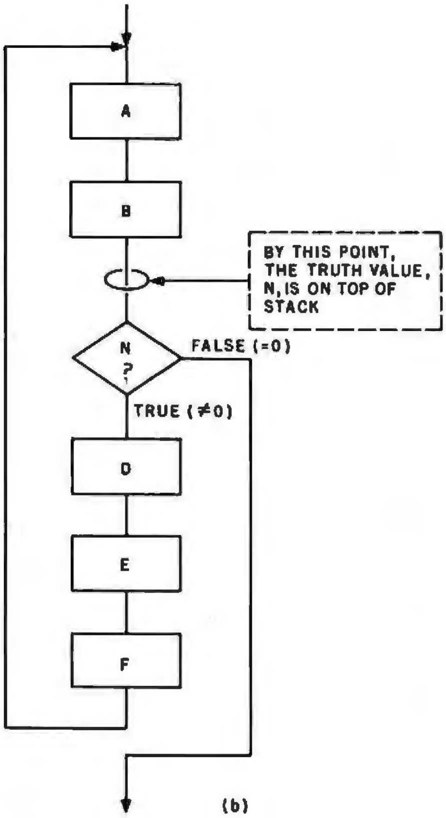

Figure 5: *An explanation of the BEGIN ... WHILE ... REPEAT construct. As shown in figure 5a, the FORTH words between BEGIN and WHILE perform operations that leave a truth value, N, on top of the stack. The value of N determines whether the body of the loop (the words between WHILE and REPEAT) is performed or not. The loop repeats until N evaluates to false (N=0). Figure 5b gives the equivalent construct in conventional flowchart notation.*

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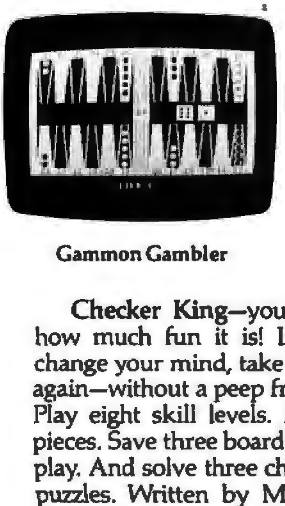

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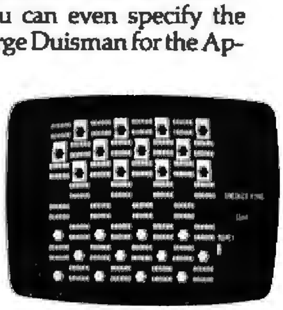

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Text continued from page 10:

You should also look at FORTH if you have limited computer or financial resources. FORTH is a *big* language in a *small* package, and you can buy a version of FORTH for as little as $20.(See "Selected FORTH Vendors," on page 98.) Unlike most new languages that gobble up more and more of the 64 K bytes allotted to an 8-bit microcomputer (some won't comfortably fit in 64 K bytes), there is plenty of room for very large FORTH programs even in a 16 K machine. FORTH takes up only about 8 K bytes, and this can be pared down; in an industrial application that will run only one program, the FORTH interpreter can be made as small as 800 bytes. Also, FORTH can be run on cassette-based systems due to its small size; although this is still more inconvenient than running FORTH on a disk system, most languages that use a disk are impractical or impossible on cassette-only systems.

Finally, you may want to consider FORTH for applications where speed is of the utmost importance. Since portions (or all) of a FORTH program can be written in the assembly language of the host computer, FORTH programs can be written that compare favorably in speed with machine-language programs. And, again, productivity is higher using FORTH than it is with machine language.

What *Is* a Threaded Language?

Imagine a language that starts with a few fundamental subroutines written in the machine language of the host computer; eg: routines to put a character to the display device, to get a character from the keyboard, to multipy two fixed-point numbers. Then imagine that the only way to combine these subroutines is to string them together (with embedded data bytes) as a series of subroutine calls; eg: a routine to get a signed multidigit number from the keyboard is written as a controlled series of calls to the subroutine that gets a character. Then *these* routines are called by other routines that perform even bigger tasks. For example, a routine to sum a series of signed numbers entered from the keyboard is written as series of subroutine calls that includes the one mentioned just above. The final program in such a *threaded language* is a series of calls to lower and lower subroutines, dipping repeatedly into machine-language routines under the control of higher-level routines. The addresses in each subroutine that point to the subroutine or machine language under it make up a "thread" of control that runs through the entire program.

FORTH has so far been implemented as a threaded language. *Threadedness is a language implementation technique, not an inherent quality of any language;* SNOBOL and FORTRAN compilers have been written using threaded code.

Special Notation Used in This Issue

Because FORTH is such an unusual language (it uses punctuation marks by themselves and within words), a pair of braces, { } , *is sometimes used to set apart FORTH words from the rest of the text. Braces are used under the following conditions:*

- *When the material being quoted is a series of FORTH words; eg:* { 26 LOAD } ;
- *When the FORTH word is or contains any of the following punctuation marks: period, comma, colon, question mark, exclamation point, single quote mark, or double quote mark. Two examples are* { . } *and* { (") }.

In addition, spaces are always used to separate FORTH words from other words or punctuation—even when this means doing something like "...the words BEGIN , WHILE , and REPEAT are all..." (spaces between FORTH words and the commas that follow them). There are two reasons for doing this: first, for clarity; and second, to emphasize that the FORTH word in question does not include the punctuation that follows. Some FORTH words do contain punctuation (eg: { IF, }*), but such words will always be enclosed in braces (except within program listings).*

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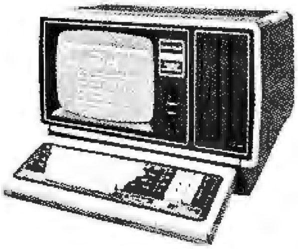

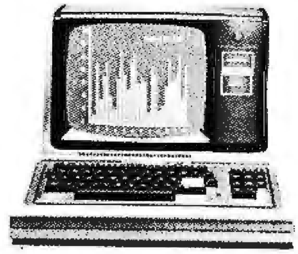

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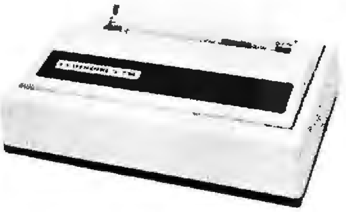

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FORTH: Pro and Con

Pros: I have already mentioned most of the advantages of FORTH. The language is:

- Compact;
- Fast, although this is due to its implementation in threaded code, not its inherent qualities;
- Structured: it has the major constructs of structured programming and, in fact, does not have any kind of *goto* statement, thus forcing it to be structured;
- Extensible;
- Highly portable.

These last two features deserve further description. The *extensibility* of FORTH is probably its most important feature. Never before in a high-level language has it been so easy to add new features, new data types, and new operators to a language. Unlike other languages, these new words (everything in FORTH is called a *word*) have the same priority and receive the same treatment as words defined in the standard FORTH vocabulary. For example, you can define a word 10+ that will add ten to any number it is given; or, in fact, you can even redefine the addition operator + . You can also define entirely new families of words in FORTH. This advanced topic is ably discussed in what I believe is the only written treatment of the subject *anywhere* in FORTH literature by Kim Harris in his article, "FORTH Extensibility," on page 164.

Most FORTH programs can be transferred from, say, a mainframe computer to a microcomputer without modification; therefore, FORTH is *highly portable*. Most of the FORTH words supplied in a given system have been defined to do the same operation regardless of the computer used. Although the vocabulary of words varies from supplier to supplier, most FORTH programs will run with minor or no modifications. A standard set of words, called FORTH-79, collectively developed by many of the major suppliers and users of FORTH, will help in this situation.

Cons: Here are some of the disadvantages of FORTH:

- FORTH code is hard to read. This is probably the most common complaint against the language. As a new user, I can say that you slowly get used to the odd syntax of the language. The stack architecture (see below) of the language contributes to the novice's initial disorientation, but this feeling is usually blamed on the unreadability of the language. In addition, the stack architecture encourages the storage of working values on the stack rather than in variables with names. Variable names, if chosen properly, give vital clues to the workings of a program; this scarcity of variable names makes most FORTH programs less readable. Adequate indentation and comments can help a FORTH program, but programmers of FORTH, like programmers of all other languages, often omit these aids to comprehension.
- The stack architecture of FORTH offers disadvantages as well as advantages. Remember the odd feeling you got the first time you used a Hewlett-Packard calculator and had to punch in " 5 ENTER 3 + " instead of the more understandable " 5 + 3 = " ? FORTH uses the same *reverse Polish notation* (abbreviated RPN), where the objects being entered come *before* the operators that work on them.

Not only does this take some getting used to (it takes even longer before you can fluently "think in FORTH"), it also encourages a scarcity of named variables, as mentioned above. In addition, stack-manipulating words like SWAP, DUP (for duplicating the top entry on the stack), ROT (for rotating the top three items on the stack), and others muddle the FORTH program and make it hard to tell just what variable is being operated on. This uncertainty is particularly evident during debugging; most of your time is spent finding out why what you *thought* was on the stack isn't there.

- FORTH encourages programming "tricks" in place of plain, easier to read programming. Although the examples to support this statement have already been mentioned, I think the statement as a generality is true. We must remember that, especially since lack of memory is usually *not* a problem in FORTH, FORTH programmers should name appropriate variables and, in general, worry less about fitting a program on one screen (a basic unit of FORTH program-

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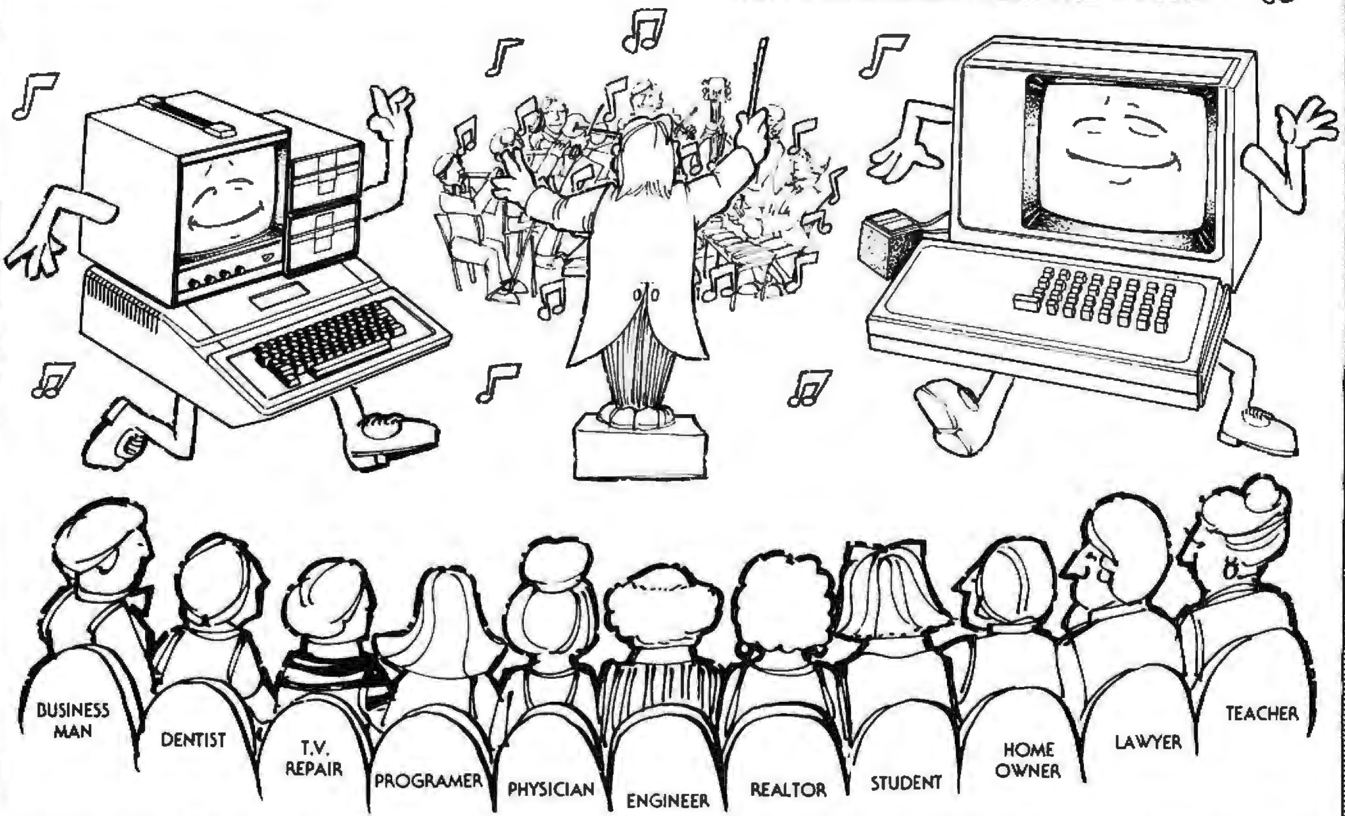

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ALL PRICES CASH DISCOUNTED   FREIGHT FOB/FACTORY   ASK FOR OUR FREE CATALOGUE ming) and more about making it readable.

However, drawing a comparison to APL, *any* language that compresses a lot of program into a small number of lines suffers from readability problems. Broad, powerful algorithms often represent complex processes; when they are described in a terse notation, they look like programming tricks. In this case, the only remedy is to use a lot of comments. The lack of such comments is solely the fault of the programmer, not of the computer language.

- FORTH lacks many of the programming constructs we are used to—strings, arrays, floating-point numbers—but that's not the whole story. Many applications, for example, can get by without floating-point numbers: look at the number of programs written in Integer BASIC for the Apple II. With a maximum absolute numeric value of 32,767, normal FORTH can handle many problems by simply assuming a decimal point. In addition, all versions of FORTH can *add* all these features and more, simply by defining new words. For example, MMSFORTH, a version of FORTH for the TRS-80 by Miller Microcomputer Services, has over ten screens (each *screen* is 16 lines of source code) that implement their version of words for double-precision math, arrays, strings, random numbers, and TRS-80 graphics. You compile a series of screens, thus adding to the size of your resident FORTH interpreter, *only if you need these features*. So you *can* have all these programming constructs and tools, but only if you write them yourself or get somebody else to write them for you.

Friends of FORTH

Almost everyone who is working in FORTH professionally is doing good work, but a few people or groups of people deserve special mention. Foremost in this group is Charles H Moore and, through him, the company FORTH Inc. Moore developed the language over a long period of time (see his article "The Evolution of FORTH, an Unusual Language," on page 76) and promoted it through his company FORTH Inc. Elizabeth Rather, who contributed significantly to the development of the language and who is vice-president at FORTH Inc, should also be mentioned in this context.

Then there is the FORTH Interest Group (POB 1105, San Carlos CA 94070), without whose efforts low-cost versions of FORTH would not be available. Although many people in the group have contributed to its working, names that must be mentioned are Bill Ragsdale (coordinator), Dave Boulton, Kim Harris, John James, and George Maverick. Over the past two years, this group has collectively raised its membership from a few dozen people in northern California to over a thousand members worldwide. In the process, they have also publicized FORTH at numerous conventions and have distributed public-domain versions of FORTH (called fig-FORTH) for all the major microprocessors; ie: 8080, 6800, 6502, 9900, PACE, and LSI-11. Although they supply only listings and documentation, versions customized for various popular microcomputers are available inexpensively. In addition, they are working on standardizing certain extensions to FORTH (floating-point numbers, arrays, etc), and they publish a very professional-looking bimonthly magazine called *FORTH Dimensions*. The group has monthly meetings at the Liberty House Department Store in Hayward, California, on (what else?) the fourth Saturday of each month. Membership in the FORTH Interest Group (which includes a subscription to its magazine) is $12 per year, $15 overseas.

A final group that must be mentioned is Miller Microcomputer Services of Natick, Massachusetts, which sells and supports a version of FORTH, called MMSFORTH, and other related FORTH products for the Radio Shack TRS-80 Model I. Not only do they provide a fine version of FORTH with arrays, strings, graphics, and other extensions, they are the only microcomputer-FORTH vendor that supports its product with both information and new vocabularies of FORTH words. (For example, they have a set of FORTH words that add 6- and 15-digit floating-point arithmetic, complex numbers, and a full Z80 assembler, all for $29.95.) They also publish an *MMSFORTH Newsletter* that always has some

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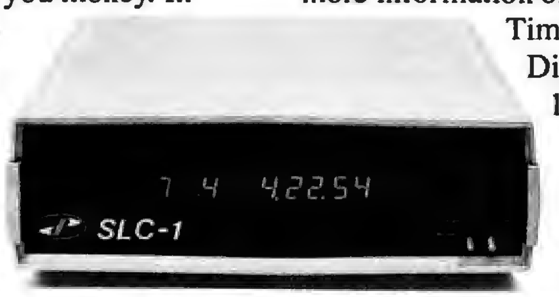

GET INTO THE TIME MACHINE.

DIGITAL PATHWAYS

goodies you'd expect to pay money for. The people at MMSFORTH are A Richard (Dick) Miller and Judy Miller, along with free-lance programmer Tom Dowling, who wrote MMSFORTH for the TRS-80.

In addition, the major vendors of FORTH should be commended for the way they have worked and are working together to help standardize the language. The people mentioned above, along with the European FORTH Users' Group (EFUG), have met as the International FORTH Standards Team to work out a standard set of FORTH words (with standard behavior) that can be used to increase the already high portability of FORTH programs. Once the proposed FORTH-79 standard is approved by this standards team, FORTH Inc, the FORTH Interest Group, and Miller Microcomputer Services have indicated that they will bring out new FORTH versions conforming to this standard.

Variants of FORTH

A few other FORTH-like languages should be mentioned here. URTH (University of Rochester THreaded language) is simply FORTH by another name. I am told that CONVERS, an experimental language that was offered by the Digital Group, is a FORTH-like language.

STOIC is a language that is different from FORTH primarily in some small syntax rules, although its enthusiasts claim it is more powerful than FORTH. From reading the documentation, I have found that STOIC interacts differently and has more sophisticated disk access than FORTH. CP/M Users Group (1651 Third Ave, New York NY 10028) distributes STOIC on two 8-inch single-density CP/M floppy disks; the cost is $20, which includes postage, documentation (on CP/M DOC files), and group membership fees. STOIC was developed by Roger G Mark and Stephen K Burns in the Biomedical Engineering Center for Clinical Instrumentation, funded by the Harvard-MIT Program in Health Sciences and Technology in Cambridge, Massachusetts.

Also, I am very excited about a book nearing publication: *Threaded Interpretive Languages* by Ron Loeliger. This book, to be published soon by BYTE Books, delves deeper into the practical aspects of designing and implementing a threaded language than any book I have seen. Not only does it demonstrate exactly how the machine code must work, it also details the specific implementation of ZIP (which looks like FORTH under another name) in Z80 assembly language. The book promises to be *the* definitive work on how threaded languages perform.

Final Notes

As we received more and more FORTH articles, I realized that we would soon have too many for this special August issue. I immediately scheduled for subsequent nontheme issues those extra articles we could not use at this time, a process known as "holding down the FORTH." In any case, we have several FORTH articles that will appear in upcoming issues of BYTE. These include an article on recursion in FORTH by George Flammer, a tutorial on string-manipulating FORTH words by John Cassady, a history of the FORTH Standards Team by Bill Ragsdale, and a detailed discussion of the different kinds of threaded codes by Terry Ritter and Gregory Walker.

We hope you will enjoy looking at the FORTH tapestry presented in this issue. ■

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- READ & WRITE • REPEAT . . . UNTIL • more

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- programs • tax records • mailing lists

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Encode/Decode I provides a level of security suitable for normal use. Encode/Decode II provides enhanced security for the most demanding needs. Both versions come supplied on discette and with a complete user manual.

Encode/Decode I: $50.00

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- send files • receive files

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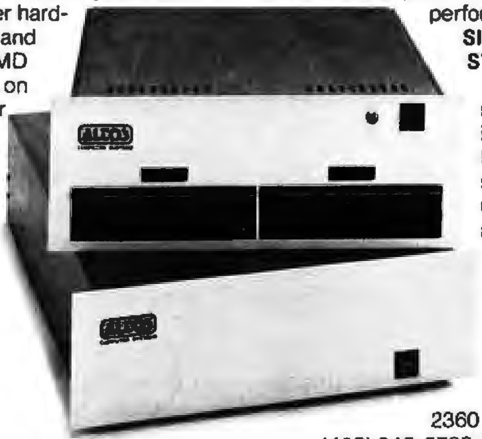

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	BASF Systems Bedford MA	Corvus Systems, Inc. San Jose CA	IBM Corporation General Systems Div	International Memories Inc (IMI) Cupertino CA
Model	6171/6172	11T	4963 29A/64A	7710/7720
Unformatted Capacity (millions of bytes)	8/24	11	29/64	11/20
Platter Size	210mm (8.27 inch)	200mm (7.87 inch)	210mm (8.27 inch)	200mm (7.87 inch)
Number of Platters	1 or 2	2	3 or 6	2
Average Access Time	42 ms	50 ms	27 ms	50 ms
Maximum Data Transfer Rate (K bytes per second)	800	648	1030	648
Average Latency	8.3 ms	8.3 ms	9.7 ms	8.3 ms
Rotational Speed	3600 rpm	3600 rpm	approx. 3100 rpm	3600 rpm
Motor Type	brushless DC	brushless DC	—	brushless DC
Spindle Drive	direct drive	direct drive	—	direct drive
Actuator Type	linear voice coil	linear voice coil	rotary voice coil	linear voice coil
Positioning Mechanism	servo	servo	servo	servo
Density bpi	6542	5868	8530	5868/6000
Density tpi	500	300	450	300
Physical Size (inches)	4.59 by 8.99 by 18	5.5 by 8.57 by 19.25	—	5.5 by 8.57 by 19.25
Weight (pounds)	20	22	—	22
Single Quantity Price	—/$3,100[1]	$5,350[2]	approx. $9,300/$10,700	$2,990/$3,590
OEM Discount Price	Competitive OEM discounts available	—	—	$1,900/$2,290 (100)
Cost Per Thousand Bytes (OEM Discount)	—/—	—	—	$.173/$.112
Comments	Available with integrated SMD interface @$3,500 and integrated controller with host bus interface for $3,900; all prices quoted are for 24 megabyte Model 6172. 1. Includes disk bus interface	Up to 4 drives per subsystem. Add-on drives @$2,990. Uses IMI 7710 drive. 2. Complete subsystem	Integrated into System/34. Add-on peripheral for Series 1.	Optional integrated controller available @$500 (quantity 1); $325 (quantity 100). Power supply @$250

Text continued from page 70:

- hardware-oriented control and status

The main characteristics for the host level are:

- *parallel* data transfer
- formatting/de-formatting included in drive electronics
- function-oriented control and status by functional command like read/write sector and format

Device-level interfaces can be divided into four groups:

- ANSI
- ANSI-like
- SMD
- Floppy-disk-like

The *ANSI interface*, as far as it is currently defined, will use a single 50-conductor flat cable. Up to four drives can be connected in a daisy-chain configuration. Differential drivers and receivers will be used only for block and data signals for read and write functions. All other lines will use standard TTL (transistor-transistor logic) signals. Control commands and status information will be transferred over an 8-bit-wide bidirectional bus. The bus control lines use an asynchronous handshake mechanism, allowing simple adaptation of the bus speed to any microprocessor. Data is transferred in serial NRZ (nonreturn-to-zero) format separated from the clock signal.

In the *ANSI-like* interface, most of the current device-level interfaces are more or less similar to the ANSI interface. Common to all are an 8-bit parallel control bus and serial NRZ data transfer.

SMD (storage module drive) *interface* is a *de facto* industry standard for 14-inch drives and is being adapted for 14-inch drives by ANSI. It has also been implemented for 8-inch drives. The SMD interface uses differential drivers and receivers for all signals. (They give excellent performance as regards high speed, long cable lengths, and high noise immunity.) The drives are connected through

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7000	MSC-8000	1201-I/1202-I/1203-I	D8000	2050/3450
4/12/20	40	9/27/45	20	20/34
210mm (8.27 inch)	8 inch	200mm (7.87 inch)	210mm (8.27 inch)	8 inch
1, 2, or 3	3	1, 2, or 3	2	2 or 3
50 ms	25 ms	42 ms	50 ms	50 ms
—	1200	922	870	1030
8.3 ms	—	8.3 ms	—	6.4 ms
3600 rpm	—	3600 rpm	—	4700 rpm
AC	—	brushless DC	—	brushless DC
belt drive	—	direct drive	—	direct drive
rotary	—	rotary voice coil	—	linear voice coil
servo	—	servo	servo	servo
5280	—	8626	6000	6370
300	—	478	476	480
5.25 by 8.5 by 16.5	—	4.62 by 8.55 by 14.25	4.62 by 8.55 by 14.25	4.62 by 8.55 by 14.25
20	—	22	—	20
\$2,100/\$2,300/\$2,650	—	\$1,962/\$2,591/\$3,007	\$3,000	\$3,000/\$3,750
\$1,680/\$1,840/\$2,120(100)	—	—	\$1,800	\$2,200/\$2,750(100)
\$.42/\$.153/\$.106	—	—	\$.09	\$.11/\$.08
	Included in package is an 80 megabyte, ½ inch magnetic-tape drive on the same motor spindle for removable back-up storage	Available with integrated controller as Models: 1221-I \$2,834; 1222-I \$3,463; 1223-I \$3,879, single quantities		

Table 4: *Specifications and characteristics of high-end, 8-inch hard-disk drives.*

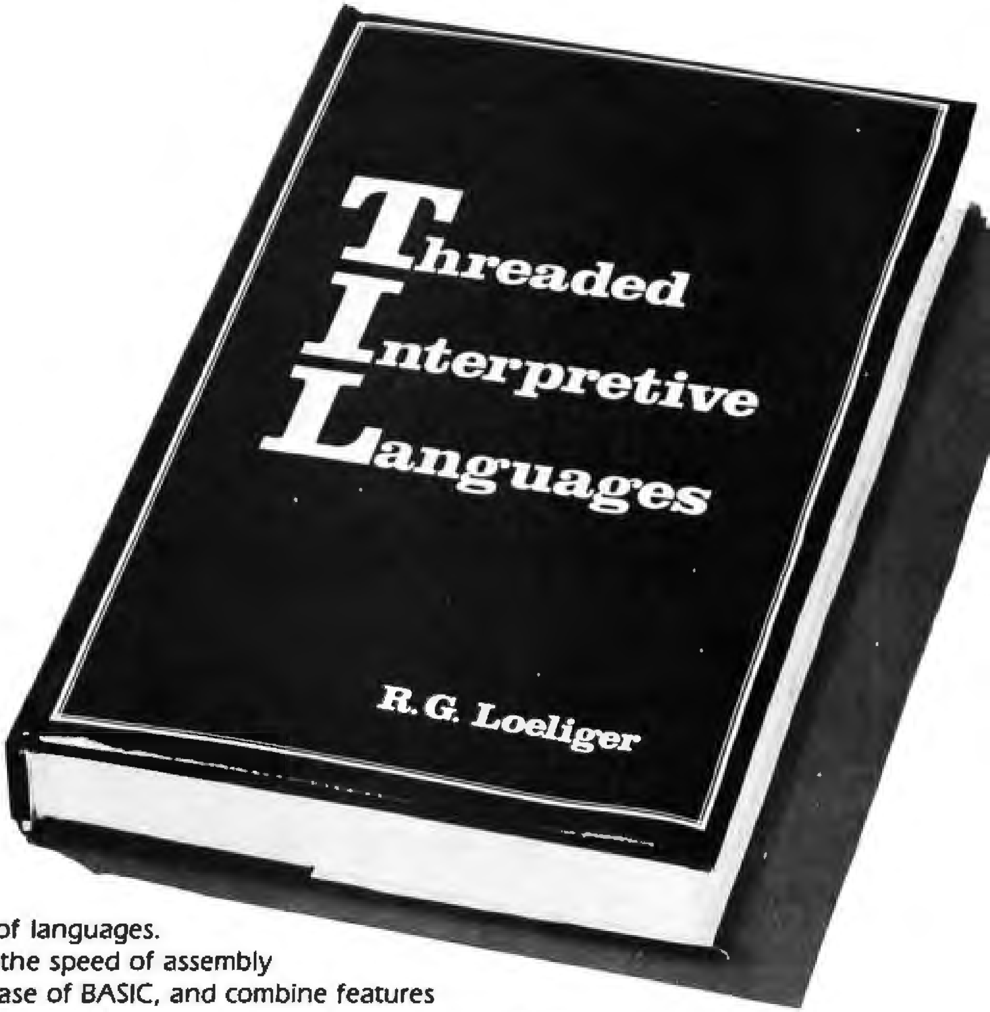
one daisy-chain cable for control and one radial cable for read/write and additional control. Control information is transferred on a 10-bit-wide unidirectional synchronous bus. Data is transferred in serial NRZ format.

The SMD interface allows very high transfer rates and long cable lengths. Because SMD uses differential drivers and receivers for all signals, it is somewhat more costly than other interfaces using TTL circuits. Because of the 10-bit synchronous bus structure, SMD is not easy to interface to current 8-bit processors. The main advantage of SMD for 8-inch drives is that it is a standard, and controllers are readily *available* for easy integration into existing or currently supplied systems.

Having a *floppy-disk-like interface* for 8-inch hard disks allows the combination of floppy-disk drives and hard-disk drives in one system. Because of the differences in transfer rates and other parameters, floppy- and hard-disk drives are not fully interface-compatible. Hard-disk users must add a radial cable for differential read/write signals in addition to the normally used daisy-chain cable. By adding 15% to 20% more circuitry, a hard-disk controller can be designed to also control floppy-disk drives. However, a floppy-disk controller cannot handle a Winchester-type hard-disk drive.

In comparing floppy-disk-like interfaces with other device-level interfaces, there are three major differences. First, with floppy-disk-like interfaces there is no control bus because commands and status signals are transferred on discrete lines. Second, positioning control is achieved with step and direction signals as opposed to the transfer of a parallel-cylinder address with other interfaces. Third, data is transferred in the raw format as recorded on the disk. This implies that synchronization, separation (or generation) of clock and data, and generation and detection of sector and address marks must all be performed externally to the drive. The floppy-disk-like concept minimizes drive electronics, but puts the burden of developing and producing the balance of the required electronics on the user.

Anatomy of a Threaded Language



Threaded languages (such as FORTH) are an exciting new class of languages. They are compact and fast, giving the speed of assembly language with the programming ease of BASIC, and combine features found in no other programming languages. An increasing number of people are using them, but few know much about how they work. Is a threaded language interpreted or compiled? How much memory overhead does it require? Just what is an "inner interpreter"? **Threaded Interpretive Languages,** by R. G. Loeliger, concentrates on the development of an interactive, extensible language with specific routines for the ZILOG Z80 microprocessor. With the core interpreter, assembler, and data type defining words covered in the text, it is possible to design and implement programs for almost any application imaginable. Since the language itself is highly segmented into very short routines, it is easy to design equivalent routines for different processors and produce an equivalent threaded interpretive language for other development systems. If you are interested in learning how to write better FORTH programs or you want to design your own powerful, but low-cost, threaded language specific to your needs, this book is for you.

McGraw-Hill

This and other BYTE/McGraw-Hill books are available from BYTE Books or your local computer store.

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Law Office Systems Aspects of Word Processing, Bernard Sternin, 2 pm, Oct. 30.
Future Smart Machines: 2000 A.D. and Beyond, Dr. Earl Joseph, Sperry Univac, 2pm, Oct. 30.
Computer Contracts - Facing the Issues, Alan C. Verbit, Verbit & Co., 3 pm, Oct. 30.
Acc'ts Receivable/Acc'ts Payable/Gen'l Ledger, 3pm, Oct. 30.
Advantages of Distributed Processing & Multi-Processing, John Steele, QI Corp., 4 pm, Oct. 31.
Investment Analysis of Stocks & Commodities on a Microcomputer, Fred Cohen, Shearson Loeb Rhodes, Inc., 4 pm, Oct. 30, 3 pm, Oct. 31.
BASIC Programming, Michael Mulcahey, Worcester State College, noon, Oct.31.
Videoprints: Full-Color, Low-Cost, Hard-Copy Computer Graphics, Warren Sullivan, Image Resource Corp., 1pm, Oct. 31.
Business Applications Software Development Via Data Base Management, Dr. Andrew Whinston, Micro Data Base Systems, 2 pm, Oct. 31.
Application of PASCAL to Small Systems for Business, Panel, Stan Veit, Associated Computer Ind., Moderator, 3 pm, Oct. 31.
Educational Software: the Good, the Bad, the Ugly, Jo Ann Comito, S.U.N.Y. at Stony Brook, noon, Nov. 1.
Introduction to Personal Computing, noon, Nov. 1.
Computer-Assisted Mathematics Courses, Dr. Frank Scalzo, Queensborough Community College, 1 pm, Nov. 1.
Artificial Intelligence Update, Prof. Peter Kugel, Boston College, 1 pm, Nov. 1.
Compiling and Retrieving Personal Medical Data with a Microcomputer, Derek Enlander, MD, St. Luke's Hospital, 2 pm, Nov. 1.
The Present State of CP/M Compatible Software, Tony Gold, Lifeboat Associates, 2 pm, Nov. 1.
High Volume Data Handling: Intro. to File Processing, Prof. Peter Kugel, Boston College, 3 pm, Nov. 1.
Connecting the Computer to the Outside World, Prof. James Gips, Boston College, 3 pm, Nov. 1.
Educational Applications in the Home, David Ahl, Creative Computing Magazine, 4 pm, Nov. 1.
Household Applications - Some of Them New, Dr. Dennis J. McGuire, 4 pm, Nov. 1.

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	Century Data Systems Anaheim CA	Century Data Systems Anaheim CA	Fujitsu America Inc Santa Clara CA
Model	Marksman M-10/M-20/M-30	Hunter H-32/H-64/H-96	M2282/M2283/M2284
Unformatted Capacity (millions of bytes)	10/20/30	34/67/100	66/133/166
Platter Size (inches)	14	14	14
Number of Platters	1, 2, or 4	2, 3, or 4	—
Average Access Time	60 ms[1]	30 ms	27 ms
Maximum Data Transfer Rate (K bytes per second)	960	1209	1012
Average Latency	12.5 ms	8.3 ms	10.12 ms
Rotational Speed	2400 rpm	3600 rpm	3000 rpm
Motor Type	—	—	—
Spindle Drive	—	—	—
Acutator Type	band	—	rotary
Positioning Mechanism	stepper motor	servo	servo
Density bpi	—	—	6475
Density tpi	—	—	668
Physical Size (inches)	8 by 16.5 by 21.5	10.5 by 17.5 by 30	10.3 by 18.9 by 26.6
Weight (pounds)	45	175	100
Single Quantity Price	—	—	$4,350/$5,200/$5,500
OEM Discount Price	—	—	$3,450/$4,300/$4,600 (quantity 100)
Cost Per Thousand Bytes (OEM Discount)	—	—	$.052/$.033/$.028
Comments	Winchester Technology	16.7 megabytes of removable storage on each model (5440 Type)	Optional 655 K byte fixed head storage for $700

[1] includes settling time

Host-Level Interface

A typical implementation for host-level interface is the BASF 6170 series drive with integral formatter/controller. The BASF host bus interface uses a single daisy-chain cable that can connect one or more units to the host adapter. Transfer of data, command, and status information is done across one common 8-bit-wide bidirectional asynchronous bus. The eight bus lines, as well as additional lines for bus control and interrupt generation, all use standard TTL drivers and receivers. Using a host-level interface is the easiest and fastest way to interface an 8-inch Winchester drive to a given host system.

How Intelligent Should a Controller Be?

With the decreasing cost of microprocessors and memories, the trend is toward the use of intelligent subsystems to handle all I/O-related functions, rather than tying up the processor.

These subsystems can communicate with the main system through a high-level command language (eg: one that is file-oriented as opposed to hardware-oriented). Functions such as automatic backup, automatic error recovery, power-on bootstrap loading, etc, can be completely controlled locally in the subsystem, thus taking the burden off the main processor and improving the system's performance.

Further improvement can be gained by adding hardware and software for such things as double-buffering for data transfer, overlapped operation in a multiple drive configuration, and RPS (rotational-positioning sensing) for access optimization.

There is a limit to the transparency of the disk system to the operating system. If a disk with higher packing density is substituted, the number of sectors on each track or the number of tracks per surface will likely be different. This information must be communicated to the operating system. (With luck, this is a small parameter change in the I/O driver of a well-designed, modular operating system). But, however easy or difficult it is to change, it must be done to take full advantage of the new higher-capacity drive.

The Question of Backup for Fixed Disks

The usefulness of removable media on fixed-disk-based systems arises from three needs:

- system backup for crash/fault recovery
- program and data-base dissemination
- archival storage of information

The excellent reliability record of Winchester-technology disks is caus-

Fujitsu America Inc Santa Clara CA	Kennedy Co Altadena CA	Priam San Jose CA	Shugart Associates Sunnyvale CA
M2201/M2211	5300	3350/6650/15450	SA4000
50/83	14/42/70	33/66/154	14.5/29
14	14	14	14
2 or 3	1, 2, or 3	1	1
30 ms	70 ms	50 ms	87 ms
819	—	1030	—
12.5 ms	10 ms	9.7 ms	—
2400 rpm	3000 rpm	approx. 3100 rpm	—
—	AC	brushless DC	—
—	—	direct drive	—
linear motor	rotary	linear voice coil	band
servo	servo	servo	stepper motor
6135	6000	6370	5534
370	300	480/960/—	172
10.3 by 19 by 30.2	7 by 19 by 22	6.8 by 16.6 by 20	—
150	75	33	—
\$5,400/\$7,200	\$3,200/\$3,700/\$4,200	—	—
\$3,900/\$4,990 (quantity 100)	\$2,560/\$2,960/\$3,360 (quantity 100)	\$1,800/—/—	—
\$.078/\$.060	\$.183/\$.07/\$.048	\$.055/—/—	—
Front-loading cartridge removable storage	Winchester Technology	Winchester Technology	Winchester Technology

Table 5: *Specifications and characteristics of 14-inch, hard-disk drives.*

ing some system builders and users to take a fresh look at backup requirements for data storage. They are concluding that, for *some* applications, it is no longer necessary to include removable media for backup protection in systems design.

Error-correcting capabilities of system software and intelligent controllers help to eliminate the need for backup in some cases. However, there will probably always be applications—perhaps the majority—in which backup cannot be eliminated. Many systems require removable media for program and data-base dissemination and/or archival storage in addition to any backup considerations. Therefore, it seems that there will be a continuing need for removable-media storage peripherals on some fixed-disk-based systems.

According to many small-system designers and users, system backup is needed regardless of the *hardware* reliability of the fixed-storage subsystem. System crashes or failures can be caused by software bugs and human error as well as by hardware faults.

Until the new wave of small Winchester disks came on the scene beginning about a year and a half ago, the small-systems hard-disk market was being served primarily by products based on IBM 5440-type removable-cartridge disk technology. Most of these products have the unique characteristic of having 50% of their spindle capacity removable—in other words, they have built-in backup. But the major drawbacks to their use in small systems are relatively low performance (70 ms average access time); relatively high cost per byte; large physical size; and high maintenance costs that get higher as field engineering labor costs grow. Even with the introduction of cost-effective, small, reliable Winchester-type products, these 5440-based products still have a place in some small systems. After all, the backup problem is solved, whereas no generally accepted backup method has yet emerged for the "mini Winnies" to make most customers feel comfortable. It is a problem yet to be solved.

Several approaches are being tried for backup. There are floppy disks, tape cassettes, tape cartridges, reel-to-reel tape drives, and, in at least one case, videocassettes.

The ideal characteristics of a backup device are:

- The cost of the modular removable medium should be low (less than \$20).
- The cost of the transport device should be low.
- The data-transfer rate should be similar to the transfer rate of the disk.
- A single removable module should hold more, or at least as

Error Rates

Recoverable	Unrecoverable	Seek Errors
1 in 10^{10} bits	1 in 10^{12} bits to 1 in 10^{13} bits	1 in 10^{6} seeks to 1 in 10^{7} seeks

Maintainability

Preventive Maintenance	(MTBF) (Mean Time Between Failures) (sealed modules)	(MTBF) (Mean Time Between Failures) (product)	(MTTR) (Mean Time to Repair)	Component Life
None	25,000 hours	8000 to 10,000* POH (power-on hours)	½ to 1 hr	5 years

* Exception: Kennedy 7000 Series, 1500 hours

Table 6: *Reliability data for hard-disk drives.*

much, data as the fixed disk, preferably an integer multiple of the disk capacity (ie: a 100-megabyte videocassette to back up a 20-megabyte disk).

With the relatively unsophisticated operating-system software present in many small systems today (though this is rapidly changing), the backup strategy is usually to write the entire contents of the disk to a removable backup medium on a daily basis. This procedure results in a significant loss in system availability (while dumping or restoring) unless the backup device has a fast transfer rate and a large capacity.

Perhaps the most appropriate backup for a small Winchester is a device that can be included in the same package, sharing the same spindle drive mechanism and/or some of the same electronics. For the low end this may be a floppy disk; for the high end it can be a cartridge tape drive or a streaming reel-to-reel tape drive. But, except for the very low end where system cost is a prime consideration, a small-capacity, slow floppy disk is not an ideal backup for a large, fast, fixed disk. Streaming tape drives may be good backup devices for high-performance, high-capacity hard disks, but they are too expensive for most personal computer systems. Nevertheless, some streaming tape drives are becoming available. Kennedy Company of Monrovia, California, is delivering (60 to 90 days) its Model 6809 Data Streamer. It is a microprocessor-controlled reel-to-reel (10.5-inch reels) tape transport with formatter for reading, writing, and controlling the 9-track, 100 ips (inches per second), 1600 character per inch, ANSI- and IBM-compatible half-inch tape drive. It has an unformatted capacity of 46 megabytes per reel. It can transfer 12 megabytes in 75 seconds and 40 megabytes in 250 seconds. It costs about $2500 in OEM quantities. Data Electronics Inc (DEI), of Pasadena, California, is marketing a 34-megabyte streaming microtape cartridge drive for $1219 (OEM quantities). Cypher Data Products Inc of San Diego, California, produces a 37-megabyte streaming reel-to-reel tape drive for under $2000 (OEM quantities). IBM's answer to the backup problem for its 8-inch disk drive is the model 8809 streaming tape drive.

The Products and the Companies

The specifications in tables 3, 4, and 5 speak for themselves. There are a few special features of some of these products worth mentioning. BASF Systems of Bedford, Massachusetts (whose parent corporation, the BASF Group based in Germany, invented magnetic recording tape in 1934), established a Memory Division in early 1979 to manufacture computer-disk drives. Their first product is the 6170 Series 210 mm Fixed-Disk Drives available in 8- and 24-megabyte versions. The 24-megabyte version with the integrated, microprogrammed BASF host-bus interface and controller at $3900 (single quantity price, substantial discounts available for OEM quantitites) is a cost-effective, high-performance source of reliable data storage for small systems. BASF offers a variety of interfaces. BASF is also a supplier of disk and tape media.

Century Data Systems, a Xerox Company, of Anaheim, California, offers a wide range of disk products for small systems including the 14-inch Marksman model (Winchester technology) with capacities from 10 to 30 megabytes, and the Hunter model with a removable 16.7-megabyte 5440-type cartridge, plus fixed-disk capacity ranging from 16.7 to 83.9 megabytes. Century Data Systems is a long-time manufacturer of computer peripherals. Corvus Systems Inc, San Jose, California, is offering a complete hard-disk subsystem based on the IMI 7710 10-megabyte 8-inch disk. It includes the Z80-based Corvus intelligent disk controller with comprehensive diagnostics and interfaces for TRS-80, Apple II, S-100-bus, and LSI-11 computers. As mentioned above, Corvus also markets a 100-megabyte removable backup in the form of an interface to a standard videocassette recorder using the microprocessor and interface bus of the Corvus disk subsystem. IMI was the first manufacturer to deliver a high-performance 8-inch Winchester drive.

Memorex Corporation of Santa Clara, California, is introducing its first in a planned family of 8-inch hard-disk products, the Model 101. It offers low cost per megabyte, low weight (10 pounds), low power requirements (56 W), and high reliability. With 11.7 megabytes and 70 ms access time, it is a good example of a product in the low-end segment of the small hard-disk-drive market. Memorex has been manufacturing disk drives since 1967 and has been a major supplier of magnetic media since the company was formed in 1961. The MSC-8000 from Microcomputer Systems Corporation of Sunnyvale, California, is an 8-inch disk drive with built-in removable backup in the form of an 80-megabyte half-inch tape drive on the same motor spindle. Micropolis Corporation, of Chatsworth, California, is offering the largest capacity (now available) 8-inch Winchester disk, the Model 1203-I, with 45 megabytes on five surfaces. The density is high (8626 bpi, 478 tpi), the access time fast (42 ms), and the price reasonable. It is another good example of a high-capacity, high-performance 8-inch disk in the high-end segment. New World Computer Company Inc, of Costa Mesa, California, is making an unconventional, miniature hard disk, the Mikro-Disc 211. It is a cross between a high-performance, one-head-per-track disk and a cost-effective moving head mini-Winchester drive. It is small, light (8 pounds), and very fast (18.825 ms access time). It has relatively low capacity (2.1 megabytes) but makes up for it in performance, price (less than $1000 in large OEM quantities), size (9½ inch by 9½ inch), weight, and power requirements (less than 50 W). In the words of company president, Phil Haines, "It's a little screamer." The Mikro-Disc 211 is a versatile storage system suitable for a variety of uses: it can efficiently augment or replace floppy-disk drives, supplement other larger and slower mass-storage devices by acting as a high-speed cache memory, improve system response time by providing fast-access key-directory storage, and be the primary file device in small systems. It has an assembly with twenty proprietary low-cost heads that write and read data onto 0.008-inch-wide tracks. The head assembly is moved only seven 0.010-inch steps (eight positions) across the disk. Each step is accomplished in 5 ms, precisely and accurately, by a low-cost open-loop stepper motor.

The Model 3450 from Priam, San Jose, California, is another example in the high-end segment, along with BASF and Micropolis. It has 34 megabytes on five surfaces, fast transfer rate (1.02 megabytes per second), and high density (6370 bpi, 480 tpi). It is a state-of-the-art product at a reasonable price. The Shugart Associates SA1000-series drives are another example of the low-end segment along with the Memorex 101 with 5- and 11-megabyte models.

Shugart Technology of Scotts Valley, California (a new company *not* connected with Shugart Associates or Xerox) has just announced its Model ST506 5-inch 6-megabyte Winchester disk drive. It is the size of a 5-inch floppy drive and weighs only 3.5 pounds — 6 megabytes of reliable Winchester disk storage in the palm of your hand for $925 (OEM quantity 500)! In the popular parlance, this is a hot little product for the small computer system. Evaluation units are scheduled to be available this month and production quantities by next month.

The latest in disk drives for small systems are these 8-inch and 5-inch wonders. The hard disks are upon us, and they're taking personal computing forward by a giant step.■

Directory of Hard-Disk Manufacturers

BASF Systems
OEM Peripheral Sales
Crosby Dr
Bedford MA 01730
(617) 271-4000

Century Data Systems Inc
A Xerox Company
1270 North Kraemer Blvd
Anaheim CA 92806
(714) 632-7500

Corvus Systems Inc
900 S Winchester Blvd
San Jose CA 95128
(408) 246-0461

Fujitsu America Inc
2945 Oakmead Village Ct
Santa Clara CA 95051
(408) 985-2300

International Memories Inc
10381 Bandley Dr
Cupertino CA 95014
(408) 446-9779

Kennedy Company
1600 South Shamrock Ave
Monrovia CA 91016
(213) 357-8831

Memorex Corporation
Recording Components Div
San Tomas and Central Expys
Santa Clara CA 95052
(408) 987-1000

Microcomputer Systems Corporation
432 Lakeside Dr
Sunnyvale CA 94086
(408) 733-4200

Micropolis Corporation
21329 Nordhoff St
Chatsworth CA 91311
(213) 709-3300

New World Computer Company Inc
3176 Pullman St, Suite 119
Costa Mesa CA 92626
(714) 556-9320

Pertec Computer Corporation
Peripherals Div
9610 De Soto Ave
Chatsworth CA 91311
(213) 999-2020

Priam
3096 Orchard Dr
San Jose CA 95134
(408) 946-4600

Shugart Associates
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Sunnyvale CA 94086
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The CBM 8050 Dual Drive Floppy Disk is an enhanced version of the intelligent CBM 2040 Disk Drive. The CBM 8050 has all of the features of the CBM 2040, and provides more powerful software capabilities, as well as nearly one megabyte of online storage capacity. The CBM 8050 supplies relative record files and automatic diskette initialization. It can copy all the files from one diskette to another without copying unused space. The CBM 8050 also offers improved error recovery and the ability to append to sequential files.

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- Two microprocessors
- 974K Bytes storage on two 5.25" diskettes (ss)
- Tracks 70
- Sectors 17-21
- Soft sector format
- IEEE-488 interface
- Combination power (green) and error (red) indicator lights
- Drive Activity indicator lights
- Disk Operating System Firmware (12K ROM)
- Disk Buffer (4K RAM)

FIRMWARE

- DOS version 2.0
- Sequential file manipulation
- Sequential user files
- Relative record files
- Append to sequential files
- Improved error recovery
- Automatic diskette initialization
- Automatic directory search
- Command parser for syntax validation
- Program load and save

CBM	PRODUCT DESCRIPTION	PRICE
2001-8KN	8K RAM-Graphics Keyboard	$ 795.00
2001-16KN	16KN RAM-Graphics Keyboard	$ 995.00
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Editor's Note

We are particularly pleased to include this article by Dick and Jill Miller in this FORTH theme issue. One of the problems with past BYTE language issues has been the lack of concrete examples of the language being showcased—namely, a full, nontrivial program that does something useful or fun and, at the same time, shows an example of the language at its best.

The program BREAKFORTH, written for the MMSFORTH language running on the Radio Shack TRS-80, does show the language FORTH at its best. This real-time video game, which is a version of the arcade-type game that requires the user to chip away at a "brick wall" by directing a bouncing ball at it with a paddle, is what Dick Miller calls "electronic flypaper"—a game so addictive that it keeps people trapped at their TRS-80, unable to stop playing.

In addition to being playable (quite a testament to the speed of FORTH, especially if you have ever seen the same game written in TRS-80 BASIC), the game also gives an example of how a good FORTH program is put together, as well as how it can be more readable when properly written out with adequate indentation and comments.

Another departure from previous language issues is the availability of the language FORTH at reasonable cost on a wide range of microcomputers (see chart of FORTH sources, elsewhere in this issue). Miller Microcomputer Services (MMS) supplies one of the most complete and well-supported versions of FORTH available, along with a newsletter and other FORTH products available at reasonable prices. (For example, MMS sells a FORTH software package that adds floating-point arithmetic (both single- and double-precision), complex arithmetic, and a full *Z80 assembler, all on floppy disk for $29.95.)*

This article was produced with the help of two other people not yet mentioned. The first is Tom Dowling, who wrote the MMSFORTH language for the TRS-80 and who does a large portion of the FORTH programming for MMS. The second person is Arnold Schaeffer, who wrote the BREAKFORTH program as his first FORTH program. If this achievement were not impressive enough, then I should add that Arnold is a high school student. This is proof that FORTH can be learned by anyone with sufficient enthusiasm for the language.

Analyzing the BREAKFORTH program is a great way to learn about FORTH and how to program in it. The program can be typed in as is on a TRS-80 using MMSFORTH's full-screen editor and virtual memory, but I suggest that you first read John James' article in this issue, "What Is FORTH? A Tutorial Introduction," before seriously studying the BREAKFORTH program.

*One final note on alteration: this program is meant to work on a TRS-80 Model I running MMSFORTH. Users of other FORTH systems having a graphic display of 48 by 128 resolution or better can probably get the program running by rewriting some words unfamiliar to their system. Some information designed to help in this conversion effort has been supplied in this article....*GW

BREAKFORTH Into FORTH!

A Richard Miller and Jill Miller
Miller Microcomputer Services
61 Lake Shore Rd
Natick MA 01760

About the Authors

A Richard (Dick) and Jill Miller founded Miller Microcomputer Services in 1977 as a consulting firm specializing in support for the Radio Shack TRS-80. After continued dissatisfaction with other languages available for the TRS-80 (FORTRAN, COBOL, Pascal, PILOT, BASIC), they settled on FORTH as a language that combines the seemingly incompatible traits of language complexity, high operating speed, and low memory overhead. They released their first version of MMSFORTH (version 1.5) in June 1979, and have been improving disk and cassette versions of the system ever since. MMSFORTH resembles the FORTH Inc version of the language called microFORTH, and was written independently with permission from that company.

Introduction to BREAKFORTH

This BREAKFORTH program was created by Arnold Schaeffer. The program, which was purchased by MMS, has received minor modifications and is now included with the purchase of MMSFORTH version 1.9 (on a different range of blocks from those shown here, blocks 69 thru 74). We think it is a classic game as is, and fully expect individuals to modify it in accord with their game preferences—for their individual use.

The BREAKFORTH program is a straightforward one, although it is not a trivial one. It combines many of the techniques of FORTH and can be followed easily with a little time and study. Figure 1 shows a typical BREAKFORTH video display, with an operator-controlled game paddle at the bottom, a bouncing ball, and a barrier to be knocked out one brick at a time by successive bounces until all the bricks have been cleared away. Each removed brick scores one point or more depending on its level, and there is a surprise bonus for a completely cleared barrier. Ball speed and number of balls are selectable, but be warned that, as you bounce your way up to the higher layers, the ball speed increases! You might want to start with short games using five balls and

a ball speed of seven. Fifty balls and a speed of four will present a challenge for high scorers.

BREAKFORTH offers some other features, too. As you and your friends try for better scores, a BEST score is kept to challenge your present effort. In addition, the paddle adds backspin in certain cases that we will leave you to discover.

To add sound, plug an external speaker into the EAR jack of your cassette tape recorder, attach the middle cable from the keyboard unit (not the motor remote cable) to the AUX jack of the tape recorder, and open the tape compartment door. While depressing the write-protect detector switch at the left side of the back of this compartment, simultaneously press the Record and Play keys. This procedure allows the cassette tape recorder to be used as an amplifier. The BREAKFORTH program manipulates the cassette port (normally used for writing a program to tape), causing a sound to be amplified by the recorder and played on the speaker.

Like other brands of electronic flypaper, BREAKFORTH may keep you glued to the keyboard. If you have to leave but do not want to give up the game, press shift-@ to pause the game. Pressing any other key will cause the game to resume where you left off. To start a new game in midstream while keeping the BEST score, press the Break key, type in the word BREAKFORTH , and press the Enter (Return) key.

BREAKFORTH is developed in the FORTH manner, with top-down design and bottom-up programming.

BREAKFORTH is developed in the FORTH manner, with top-down design and bottom-up programming. Figure 2 shows the organization of the program. These modules shown in figure 2, along with the various 1-byte and single-precision (2-byte) variables and constants they invoke, are listed with explanations in table 1, a directory of the BREAKFORTH words that this program will add to the FORTH vocabulary.

The program's source code is on six consecutive blocks, and in this case happens to be located on blocks 50 thru 55; see listing 1. In MMSFORTH, one enters { 50 6 LOADS } to load the program—that is, to compile and execute all the information on blocks 50 thru 55, ending with the immediate execution of the word BREAKFORTH from line 15 of block 55 (which causes the program to be run). (Other versions of FORTH that lack the consecutive-blocks word, LOADS , will have another way of doing this.)

The First Block

Let us take a detailed look at block 50 in listing 1. Lines 0 thru 2 are all comment lines, as are any words surrounded by parentheses. Notice that because FORTH words are set off by spaces on either side, the "begin comment" word, { (} , must be separated from the first word of the comment by at least one space. (Because of the way { (} is defined, the closing parenthesis need not be separated from the last word of the comment by a space.)

Most definitions in FORTH begin with a colon ({ : }) and end with a semicolon ({ ; }), where the first word after the colon is the word being defined. In line 3, the first word defined is TASK . Since the only word following TASK is the closing semicolon, we can conclude that the word TASK does not do much. However, it does serve as a "bookmark," marking the beginning of the words and variables that are specific to this application (game). We will come back to TASK later, at the end of block 55.

Line 3 also causes two other blocks on the MMSFORTH system disk to be loaded into memory. Block 32, when loaded, adds several special-purpose words having to do with random numbers: RANDOMIZE and RND . Block 33, when loaded, adds several words that have to do with graphics: DCLR , DSET , { D? } , ECLR , ESET , and { E? } . (The last three are the same as TRS-80 BASIC words RESET, SET, and POINT, and the variables beginning with D are the same, but referencing double-width characters.)

Lines 4 thru 6 initialize seven double-byte variables and two single-byte (CVARIABLE) variables. In FORTH, unless specified, all variables, constants, and stack entries are 16 bits (2 bytes) long. See table 1 for the meaning of these variables.

Line 7 defines a new word, LINE , using a colon to begin the definition and a semicolon to end it. Several spaces (usually three) are placed be-

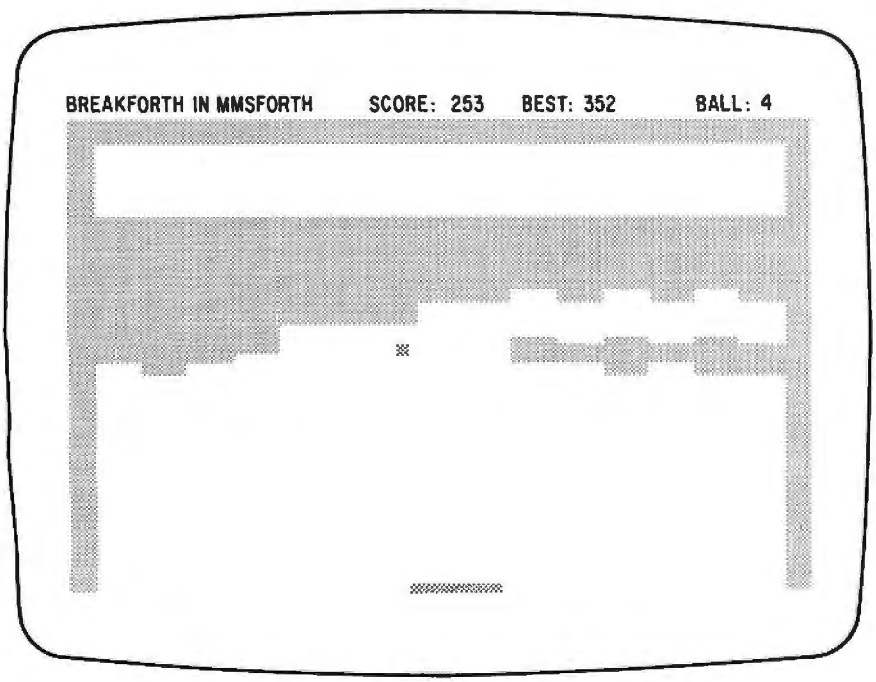

Figure 1: *One view of the TRS-80 video screen during a BREAKFORTH game.*

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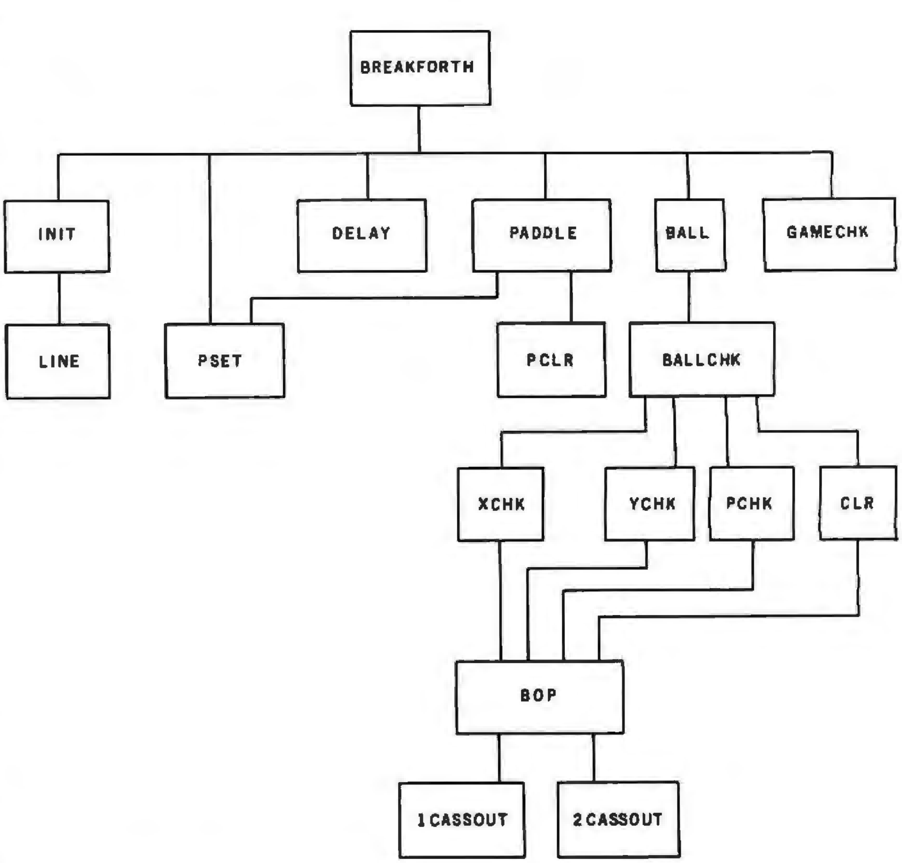

Figure 2: *A hierarchical diagram of the BREAKFORTH program. Each box contains a word used within the BREAKFORTH program and is used by the word(s) in the box(es) above it. See table 1 for a definition of each word.*

tween the word being defined and the first word of the definition; this adds to the clarity of the definition. PTC (for "put cursor") places the cursor at a given point on the screen, much like the PRINT@ instruction in TRS-80 BASIC. It expects two numbers on the stack, the row (second-to-top) and the column (on top) giving the desired position for the cursor. (For example, [8 32 PTC] puts the cursor near the center of the screen, 8 rows from the top and 32 characters from the left edge of the screen.)

However, our new word LINE expects only one number on the stack because the first thing it does when it is called is to put a zero on top of the stack. So the words [0 PTC] put the cursor at the beginning of a given line (that is, at position (x,0), where x is the number on top of the stack when LINE is called).

The FORTH word ECHO (EMIT in some other versions of FORTH) is like the PRINT CHR$ function in BASIC—it outputs the corresponding ASCII character for the number. In this case, [30 ECHO] outputs a clear-to-the-end-of-the-line signal on the TRS-80. (By the way, the 30 is the decimal number thirty; although you can change to hexadecimal with the word HEX or to any other numeric base, MMSFORTH assumes decimal numbers unless told otherwise.)

Now we are finally able to say what the word LINE does: the phrase [x LINE] clears line x and leaves the cursor at row x, column 0. [0 PTC] puts the cursor at the beginning of the line, and [30 ECHO] clears the line with a special character (ASCII decimal 30) and leaves the cursor where it is.

The final word described in block 50, INIT , begins in line 8. Its definition is longer than most words, but its function is not at all mysterious once you know a few FORTH words. CLS clears the video screen (as in TRS-80 BASIC), [0 LINE] clears line zero, and ["] ([".] in some FORTHs) causes the character string until the next quote mark to be printed, just as PRINT " *STRING* " does in BASIC. The word #IN causes a single-

Text continued on page 158

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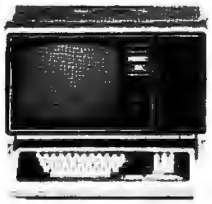

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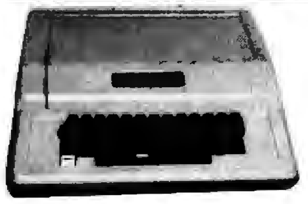

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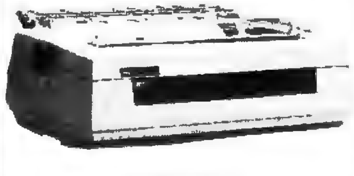

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Listing 1: *The BREAKFORTH program. These six blocks, when loaded into an MMSFORTH system, cause the BREAKFORTH program to compile, execute, and, once finished, erase itself from the system. Tape-based users should omit the last three words in the last block. This program does require that the MMSFORTH words for random numbers (block 32 on the MMSFORTH system disk or cassette) and for TRS-80 graphics (block 33) be available to the FORTH system. If these blocks have already been loaded, delete the two LOAD commands in block 50, line 3. Also, the sequence* [*A MVI 255*] *in lines 10 and 11 of block 51 is the notation FORTH uses for the 8080 assembly-language statement MVI A,255.* [To speed up paddle response, you can replace the 3 in block 55, line 8 with a higher value. Personally, I enjoy playing the game at speed level 1, with a 12 replacing the 3....**GW**]

```
BLOCK : 50

 0 ( BREAKFORTH/MMSFORTH, BY ARNOLD SCHAEFFER, PART 1 OF 6        )
 1 (    COPYRIGHT 1980 BY MILLER MICROCOMPUTER SERVICES           )
 2 (  W/SOUND - USE THE LEFT AND RIGHT ARROWS TO MOVE THE PADDLE  )
 3   : TASK ; 32 LOAD ( RANDOM #'S ) 33 LOAD ( GRAPHICS ) RANDOMIZE
 4   0 CVARIABLE SPEED  0 CVARIABLE SPVAR  0  VARIABLE SCORE
 5   0  VARIABLE XPOS   0  VARIABLE YPOS   2  VARIABLE PPOS
 6   1  VARIABLE YDIR   1  VARIABLE XDIR   0  VARIABLE BEST
 7 : LINE  0 PTC 30 ECHO ;
 8 : INIT  CLS 0 LINE " SPEED ( 1 - 10, 1 IS FASTEST )"
 9         #IN 1 MAX 10 MIN 10 U* SPEED C!
10         0 LINE " NUMBER OF BALLS DESIRED"   #IN
11         CLS  64 0 DO 3 I DSET 4 I DSET LOOP
12         48 3 DO I 0 DSET I 63 DSET I 1 DSET I 62 DSET LOOP
13         191 15616 320 FILL   0 SCORE !
14         0 LINE " BREAKFORTH IN MMSFORTH    SCORE: 0     BEST:"
15         BEST ?    0 54 PTC " BALL:"  ;


BLOCK : 51

 0 ( BREAKFORTH/MMSFORTH, BY ARNOLD SCHAEFFER, PART 2 OF 6 )
 1
 2 : PCLR   32 PPOS @ 16320 + 8 FILL ;
 3 : PSET  176 PPOS @ 16320 + 8 FILL ;
 4
 5 : PADDLE
 6   14400 C@ 32 = IF PCLR -1 PPOS @ +  2 MAX PPOS ! PSET THEN
 7   14400 C@ 64 = IF PCLR  1 PPOS @ + 54 MIN PPOS ! PSET THEN
 8 ;
 9
10 CODE 1CASSOUT   1 A MVI 255 OUT NEXT    ( THESE 3 LINES      )
11 CODE 2CASSOUT   2 A MVI 255 OUT NEXT    ( PRODUCE THE SOUND. )
12 : BOP   10 0 DO  1CASSOUT  2CASSOUT  LOOP ;
13
14
15


BLOCK : 52

 0 ( BREAKFORTH/MMSFORTH, BY ARNOLD SCHAEFFER, PART 3 OF 6 )
 1
 2 : XCHK
 3   XPOS @  2 < IF XDIR @ MINUS XDIR !  2 XPOS !  BOP THEN
 4   XPOS @ 61 > IF XDIR @ MINUS XDIR ! 61 XPOS !  BOP THEN
 5 ;
 6
 7 : YCHK
 8   YPOS @  5 < IF 1 YDIR !  5 YPOS !  1 SPVAR C!  BOP  THEN
 9   YPOS @ 23 < IF SPVAR C@ 4 MIN SPVAR C!  THEN
10   YPOS @ 19 < IF SPVAR C@ 3 MIN SPVAR C!  THEN
11   YPOS @ 15 < IF SPVAR C@ 2 MIN SPVAR C!  THEN
12 ;
13
14
15

BLOCK : 53

 0 ( BREAKFORTH/MMSFORTH, BY ARNOLD SCHAEFFER, PART 4 OF 6 )
 1
```

Listing 1 continued on page 158

Text continued from page 154:

precision number to be entered from the keyboard and placed on top of the stack. The phrase [1 MAX] causes the number to be replaced by 1 if the number just entered is smaller. Similarly, the phrase [10 MIN] limits the number on the top of the stack to a maximum value of 10. [10 U*] multiplies the number by 10 (U* is an unsigned single-precision multiply), and [SPEED C!] stores the value from the top of the stack in the single-byte variable SPEED .

Each of the above phrases contains a number and an operation. Since each operation requires two numbers on the stack, the number entered by #IN is the first number, with the second number always being supplied by the first word of the phrase.

Using the same words as listed above, line 10 again clears line 0, prompts for the number of balls to be used in the game, putting that number on top of the stack with the word #IN .

Line 11 clears the video screen again and sets up the back (top) wall of the BREAKFORTH "court" using a do-loop and double-width graphics. In FORTH, the parameters of the loop go on the stack before the loop is called, so [64 0 DO] begins the loop, and the word LOOP ends it. The loop will be executed sixty-four times, and the word I puts on top-of-stack the current value of the loop (0, 1, 2, 3, ... ,63); note that I does not take on the limit value of 64. The phrase [3 I DSET] sets a double-width character at row 3, (double-width) column I; similarly, [4 I DSET] sets the double-width character on the next row below the first.

Similarly, line 11 sets the right and left walls of the BREAKFORTH court, columns 0 and 1 for the left wall and columns 63 and 64 for the right wall.

The phrase [191 15616 320 FILL] in line 13 creates the initial wall of bricks by using character code decimal 191 (a whited-out character cell) to fill an area of *memory* (the video display area of the TRS-80) starting at location 15616 and filling for a total of 320 bytes.

The phrase [0 SCORE !] , also in line 13, shows us how we store a

Listing 1 continued:

```
 2 2 CONSTANT 2   -2 CONSTANT -2
 3
 4 : PCHK  0  YPOS @ 47 >=
 5   IF 46 YPOS !  XPOS @ PPOS @ - DUP 0 >= OVER 8 < AND
 6      IF  -1 YDIR !   BOP
 7         NCASE 0 1 2 3 4 5 6 7 " -2 -1 -1 -1 1 1 1 2 CASEND
 8         XDIR !
 9      ELSE DROP 1+
10      THEN
11   THEN
12 ;
13
14
15
```

```
BLOCK : 54

 0 ( BREAKFORTH/MMSFORTH, BY ARNOLD SCHAEFFER, PART 5 OF 6 )
 1
 2 : CLR
 3   XPOS @ 2 - 124 AND 2+ DUP 4 + SWAP DO YPOS @ I DCLR LOOP
 4   YPOS @ 27 - ABS SCORE +!  0 32 PTC SCORE ?   BOP
 5   YDIR @ MINUS YDIR !
 6 ;
 7
 8 : BALLCHK  YDIR @ YPOS +!  XDIR @ XPOS +!  XCHK  YCHK  PCHK
 9            YPOS @ XPOS @ D? IF  CLR  THEN
10 ;
11
12 : BALL  YPOS @ XPOS @ DCLR
13        BALLCHK  DUP 0= IF  YPOS @ XPOS @ DSET  THEN  ;
14
15 : GAMECHK  SCORE @ 1800 MOD 0= IF  191 15616 320 FILL  THEN  ;
```

```
BLOCK : 55

 0 ( BREAKFORTH/MMSFORTH, BY ARNOLD SCHAEFFER, PART 6 OF 6 )
 1 : DELAY SPEED C@ SPVAR C@ U* 0 DO LOOP ;
 2 : BREAKFORTH
 3   BEGIN INIT 0    PSET
 4      DO  2000 SPEED C@ / 0 DO  DELAY  PADDLE  LOOP
 5          0 60 PTC  I 1+ .    5 SPVAR C!
 6          2 RND 1 = IF 1 ELSE -1 THEN  XDIR !   1 YDIR !
 7          58 RND 2+ XPOS !  29 YPOS !
 8          BEGIN  3 0 DO PADDLE LOOP
 9             BALL  GAMECHK  DELAY
10          END
11      LOOP    SCORE @  BEST @  MAX BEST !
12      8 18 PTC "  RUN GAME AGAIN "    Y/N
13   END
14 ;
15 BREAKFORTH   FORGET TASK DIR
```

value (0) in a variable (SCORE) by using the *store* operator [!] . Two points should be mentioned here. First, executing a variable name (like SCORE) causes the *address* of the variable, *not* its value, to be pushed onto the top of the stack. Second, the *store* operator [!] requires the value to be the second-to-top item in the stack and the address of the variable receiving the new value to be the top item in the stack.

The words in line 14 clear line 0 and print a message on the same line, setting the score to zero but leaving the cursor just after the colon that ends the message.

In line 15, the phrase [BEST ?] causes the value of BEST to be displayed on the screen, and the rest of line 15 completes the message that is shown on line 0 of the screen. Finally, the semicolon on line 15 ends the definition of INIT begun on line 8.

The Middle Blocks

Whew, that was a lot of explaining! Now you see why FORTH is not very easy for beginners to read—you are packing a lot of work into a small space, using an ever-more-specialized

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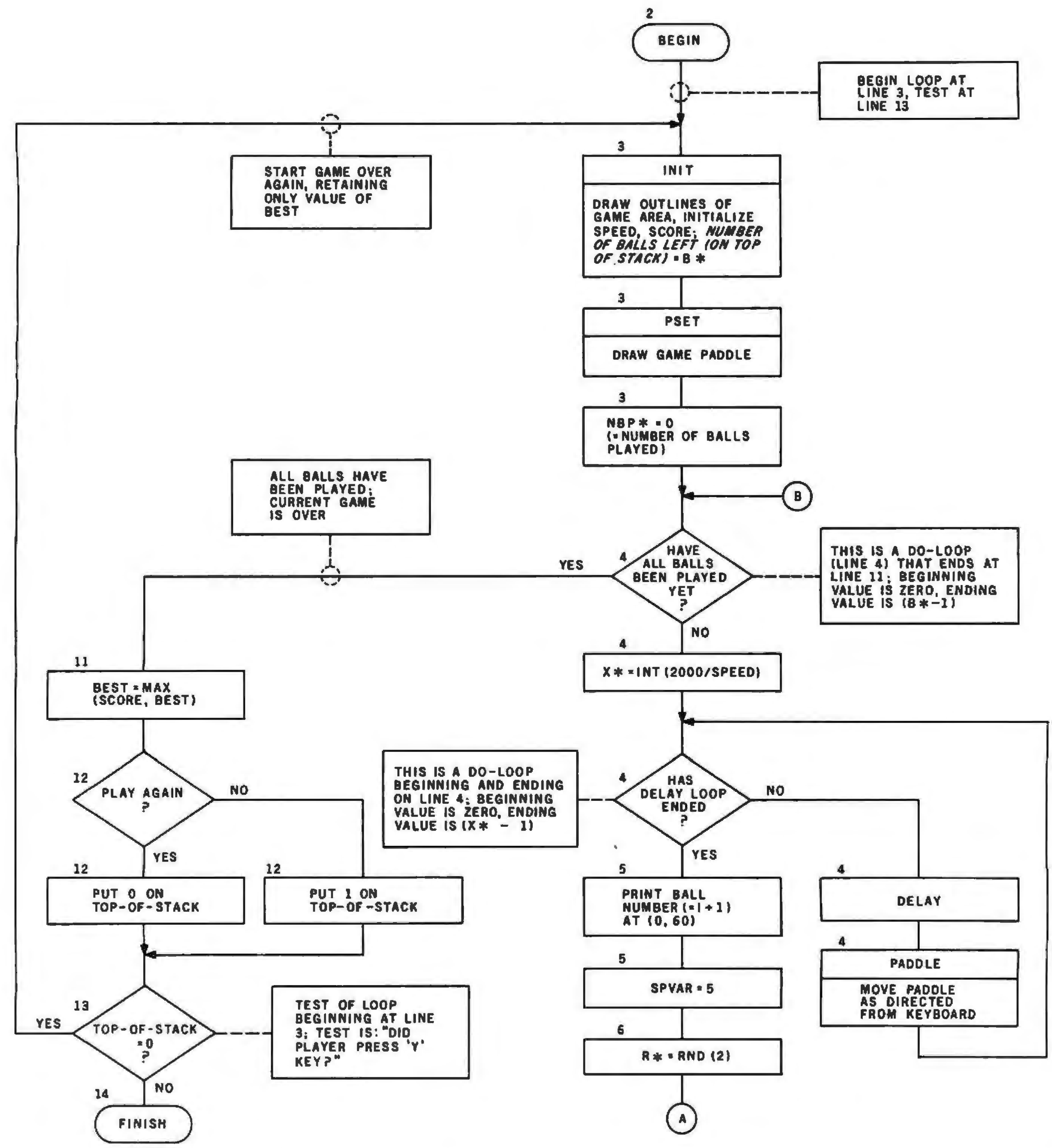
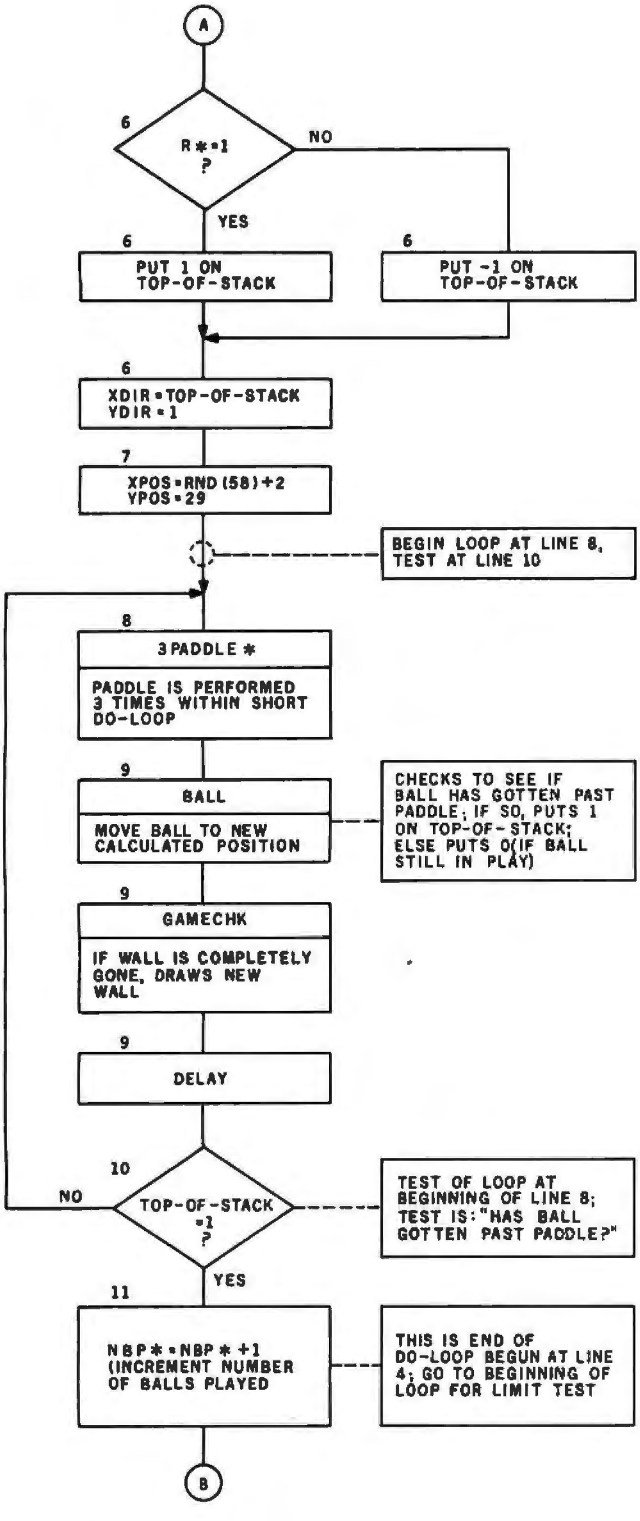


Figure 3: *A flowchart for the BREAKFORTH program (given in listing 1, block 55). The number above each box is the line number within block 55 that performs the action of the box. Many calculations in FORTH are done on the stack and do not acquire variable names. Because of this, an asterisk in a variable or procedure name (eg: X*, 3PADDLE*) denotes that the name was given only in this flowchart to add clarity.*

instruction set. Experience with reading and writing FORTH code makes the process easier, but spacing, indentation, use of descriptive word names, and lots of comments are always helpful. A surprise to the BASIC user: none of these source-code editing improvements use any extra programmable memory space.

Table 1 explains much of what the words in blocks 51 thru 54 do, but let us look at some of the interesting features contained in these lines of FORTH code.

When the ten-to-twenty times speed increase of FORTH over BASIC is not enough (or when we want to do things that cannot be done with existing FORTH words), we can redefine some FORTH words in the assembly language of the computer



(in the case of the TRS-80, 8080 or Z80 assembly language). When we want a FORTH word (program) to run faster, usually a short assembly-language definition of the word that gets used the most will speed things up sufficiently. Lines 10 and 11 of block 51 are the only two words used in BREAKFORTH that are defined in 8080 assembly language. (MMSFORTH comes with a compact 8080 assembler built in, like many Z80-based FORTHs. A *full* Z80 assembler also is available from MMS at a modest price.)

Inspection of lines 10 and 11 of block 51 shows that assembly-language definitions begin with the word CODE (instead of { : }) and end with the word NEXT (instead of { ; }). Here, FORTH's 8080 assembler is used to define a new type of word to output to a port. Both 1CASSOUT and 2CASSOUT drive the cassette recorder port (I/O port 255 on the TRS-80), and the word BOP executes both these words in a do-loop ten times to create a short square-wave sound on the external speaker.

The definition of PCHK ("paddle check" of ball location) in block 53 uses two more constructs. There are two *if* constructs, the inner one beginning in line 6 and ending in line 10, the outer beginning in line 5 and ending in line 11. (Notice that only the inner loop uses the optional *else* clause, as in line 9.) The second construct is a numeric *case* construct, NCASE ; as shown in line 7. When NCASE is executed, it expects the number on top of the stack to be one of the numbers listed between NCASE and the double quote marks (here, zero thru seven). The value found causes the execution of the corresponding FORTH action word in the series of apparent numbers between the double quote mark and the word CASEND. (Numbers are words but are not in FORTH's dictionary—when they are "executed," they are pushed on top of the stack. MMSFORTH case statements require their action words to be words in the FORTH dictionary and not numeric literals, so in block 53, line 2, 2 and −2 are defined as constants (FORTH words). 1 and −1 are already defined as constants by standard FORTH. Taking { 2 CONSTANT 2} as an example, the first 2 is the value of the constant, while the second 2 is the name of the constant; we might have used the word TWO in its place.) In our program, { 0 NCASE } causes the word −2 to be executed. { 1 NCASE } , { 2 NCASE } , or { 3 NCASE } cause −1 to be pushed on top of the stack, and so on. Only one of the words is executed; execution then continues with the first word after CASEND . MMSFORTH also has an alphanumeric case statement that branches on the value of a single character. Each may be thought of as a compact, structured, many-branched alternative to a nested series of *if* statements.

The Last Block

Block 55, the last block used to

Word Name	Usage
SPEED	CVARIABLE contains speed of play.
SPVAR	CVARIABLE contains speed multiplier, depends on height ball reaches.
SCORE	VARIABLE contains current score.
XPOS	VARIABLE contains current ball X position (range, 2 thru 61).
YPOS	VARIABLE contains current ball Y position (range, 5 thru 47).
PPOS	VARIABLE contains current paddle position (range, 2 thru 54).
XDIR	VARIABLE contains current ball X increment (possible values: −2, −1,1,2).
YDIR	VARIABLE contains current ball Y increment (possible values: −1,1).
LINE	Expects *n* on top of stack; moves cursor to line *n*, clears line.
INIT	Asks questions and draws display.
PCLR	Clears paddle.
PSET	Draws paddle.
PADDLE	Checks for right- or left-arrow key being pressed and moves paddle appropriately.
1CASSOUT	8080-code procedure for sound.
2CASSOUT	8080-code procedure for sound.
BOP	Makes one bounce noise.
XCHK	Checks if ball hit either side wall, modifies XDIR and XPOS if necessary.
YCHK	Checks if ball hit top wall and modifies YDIR and YPOS if necessary; also sets speed multiplier.
PCHK	Checks if ball at paddle level; if so, did it hit paddle or is it out of play? Leaves F on top of stack; F = 0 if ball still in play, else 1.
CLR	Clears brick, modifies score and YDIR.
BALLCHK	Increments ball position and checks for wall, paddle, or brick hits. Leaves F on top of stack; F = 0 if ball still in play, else 1.
BALL	Clears old ball position, calls BALLCHK, and draws new ball; see BALLCHK for value left on top of stack.
GAMECHK	Checks if all bricks cleared and draws new barrier if so.
DELAY	Causes a given time delay between ball moves.
BREAKFORTH	Main game loop.

Table 1: *Table of variable names and FORTH words used in the BREAKFORTH program. Note that all variables leave their address on the stack, that LINE removes one entry from the stack before executing, and that PCHK , BALLCHK , and BALL add one entry to the stack after executing.*

define the word BREAKFORTH , defines one last word (DELAY , in line 1), then puts all the words defined so far together to define the word (which is also the program) BREAKFORTH . This is a good demonstration of how FORTH is meant to work: first you define specialized words that are helpful in solving problems of a given class or application, then you use them to write the specific program needed.

(The building words, if chosen and defined properly, can be used to help write other programs in the same class.)

The word BREAKFORTH is defined in lines 2 thru 14. A flowchart for the program is given in figure 3; the number to the left of each box gives the line number within block 55 which the box is associated with.

Line 15, the last line of block 55, is interesting in that it triggers all the work done so far. The word BREAKFORTH causes the definition of the word to be executed. Once the game is finished, the next words, (FORGET TASK) , are executed; these words cause the word TASK (remember block 50?) and every word defined after it to be erased from the vocabulary of the language. This is done to free up the computer once we are finished playing BREAKFORTH. You can omit these words if you wish, but the disk program is recalled into memory so easily (with the phrase (50 6 LOADS)) that most people prefer to keep the FORTH dictionary as uncluttered as possible. The last word, DIR , causes the standard disk MMSFORTH directory to be displayed on the screen. (The last three words should be deleted if you are running the cassette version of MMSFORTH.)

Summary

It takes some work to understand your first FORTH program. But this work is only the flip side of the same coin that makes FORTH such a powerful language—where else can you easily write such a large and speedy program in such a small space? [*The only other candidate language I can think of is APL, which is also known for its compactness and unreadability to the uninitiated. . .* GW] But, of course, your second FORTH program is easier than your first, and so on. Better yet, your second program may be 90% written by your first, thanks to FORTH's structured and modular design.

We hope you have enjoyed this introduction to FORTH. We can assure you that it has just scratched the surface of FORTH, which performs equally well in process control projects and business applications. FORTH improves our programming skills while improving our computer's effective speed, memory capacity, and instruction set. It is a most satisfying language. ■

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FORTH Extensibility

Or How to Write a Compiler in 25 Words or Less

Kim Harris
1055 Oregon Ave
Palo Alto CA 94303

A computer language should help users solve problems. Languages bridge the gap between the primitive operations the computer can perform (add, fetch from memory, etc), and the tasks a user needs (invert a matrix, search a file, etc). When the operations of an application are well matched to those of a language, the solution can be simplified and developed in less time; in addition, the resulting program becomes more readable.

Because all applications have various needs, it is impossible for a nonextensible computer language to satisfy all needs equally well. Although languages have been produced which attempt to include all possible operations, structures, and facilities, these have not been satisfactory.

FORTH's approach is to provide a few techniques that allow a user to quickly add the special operations his particular application requires. The remainder of this article will describe some of these techniques and give examples that add arrays (with and without subscript range checking), virtual arrays, and a case selection control structure.

Extending the Language

The ability to add language facilities and compiler structures is called *extensibility*. FORTH is extensible on three levels of increasing power:

- using existing compilers
- creating new compilers
- creating new operating systems

Editor's Note

*In this article, Kim Harris uses the syntax of FORTH-79, which is different from that of existing FORTH implementations, for his examples. FORTH-79 is a standard set of FORTH words that, if used to build all other FORTH words needed for a given application, insures the complete portability of a given program between different versions of FORTH. Members from FORTH Inc, the FORTH Interest Group, the European FORTH Users' Group, and MMS worked together to define FORTH-79. I have noted the differences between the text and existing FORTH implementations (in particular, fig-FORTH and MMSFORTH) where known....*GW

This article focuses on the second level and demonstrates the construction and use of specialized compilers. The specialized compilers are usually simple (definable in a few source lines), but permit entire new classes of language or compiler facilities to be added to a FORTH system.

The compilation of any computer language is diagrammed in figure 1. Compilation is the process of converting a source language program into a form that a computer can use.

FORTH uses multiple compilers to implement different compiler functions. For example, compiling a data structure declaration (eg: an array) is distinctly different from compiling an executable statement. FORTH uses separate compilers for these two activities. Such compilers are many times simpler than the compilers for most popular languages (eg: BASIC, Pascal, COBOL); however, a collection of FORTH compilers can perform all the functions of the other languages' compilers (when these functions are adapted to a FORTH-like environment).

FORTH uses the English word "word" to mean an executable procedure, not a piece of memory. In this article, "word" will be used in the FORTH sense, and storage sizes will be specified in terms of 8-bit bytes.

User-Defined Words

The input language to the FORTH compilers is a sequence of FORTH source language word-names separated by spaces. (Unlike other languages, a space in FORTH is *very* important.) The output is one *dictionary definition* for each new word (procedure) compiled. The compilation process is controlled by special FORTH procedures called *defining words*. A *source definition*, which is a series of FORTH words including defining words, specifies a procedure that can be compiled by executing (typing in) the sequence. The result of compilation is a

Figure 1: *Compilation of any computer language. A program in some computer language is input to a compiler. The compiler produces a functionally equivalent program in a different, object language.*

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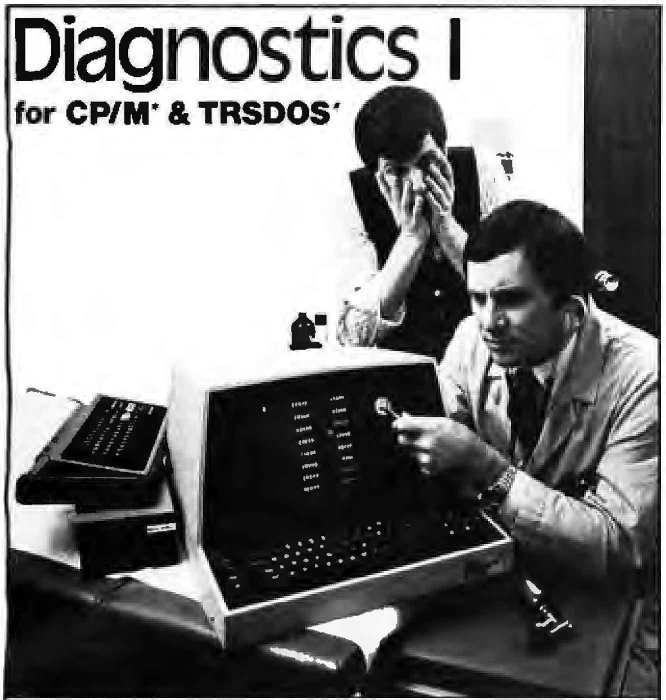

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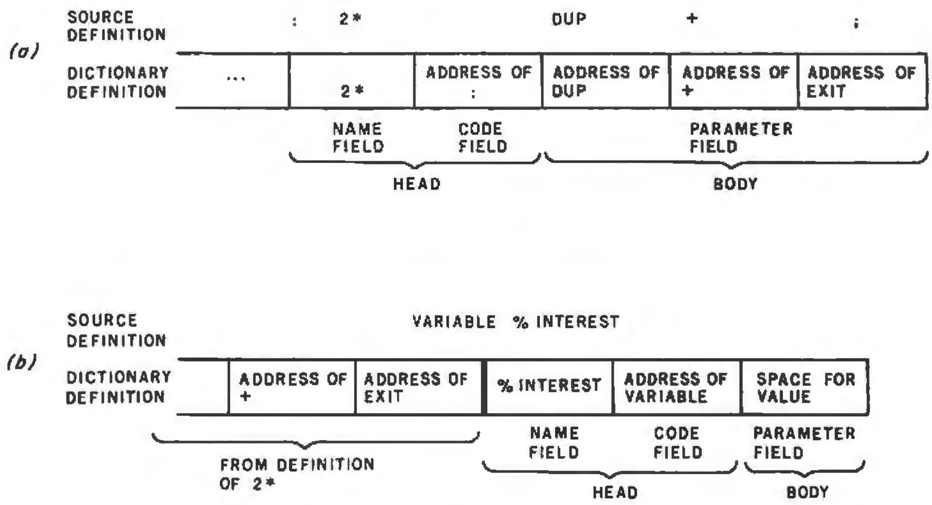

Figure 2: *Examples of extending the FORTH language. The first source line adds a new operator named 2* (see figure 2a); the second source line adds a new operand named %INTEREST (see figure 2b).*

dictionary definition, which is a block of FORTH-interpretable instructions. All compiled FORTH words are kept in this dictionary, which is usually located in the computer's memory.

User-defined words are treated the same as system-supplied words. If some new words are defined which behave like operators (eg: triple-precision versions of the FORTH words + , − , * , / , etc), then the language has been truly extended to include these operators. Subsequent words may use these new words as system-supplied operators.

Examples of standard, system-supplied defining words are { : } (colon), which starts the compilation of subroutine-like procedures, and VARIABLE , which compiles a named memory location for the variable's value.

A source definition consists of a defining word followed by the name of the word being defined and then by other FORTH words and numbers. Figure 2 illustrates the source definitions and the corresponding dictionary definitions for two new words named 2* and %INTEREST . (FORTH word-names may be made of *any* nonblank characters.) The word 2* simulates a multiplication by 2 by adding a value to itself.

The defining word { : } compiles the words that follow it in a definition, which is then added to the dictionary. Each FORTH dictionary definition consists of two parts: a *head* and a *body*. The head contains system-internal information including a *name field* and a *code field*. (A *link*, which points from a definition to a previous definition, is part of the head but will be ignored in this article.) The name field contains the name of the word. The code field contains a pointer to the instructions that will be executed when the word is executed.

For definitions compiled by { : }, the code field points to a procedure that begins the execution of the words referenced in the definition. The body of this kind of definition, called the *parameter field*, is a series of addresses that point in order to each FORTH word in the definition. The addresses of these referenced words are placed in the parameter field by the { : } compiler, and the definition is ended by the FORTH word { ; } (semicolon). The execution of the word EXIT (compiled at the reference to { ; }) ends the execution of the word.

Some Examples

The word 2* will leave a result that is twice the value of its input. (See figure 2a.) Examples in this article will underline the input typed by the user and will end in an unseen carriage return; the computer's response follows. The following line shows the use of the word 2* :

```
3 2* .  6 OK
```

The use of 2* causes the words in its definition to be executed, as if the user had typed:

```
3 DUP     two copies of 3 on the stack
+         add both 3s
.         print result from top of stack
```

Any subsequently compiled word may call the word 2* as if it were any other FORTH word. When called, 2* performs its function and then returns. This is analogous to the execution of a subroutine call in other languages.

A word is called by simply using its name, as in the following source definition for 4* .

```
: 4*   2* 2* ;
```

The defining word { : } has been used to compile another definition into the dictionary.

Using 4* will cause 2* to be called and executed twice. Here is an example of the use of the word 4* .

```
3 4* .  12 OK
```

The second word defined in figure 2 uses the defining word VARIABLE to compile a dictionary definition that contains data. The source word-name %INTEREST is compiled into a new dictionary definition containing a

Level	Method
I	Using standard FORTH defining words to add new operations (programs).
II	Creating new user-defined defining words that, in turn, create new classes of words.
III	Creating new FORTH-like systems through metaFORTH.

Table 1: *Levels of extensibility in FORTH. Level I refers to the act of defining ordinary words in FORTH using standard defining words. Level II refers to the creation of new defining words that are then used to create a family of ordinary FORTH words. Level III refers to the act of altering and recompiling FORTH itself (sometimes called metaFORTH) to create significantly different variant FORTH-like systems. Higher levels imply greater capability and flexibility.*

2-byte area where the value of the variable will always be stored. (The use of the word-name %INTEREST , either inside or outside a definition, will cause the *address* of this variable's value to be returned, not the value of the variable.)

The dictionary definition for %INTEREST contains the variable's name, a pointer to the instructions executed when %INTEREST is executed, and a 2-byte data area. The code fields of all words defined by VARIABLE point to a procedure which returns the address of the data area of the variable when the variable's name is referenced. All FORTH words, even data words, have some code that is executable.

The two defining words of this figure are actually different compilers. The defining word { : } compiles procedure definitions, while the defining word VARIABLE compiles data definitions. All user-added operators and operands can be used exactly like the system-supplied ones. Even new control structures can be added to the FORTH compiler by the user.

Levels of Extensibility in FORTH

As shown in table 1, there are three levels of extensibility supported by FORTH. The two words defined in figure 2 are examples of extensibility level I, the most commonly used level. It comprises the "ordinary" act of programming in FORTH. Although it is very useful, this level is the most restrictive and the least powerful of the three.

The process of writing and using new defining words is the second level of extensibility. Level II, which is more powerful than level I, allows a new "family" of words to be added to the language or compiler. This is done by creating a special word, called a *defining word*, that will be used to create FORTH words in the same family. The user specifies via the defining word how the compilation of a new family member (itself an ordinary FORTH word) is to be performed and what the result will be. Also the user specifies what a member of the family will do when it is executed.

Level III, the highest level of extensibility, is called *metaFORTH*. It uses the entire FORTH system to compile a collection of source definitions (including both lower levels) in order to produce a clone or a mutation of FORTH.

(Please don't be misled by my use of the word "compiler." I have been asked, "Can you write a compiler in FORTH that will compile BASIC, Pascal, COBOL...?" The answer is not easy. Defining words *can* compile application-oriented languages, but those languages should be FORTH-like in nature. Ordinarily, the language being compiled satisfies the syntax of FORTH—words separated by spaces. The compilation will result in FORTH-interpretable instructions that will add to its dictionary of word definitions.

In keeping with the FORTH philosophy of keeping all definitions small, defining-word definitions are also small. This results in compilers (defining words) that are simple and specialized, although the range of complexity of these compilers can vary greatly. A simple defining word such as VARIABLE may accept only one source word and produce a single, simple definition in the dictionary. A more complex defining word such as { : } may take several source words and produces a more complex definition.)

The remainder of this article concentrates on level II, defining new families of words. The scope and usefulness of new defining words are discussed using functional descriptions and examples. New defining words can be created which can later compile application-oriented languages.

Creating Families of Words

The technique of creating new defining words permits

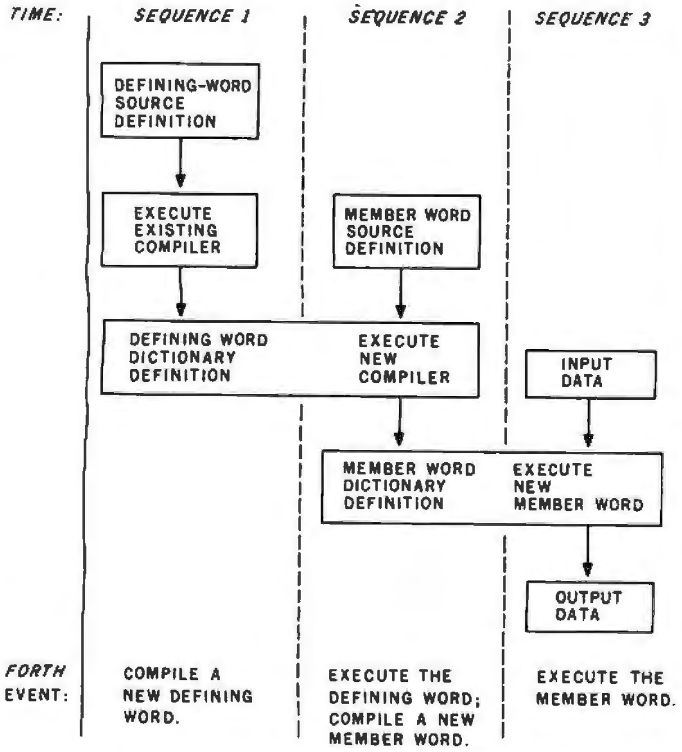

Figure 3: *The order of events governing defining words. The first event creates a word that will define a new family of words; this family currently has no members. The second event uses this new family-defining word to create a new family member, a named FORTH word. The third event occurs when any named FORTH word belonging to this family is used.*

a user to later create a family of FORTH words that can have any number of members. Each member shares some family traits but can also have individual characteristics. The family members are all the words that have been compiled by a defining word. Their common traits are specified by the defining word. However, each word in the family has individual characteristics that are assigned when added to the family.

For example, the defining word VARIABLE defines a family with individual members, each of which has a different name and value, but all share the same execution trait: specifically, the use of the name of any variable returns the address of its value.

It is important to understand that there are three time-ordered events related to defining words. These are listed in figure 3. These events will be explained using an example.

The compilation of the new words in figure 2 is a sequence 2 event (ie: using a defining word to compile another word). When the defining word VARIABLE is executed, as in:

VARIABLE %INTEREST

the source word %INTEREST is compiled.

Storing a value into the variable is a sequence 3 event.

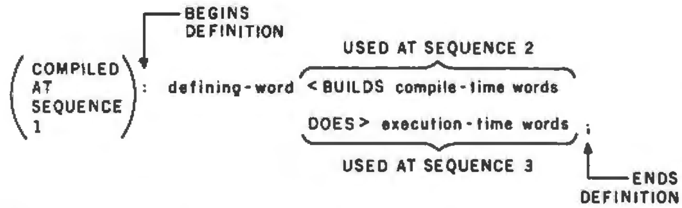

Figure 4: *The structure of the source definition of a defining word. These source lines create a defining word for a new family (sequence 1). Execution of the defining word (sequence 2) <BUILDS a dictionary definition for a new family member. The contents of that definition is constructed by the compile-time words. Executing any family member (sequence 3) DOES> (ie: executes) the execution-time words.*

The following words store a 5 into the variable.

5 %INTEREST !

Since VARIABLE is system-supplied, the sequence 1 event (the compilation of VARIABLE) occurred when the FORTH system was generated.

<BUILDS and DOES>

To illustrate a simple sequence 1 event, a definition of VARIABLE is presented.

: VARIABLE <BUILDS 2 ALLOT DOES> ;

The defining word { : } (colon) is used to compile the source definition of VARIABLE . To the word { : }, VARIABLE is an ordinary definition (level I), and its definition is a sequence 2 event for { : }. VARIABLE is a defining word because the special words <BUILDS and DOES> are used. (The < and > characters are part of the names of the words; they are used like parentheses to indicate that <BUILDS comes before DOES> .)

As illustrated in figure 4, a defining word specifies both the compile-time behavior (sequence 2) and the execution-time behavior (sequence 3) of all words compiled by this defining word. The sequence 2 behavior is specified by <BUIILDS and any following words up to DOES> . The sequence 3 behavior is specified by DOES> and any following words up to { ; }. The English meaning of <BUILDS is "compiles" and the meaning of DOES> is "executes."

Figure 5 demonstrates what occurs when VARIABLE is executed. The end result of the execution of VARIABLE is that a new dictionary definition is created for the word %INTEREST . The following describes each step in the compilation of %INTEREST :

1. The execution of VARIABLE causes <BUILDS to be executed. <BUILDS reads the next word-name after the word VARIABLE from the input text stream. (In this example, the next word-name is %INTEREST .)
2. <BUILDS then adds the head of a new definition to the end of the dictionary. Within this head, the name field contains the member's word-name

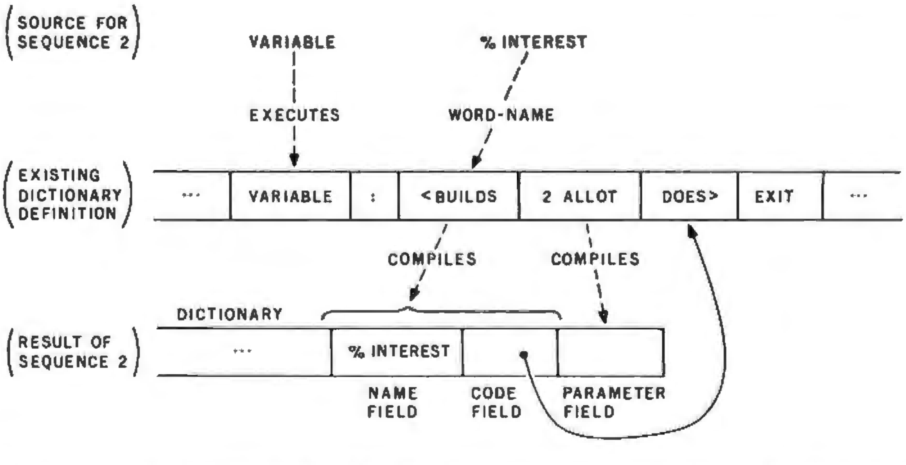

Figure 5: *The result of executing a defining word. The first line is executed, resulting in the compilation of the word-name %INTEREST . The result is a new definition in the dictionary.*

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(%INTEREST), and the code field contains a pointer to the instructions that will be executed when %INTEREST is executed (during sequence 3).

3. The two words { 2 ALLOT } are executed next. These will reserve 2 bytes of dictionary space for the value of the variable. This space is in the parameter field of the dictionary definition.
4. Finally, DOES> terminates the compilation of %INTEREST and links the code field of %INTEREST to the execution-time part of VARIABLE .

When %INTEREST is executed (sequence 3), DOES> is executed, followed by the FORTH words between DOES> and the end of the definition. (In this example, there are no words following DOES> ; the word EXIT is a routine left by the end-of-definition word { ; }.) DOES> returns the memory address of the parameter field within the dictionary definition of %INTEREST . Since the parameter field of a word defined by VARIABLE contains only the value of that word, execution of the word %INTEREST returns the *address* of its value, which is then pushed onto the parameter stack. (That is, in fact, the execution-time behavior of a FORTH variable.)

Figure 6 shows an example of the execution of %INTEREST .

[*The above definition and usage of the word* VARIABLE *are valid for existing* FORTHs. *However, the definition of* VARIABLE *supplied with most* FORTHs *requires the initial value of the variable before the word* VARIABLE *(eg:* { 5 VARIABLE %INTEREST }). *This definition of* VARIABLE *is:*
{ : VARIABLE <BUILDS , DOES> ; }
....GW]

The previous example demonstrated the following principles:

- Sequence 1: the definition of a defining word specifies both the compile-time behavior and execution-time behavior of all words belonging to the family of the defining word (ie: all words created using the defining word).
- Sequence 2: the execution of a defining word causes the compilation of the word-name(s) that follow. This creates a new dictionary

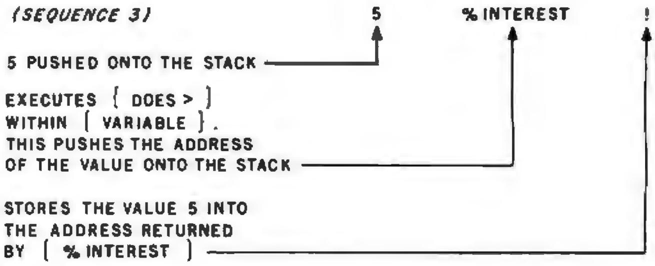
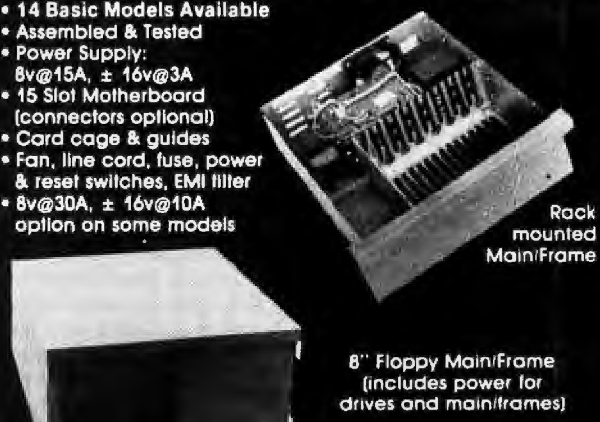


Figure 6: *The execution of a family member word. The value 5 is stored in the variable %INTEREST .*



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definition and adds a new member word to the family of the given defining word. It also extends FORTH because another user-defined procedure is added to the language.

- Sequence 3: the execution of a member word causes the execution of the execution-time words within the defining word that created the member word.

To illustrate the versatility of defining words, examples of new defining words follow. These examples present the creation of new data structures, control structures, and software tools.

Creating a String-Handling Defining Word

To show how defining words can create data structures, a one-dimensional array of 8-bit values will be created. A defining word named STRING will be constructed. After STRING has been compiled, any number of strings may be created; each can have a different name and size. Before the definition for STRING is shown, an example will first be used to describe how STRING will be used.

To create a string 5 bytes long with the name BEANS , the following words would be used (BEANS is the name of the string, not the value put into the string):

```
5 STRING BEANS
```

This is a sequence 2 event that will create a dictionary definition for BEANS ; this definition will contain 5 bytes of data space for the value of the string.

To fetch or store a character in BEANS , a subscript will be passed to BEANS . BEANS will return the address of the subscripted byte. For example, the words

```
3 BEANS C@
```

would fetch character number 3 from BEANS . This is a sequence 3 event because it is a normal use of a word defined by STRING . The subscript precedes BEANS because FORTH prefers to pass data values on a stack.

The definition of STRING can now be written as shown in listing 1. This definition is similar to that of VARIABLE .

The parameter for ALLOT is omitted in this definition; the string size declaration at sequence 2 will supply the size parameter for ALLOT . (The word ALLOT looks for the number of bytes to be reserved to already be on the stack; this is why the string size precedes the word STRING when the string variable BEANS is defined.)

Following DOES> is the word + . This will add the address of the start of the string (supplied by DOES>) to the subscript (supplied to BEANS at sequence 3). Figure 7 illustrates how this works.

Listing 1: *A user-defined defining word. The word STRING , once defined, can be used to define new FORTH words with unique properties.*

```
                                 used at sequence 2 used at sequence 3
( defined at )
( sequence 1 )  : STRING   <BUILDS ALLOT      DOES> + ;
```

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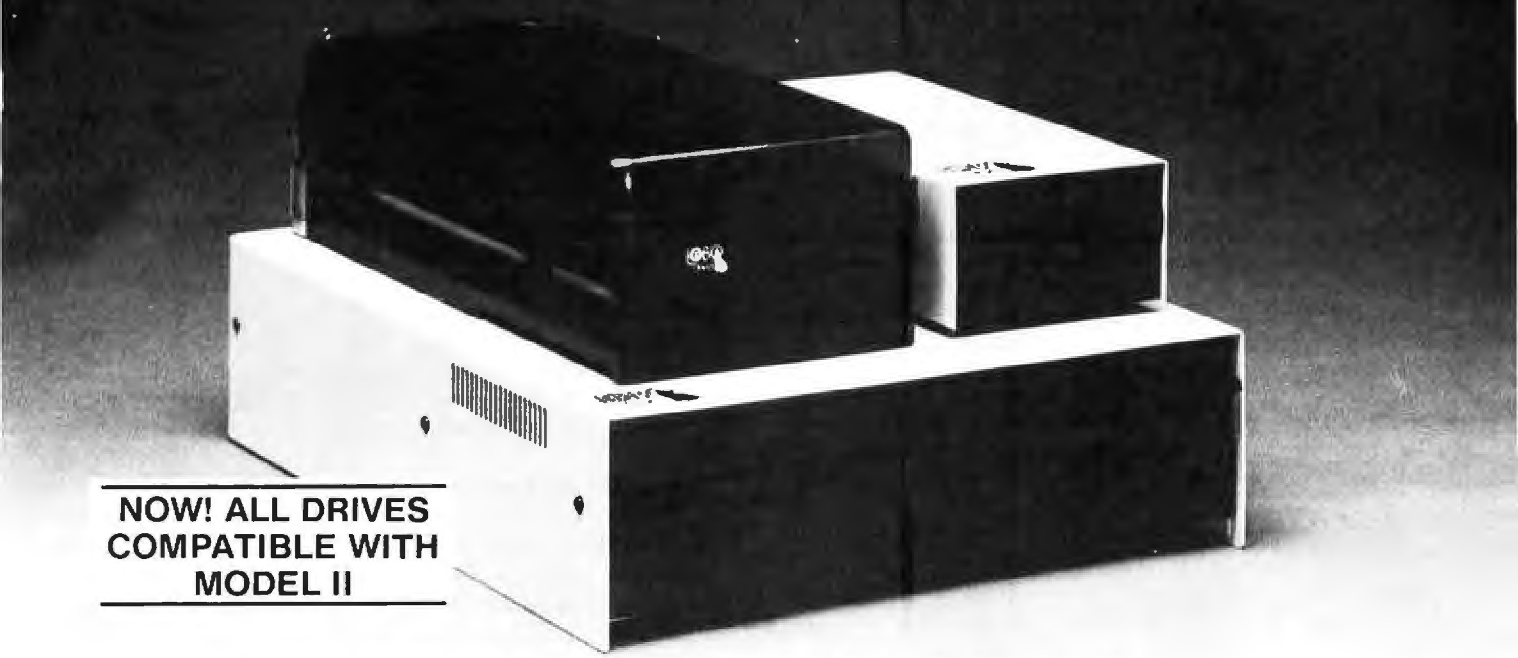

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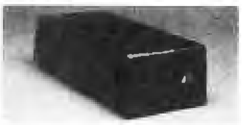

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When STRING is executed (sequence 2), it builds a dictionary definition for BEANS , which is allotted 5 bytes of data space. When BEANS is executed (sequence 3), it does the addition of the subscript on top of the stack to the address of the first character within BEANS .

The following examples show how BEANS could be used in a FORTH program. The word STUFF-BEANS will store the American Standard Code for Information Interchange (ASCII) characters A thru E in the string variable BEANS . (See listing 2a.) The word SPILL-BEANS will print the characters in BEANS on the user's terminal. (See listing 2b.) Using these words would produce the results shown in listing 2c.

In a similar way, multidimensional-array defining words may be defined; the size of each element can be any number of bytes.

Since the execution-time function of all family members is specified only once in the definition of the family's defining word, programming time is reduced, memory space is saved, and readability is improved. By changing the definition of the defining word and recompiling the FORTH words using it, the capabilities of every member word are changed. This can be done so that the use of all member words in a user's program is the same.

To illustrate the power of this technique, several variations on STRING will be presented.

Listing 2: *Using a FORTH word created by a user-defined defining word. The 5-character string variable BEANS was previously defined with the FORTH statement { 5 STRING BEANS }. Now the word BEANS can be used like any other word in FORTH. In listing 2a, the five characters of BEANS are filled with the letters A thru E. In listing 2b, the characters are printed out. Listing 2c gives the results of executing the words defined in listings 2a and 2b. (The underline denotes user input followed by a carriage return; the computer output, not underlined, follows.)*

```
: STUFF-BEANS   5 0 DO          ( for all of 'BEANS' )
                  I 65 +        ( add 65 decimal to )
                                ( do-loop index, yielding )
(a)                             ( an ASCII character )
                  I BEANS C!    ( store character in the )
                                ( 'I' th byte of 'BEANS' )
                LOOP
;


:SPILL-BEANS    5 0 DO          ( for all of 'BEANS' )
                  I BEANS C@    ( fetch the 'I' th character )
(b)               EMIT          ( print it )
                LOOP SPACE      ( print an extra space )
;

(c)
STUFF-BEANS     OK
SPILL-BEANS     ABCDE OK
```

Variations on the Defining Word STRING

The original version of STRING did not initialize the contents of the array when it created member arrays. The following version will store blanks in a string when it is created (at sequence 2). It is convenient to first define a word which allocates and blanks dictionary space. The definition of BLANK&ALLOT is a sequence 2 event. (See listing 3a.)

Next, we create a new version of STRING that is the same as the original, except that BLANK&ALLOT is substituted for ALLOT . (See listing 3b.) (The redefinition of STRING is a sequence 1 event.) This version is used exactly like the original, but initialized strings are created automatically.

Another variation of STRING checks if a subscript exceeds the string size when member strings are executed (at sequence 3). If the subscript is less than the string size, the result is the same as before; but, if the subscript is negative or greater than the string size, an error message

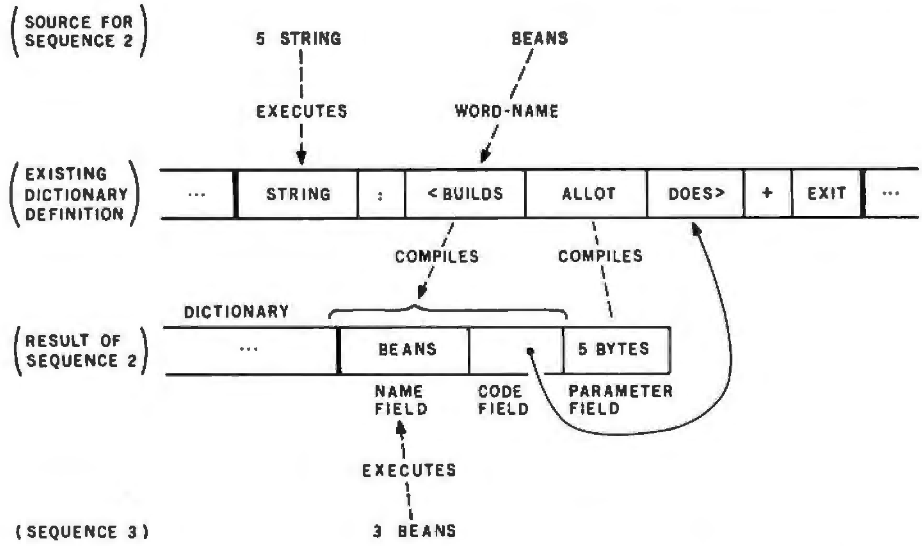

Figure 7: *The creation and use of a character array. The defining word STRING is executed, causing the compilation of a dictionary definition for BEANS containing 5 bytes of data space. When BEANS is executed (last line), the DOES> part of the definition of STRING adds the address of the parameter field of BEANS to the subscript (which is 3), returning the address of the desired character within BEANS .*

Listing 3: *A more sophisticated definition of STRING . The word BLANK&ALLOT (shown in listing 3a) allocates space for and assigns blanks to a newly defined string. The new definition of STRING (shown in listing 3b) uses BLANK&ALLOT to blank out a string when it is created.*

```
: BLANK&ALLOT
            HERE              ( get the address of the )
                              ( start of the string )
(a)         OVER BLANK        ( store blanks in the string )
            ALLOT             ( allocate space for the array )
;


: STRING    <BUILDS   BLANK&ALLOT  ( used at sequence 2 )
(b)         DOES> +                ( used at sequence 3 )
;
```

Listing 4: *Another definition of STRING . This definition stores the size of the string variable when the variable is created and checks for a correct subscript when a character within the string variable is referenced.*

```
: STRING
         ( used at sequence 2: )
         <BUILDS DUP  ,       ( store string size in )
                              ( member's parameter field )
            ALLOT             ( allocate string space )
         ( used at sequence 3: )
         DOES>   2DUP         ( duplicate both the subscript )
                              ( & parameter field address )
            @ U< IF           ( if the subscript is less )
                              ( than the string size )
               +              ( add subscript to address )
               2+             ( step over the string size )
                              ( stored in the first 2 bytes )
            ELSE              ( otherwise the subscript )
                              ( is too large or negative )
            . " RANGE ERROR"( print error message )
            OVER   .  @  .    ( print string size and )
                              ( and bad subscript )
            2+                ( leave address of first byte, )
                              ( a "safe" address )
            THEN
;
```

is produced and the illegal subscript is printed. The string size must be stored in the dictionary definition of member strings when they are compiled (at sequence 2) so that the range check can be made when they are executed (at sequence 3).

A new definition of STRING (a sequence 1 event) that does the subscript checking defined previously is given in listing 4.

The range check slows the execution of every reference to a member string, but such checking may be useful during program development. Since this version and the original version defining STRING are used exactly the same, it is possible to compile this definition of STRING while debugging (then compile all references to it or its member strings). After the program has been debugged, the original version can be compiled (followed by the compilation of all references to it or its members), and the program will run faster.

The next version of STRING allows very large strings to be created and used.

Virtual Strings in FORTH

If the maximum string size exceeds the amount of programmable memory in the computer, the only solution is to write your program using *virtual memory management*. This means that data stored on disk or tape is considered part of the memory of the computer, and that all operations working on these data take care of reading and writing data between main memory and the magnetic storage device.

Using virtual memory management, a program can operate on a string array that is larger than main memory; pieces of the string can be read into memory and written back to disk or tape when required. And, although this technique will slow the execution rate of a program using it, it may be the only way to get a problem solved—and better a slow solution than none at all.

(It is more common to need to manipulate large arrays of numbers rather than strings. Still, the same technique described here can be applied to numeric or any other kind of array.)

With most traditional languages, it would be necessary to rewrite the user program so that all array references would call some function that could perform the disk read operations. Execution time could be decreased if frequently referenced array elements were kept in memory as much as possible. Therefore, it would help if our virtual-memory-array program could keep track of what data is in memory as the program executes.

To show the difficulty of implementing this technique in traditional languages, a FORTRAN example will be used. In standard FORTRAN, the statement:

```
ARRAY(5,7,2)=AR1(1,2)+AR2(10,20,30)
```

is equivalent to the FORTH words:

```
1 2 AR1 @     10 20 30 AR2 @     +
          5 7 2 ARRAY  !
```

In either FORTRAN or FORTH, if the arrays could not fit into memory and were instead on disk, the array references would have to be changed so that some additional procedures read and wrote selected pieces of data between disk and memory. But in FORTRAN, the entire source program would have to be changed. (In FORTH, the body of the program would remain the same; only the appropriate defining word would be changed.)

The following might be the simplest modification possible in standard FORTRAN to do the previous statement using virtual memory management of the arrays:

```
TEMP=FETCH2(AR1(1,1), 1,2)+FETCH3(AR2(1,1,1),
         10,20,30)
   CALL STORE3(ARRAY(1,1,1), 5,7,2, TEMP)
```

The functions FETCH2 and FETCH3 are user-written procedures to read the referenced array elements. The subroutine STORE3 is a user-written procedure to write a given value into an assigned array element. If a large program using many normal array references had to be changed to use FETCH and STORE calls, a *lot* of work would be required.

FORTH's separation of control between defining words and their members permits the necessary changes to be made in the definition of the defining word; in this

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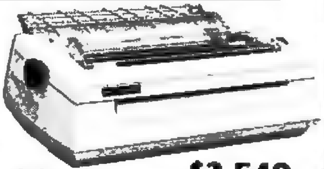

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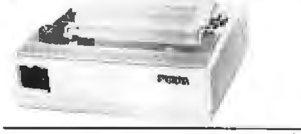

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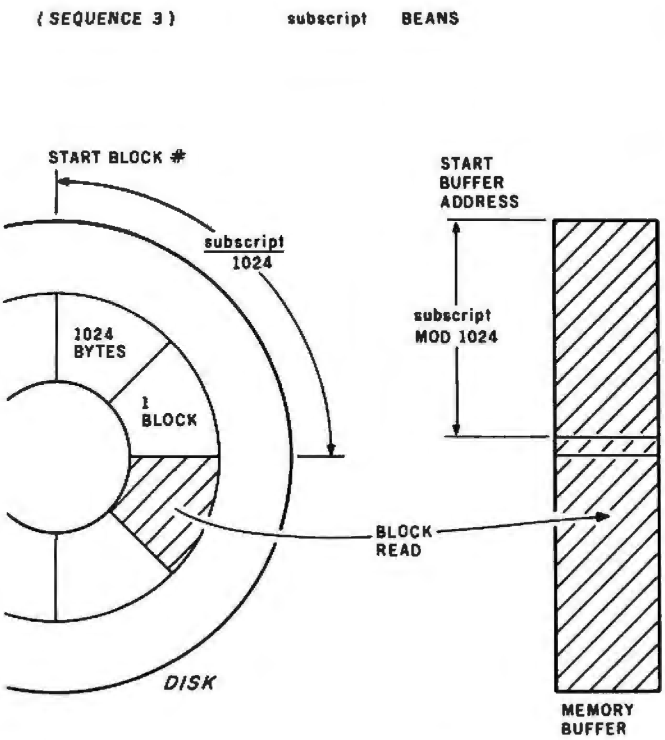

Figure 8: *Accessing a virtual array. The data for a large array is kept on a disk. When a byte is referenced, BEANS is executed. One block containing the byte is read into a memory buffer (if it is not already present). Finally, the memory address of the referenced byte is returned by BEANS .*

way, the program that uses the arrays does not have to be changed.

Furthermore, FORTH's virtual memory facility for disk reading and writing automatically keeps track of what data has been read into memory and tries to keep frequently referenced sections in memory.

Figure 8 illustrates how the array will be read in blocks of 1024 bytes into memory buffers. The new definition for the defining word STRING is given in listing 5.

Adding New Control Structures with Defining Words

The next example illustrates the use of defining words to add control structures to the FORTH compiler. FORTH supplies { IF ... ELSE ... THEN } compiler structures and also loop structures like { DO ... LOOP },{ BEGIN ... UNTIL }, and { BEGIN ... WHILE ... REPEAT } loops.

In this example, we will create a *case* (choose one of *n* alternatives) selection mechanism. A *case number* will designate one of several words to be executed. Figure 9 presents how a case statement selects one of several procedures for execution. No matter which one is chosen, execution continues with one common procedure that follows the case structure.

The new defining word will be named { CASE: } and can be used similarly to { : }, as the following

Listing 5: *Another definition of STRING . This definition creates a virtual string array that stores the string on disk and reads it into main memory when necessary. With this definition of STRING , it is possible to manipulate a string that is larger than main memory without changing the program that uses the long string. The disk operations are transparent—that is, the programmer does not know he is using the disk except for response time.*

```
: STRING
        ( used at sequence 2 )
        <BUILDS  NEXT-BLOCK#( get the next available )
                            ( disk block # )
                 ,          ( store it in the member's )
                            ( parameter field )
                 DISK-ALLOT ( reserve disk space for )
                            ( the array )
        ( used at sequence 3 )
        DOES>    @          ( get start-block # )
                 SWAP       ( subscript on top, )
                            ( start-block # beneath )
                 1024  /MOD ( divide subscript by )
                            ( # bytes in a disk block; )
                            ( the quotient is the block )
                            ( index within the array; )
                            ( the remainder is the byte )
                            ( index within the block )
                 ROT   +    ( add start-block # to the )
                            ( block index )
                 BLOCK      ( call the FORTH virtual )
                            ( disk manager to read the )
                            ( referenced block; )
                            ( if it is already in memory )
                            ( no read is performed )
                 +          ( add the byte index to the )
                            ( memory address of the )
                            ( buffer where the block is )
                            ( located, the result is )
                            ( a memory address of the )
                            ( byte specified by the )
                            ( subscript before BEANS )
;
```

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example shows. (In this implementation of the *case* construct, the selection of a case causes the execution of one FORTH word. Since there is no restriction as to the internal complexity of a given word, the selection of one case can cause any combination of conditional, loop, or case structures to be executed.)

Listing 6: *Example of a new user-defined programming construct. In listing 6a, we define the words we want to execute when the numbers 0, 1, and 2 are on top of the parameter stack. In listing 6b, the user-defined defining word { CASE: } defines the word ANIMAL , which will execute 0PET , 1PET , or 2PET , depending on the value on top of the parameter stack. Listing 6c illustrates what happens when the case-word ANIMAL is executed. See listing 7 for the definition of { CASE: } .*

```
: 0PET   ." AARDVARK " ;        ( print the quoted string )
: 1PET   ." BEAVER " ;          ( when executed )
: 2PET   ." COUGAR " ;
(a)


( sequence 2 )      CASE: ANIMAL   0PET 1PET 2PET ;
(b)


( sequence 3 )      0 ANIMAL     AARDVARK OK
                    1 ANIMAL     BEAVER OK
(c)                 2 ANIMAL     COUGAR OK
```

Listing 7: *Definition of the defining word { CASE: } in FORTH-79. This word allows the user to create case-words that execute one of several FORTH words depending on the value on top of the parameter stack.*

```
: CASE:
        ( used at sequence 2 )
          <BUILDS              ( create head for member )
            ]                  ( begin ':' compilation )
        ( used at sequence 3 )
          DOES>
           SWAP 2*             ( convert case number to )
                               ( a byte index )
            + @                ( fetch the address of the )
                               ( indexed case word )
           EXECUTE             ( execute the selected word )
```

In our example, let us first define three words, 0PET , 1PET , and 2PET , that are to be executed when the value on top of the stack is 0, 1, or 2, respectively. This is done in listing 6a. Then we use the { CASE: } defining word (which we will look at later) to define the word ANIMAL (listing 6b). Now that ANIMAL and the case words it uses are defined, calling ANIMAL with the appropriate value on the stack executes the proper case word (listing 6c). For example, pushing a 2 onto the stack and calling ANIMAL causes word 2PET to be executed; this causes the English word COUGAR to be printed.

Since { CASE: } is a defining word, ANIMAL is a member of the { CASE: } family. The definition of ANIMAL consists of a list of addresses for the case words associated with ANIMAL.

The definition of { CASE: } is a sequence 1 event. Listing 7 shows the definition of { CASE: } in FORTH-79. [*Listings 8a and 8b show the same definition for fig-FORTH and MMSFORTH, respectively....*GW] Figure 10 shows how the word ANIMAL is built using { CASE: }. The { : } compiler is used to compile the words following ANIMAL. When ANIMAL is

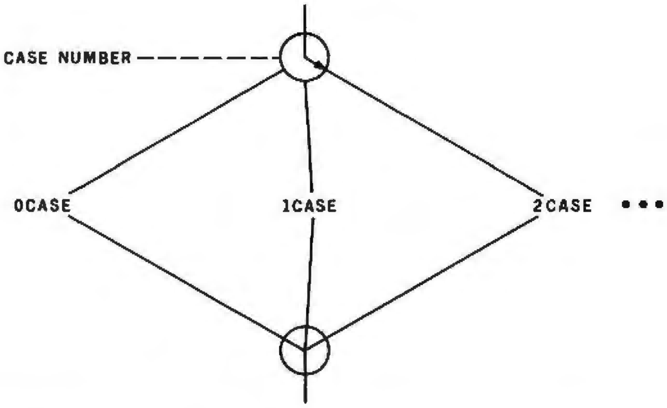

Figure 9: *The function of a case control structure. The case number selects one of several procedures for execution, then continues along a single exit path.*

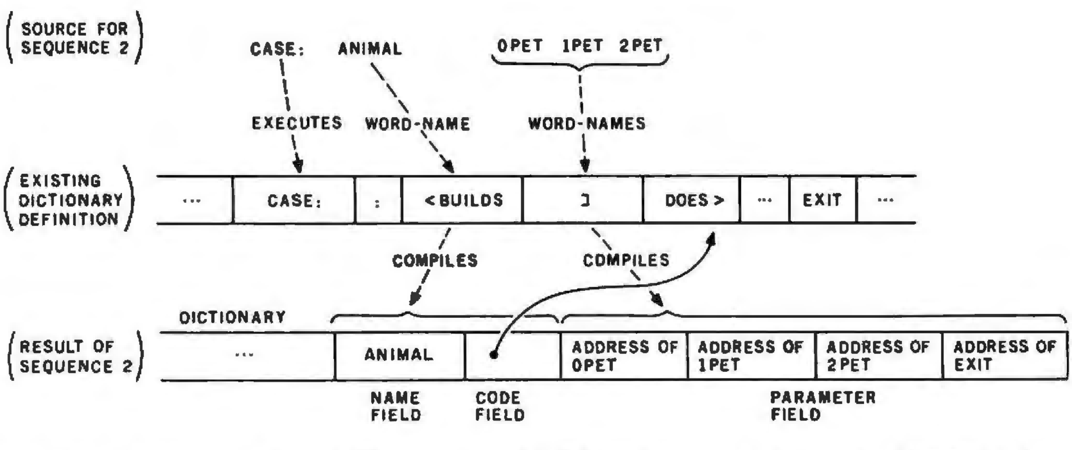

Figure 10: *The creation of a case control word. The execution of { CASE: } causes a definition for ANIMAL to be appended to the dictionary. The ']' word uses the { : } compiler to compile the addresses of the case words following ANIMAL .*

Listing 8: *Definition of the defining word { CASE: } in fig-FORTH (listing 8a) and in MMSFORTH (listing 8b).*

```
( CASE:   as implemented in fig-FORTH)
: CASE:    <BUILDS    SMUDGE ]
           D O E S >  SWAP 2*
(a)                   + @
                      EXECUTE
;
```

```
(  CASE:    as implemented in MMSFORTH)
(  new word )) replaces  SMUDGE      )
: ))   ] STATE C! 21144 ;
: CASE      <BUILDS     ))
            DOES>       SWAP 2*
(b)                      + @ 2+
                         EXECUTE
;
```

Listing 9: *Definition of a defining word that acts as a programming tool. The word LOADED-BY allows the user to execute (or load) a screen by name rather than by number. For example, if you define { 125 LOADED-BY ACCOUNTING }, executing the word ACCOUNTING will have the same effect as executing the phrase { 125 LOAD }.*

```
( sequence 1 )  : LOADED-BY   <BUILDS ,   ( store screen # )
                                          ( in members def. )
                              DOES>   @   ( fetch screen # )
                                  LOAD    ( load it )
;
```


executed, the case number that precedes it (which is now on top of the stack) is used just like an array subscript to calculate the address of the case word to be executed. Its compiled address is then fetched and executed.

As with array-defining words, many variations of { CASE: } can be constructed. A case number-range check may be added. An "otherwise" case word can be specified to be executed whenever the case number is out of range.

Defining Words as Programming Tools

The final example applies defining words to the creation of software tools. Such tools are conveniences for the user. Good tools can increase a programmer's productivity, reduce errors, and improve program readability. Defining words can be used to add powerful tools to the FORTH language and operating system.

In FORTH, the word LOAD will compile source definitions from the disk starting at a specified screen number. A *screen* is a block of disk space where source text can be stored using an editor. Additional screens may be loaded if the initial screen contains more LOAD commands.

Application programs and utility programs begin on various screen numbers determined by the user. The defining word LOADED-BY allows words to be defined which will LOAD a screen without calling it by number.

For example, assume a business application starts on screen 125. Then the defining word LOADED-BY can be used to define a word that will load screen 125 when the member word is executed. When we define:

```
125  LOADED-BY  ACCOUNTING
```

screen 125 will be loaded when the single word ACCOUNTING is executed. (If LOADED-BY *looks strange*, think of it as a FORTH word like VARIABLE .)

The definition of LOADED-BY is given in listing 9. This definition is similar to the definition of the word CONSTANT except that, rather than returning the value stored in the definition of the member word, LOADED-BY uses that value to provide a parameter to the word LOAD .

Summary

FORTH exploits its own extensibility to support a user's need for a variety of language facilities and compiler structures.

A defining word controls the compilation and execution of all words compiled by it. New defining words that define a new family of capabilities may be constructed. Subsequently, any number of individual members can be added to the family.

The source definitions of most defining words are short and simple. Proper use of defining words in a software development project reduces program development time, improves program readability, and makes program modification and maintenance easier.

Defining words are applicable to data structures, control structures used by the FORTH compiler, and software tools. The ability to create new kinds of defining words (which are, in their own way, small compilers) is a unique feature of FORTH and is one of the most powerful programming tools in the language.■

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Gregg Williams
Editor

This glossary is a compilation of most of the FORTH words used in the listings and figures of all the FORTH articles in this issue. It does not include all the standard words in FORTH (there are quite a few), nor does it include user-defined words required by each article. The pronunciations of some words are given in parentheses. Wherever possible, an example is given showing the use of the defined word. The words "before" and "after" show the stack before and after the word is executed. In these representations of the stack, the top of the stack is the rightmost number, and the words influenced by the defined word are depicted in boldface.

The columns marked "uses" and "leaves" show how the execution of a FORTH word affects the top entries of the stack. FORTH words remove the stack entries they use and sometimes leave one or more entries on the stack. Therefore, the number under "uses" and "leaves" should equal the number of entries in boldface in the "before" and "after" stacks. Asterisks in both columns mean that the numbers are not given for multiword constructs for the purpose of clarity.

Multiword constructs, like the following example:

{ IF ... ELSE ... THEN }

are enclosed in braces with the keywords separated by ellipses that represent zero or more FORTH words. Also, these constructs are listed only under the first word of the construct. In general, all the words in this table are sorted by ascending ASCII value — for example, the word * (ASCII hexadecimal 2A) is listed before the word + (ASCII hexadecimal 2B).

This glossary assumes that the output device used by the FORTH system is a video terminal. When any definition refers to the video display or display, it actually refers to whatever output device or devices are currently enabled.

FORTH Glossary

Word	Uses	Leaves	Notes
{ ! } (store)	2	0	Sees top-of-stack as address of a 2-byte variable and stores second-on-stack in this variable; for example, suppose that address 20000 points to a 2-byte variable; then: before: 9 9 **−1150 20000** after: 9 9 (−1150 is stored in a 1-byte variable.)
{ " }	0	0	{ " HI THERE!" }, when executed, prints HI THERE! on the video display.
{ ' } (tic)	0	1	Puts onto top-of-stack the address of the word that *follows* it.
{ (}	0	0	{ (THIS IS A COMMENT) } , if included in a definition, will not be compiled; { (} requires a {) } to end the comment.
*	2	1	Multiplication; example: before: 9 9 **3 5** after: 9 9 **15** The word * multiplies 5 and 3, leaving 15.
+	2	1	Addition; example: before: 9 9 **3 5** after: 9 9 **8** The word + adds 5 and 3, leaving 8.
{ , }	1	0	Embeds the number on the top of the stack into a dictionary definition, incrementing the dictionary pointer.
−	2	1	Subtraction; example: before: 9 9 **3 5** after: 9 9 **−2** The word − subtracts 5 from 3, leaving −2.
{ . }	1	0	Displays the number on the top of the stack; example: before: 9 9 3 **5** after: 9 9 3 (5 is printed on screen.)

/	2	1	Division; example: before: 9 9 13 2 after: 9 9 6 The word / divides 13 by 2, leaving 6. (Remainder is lost.)
0<	1	1	If top-of-stack is <0, it is replaced with a 1 (true); if top-of-stack is ≥ 0, it is replaced with a 0 (false); example: before: 9 9 3 5 after: 9 9 3 0
1+	1	1	Adds 1 to top-of-stack; example: before: 9 9 3 5 after: 9 9 3 6
{ : ... ; }	*	*	{ : } begins the definition of a word; { ; } ends the definition; example: { : 3* 3 * ; } defines the word 3*.
=	2	1	If the two top items on the stack are exactly equal, both of them are removed and replaced with a single 1 (true); if not, both are replaced with a single 0 (false); example: before: 9 9 3 5 after: 9 9 0
<	2	1	If the second item on the stack is less than the top item on the stack, both of them are removed and replaced with a single 1 (true); if not, both of them are replaced with a single 0 (false); example: before: 9 9 3 5 after: 9 9 1

 Circle 131 on inquiry card. Circle 132 on inquiry card.

{ <BUILDS ... DOES> }	*	*	Used to define new defining words; see "FORTH Extensibility" article, figure 4.
>	2	1	Similar to entry for < ; example: before: 9 9 3 5 after: 9 9 0 (3 is not less than 5.)
{ ? }	1	0	Sees top-of-stack as address for 2-byte variable; displays value of that variable; using the example for { ! } , then: before: 9 9 20000 after: 9 9 (−1150, contents of 20000, prints on screen.)
@ (fetch)	1	1	Sees top-of-stack as address for 2-byte variable and replaces it with value of that variable; using the example in { ! } : before: 9 9 20000 after: 9 9 −1150 (−1150 is contents of 2-byte variable at 20000.)
ALLOT	1	0	Sees top-of-stack as number of bytes to be reserved (and filled in later) *during the definition of a word.*
AND	2	1	Does an AND operation on the corresponding bits of the top two stack entries (both 16-bit numbers); example: before: 9 9 3 5 after: 9 9 1 (3 AND 5, in binary, is 1.)
BASE	0	1	BASE is a *1-byte variable* that contains the number base being used; for example, { 2 BASE C! } causes all subsequent input and output to be in binary (base 2); execution of this word causes the address of this 1-byte variable to be placed on top-of-stack.

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{ BEGIN ... UNTIL }	*	*	Looping construct that tests at the end of the loop; see "What Is FORTH?" article, figure 4.
{ BEGIN ... WHILE ... REPEAT }	*	*	Looping construct that tests at the beginning of the loop; see "What is FORTH?" article, figure 5; other forms are { BEGIN ... PERFORM ... PEND } and { BEGIN ... IF ... WHILE }.
{ C; }	*	*	Sometimes used to end a machine-code word definition; most versions use NEXT.
{ C! }	2	0	Similar to { ! } except that only low byte of second-to-top is stored in 1-byte variable pointed to by top-of-stack; for example, suppose that address 21000 points to a 1-byte variable; then: before: 9 9 103 21000 after: 9 9 (103 is stored in 1-byte variable.) Note that the maximum value that can be stored in 1 byte is 127.
C@	1	1	Same as the word @, only for 1-byte variable; using the example of { C! } , then: before: 9 9 21000 after: 9 9 103 (103 is contents of 1-byte variable at 21000.)
{ CODE ... NEXT }	*	*	Defining words, used like { : } and { ; } , used when defining a new word using assembly language only.
CONSTANT	1	0	Creates a constant that has the value of top-of-stack; for example, before executing the phrase { CONSTANT CON } , the stack looks like: 9 9 25140

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			After the phrase has been executed, the stack looks like: 9 9 and the word CON , when executed, will place 25140 on the top of the stack.
CR	0	0	Causes the cursor to jump to the beginning of the next line of the display.
{ DO ... LOOP }	2	0	Looping construct that specifies a beginning and an ending-value-plus-one; see "What Is FORTH?" article, figure 3.
DROP	1	0	Drops top entry from stack; example: before: 9 9 3 5 after: 9 9 3
DUP	1	2	Duplicates item on top-of-stack; example: before: 9 9 3 5 after: 9 9 3 5 5
ECHO	1	0	Isolates the low-order byte of the 2-byte entry on top of the stack and writes it to the video display; example: before: 9 9 32 after: 9 9 (A space, ASCII decimal 32, is printed.) ECHO is named EMIT in some versions.
FILL	3	0	Fills an area of memory with a given value; for example, { 255 3000 100 FILL } fills memory locations from 3000 thru 3099 (100 bytes) with the value 255.
FORGET	0	0	Causes system to delete all definitions including and after the word following FORGET ; for example, { FORGET BASEPGM } causes the system to delete BASEPGM and all FORTH words, variables, and constants defined after it.

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H	0	1	*2-byte variable* containing address of the top of the dictionary; execution of this word causes the *address* of the variable H (not its value, which equals the address of the top of the dictionary) to be placed on top of the stack.
HERE	0	1	Places the address of the next byte to be used in the dictionary (the *value* of H) on top of the stack.
I	0	1	When executed within a { DO ... LOOP } , the word I pushes onto the top of the stack the value of the index counter; for example, { 10 0 DO I . LOOP } prints the numbers from 0 thru 9.
{ IF ... ELSE ... THEN }	1	0	Conditional execution of words depending on value of top-of-stack. If nonzero, execute words between IF and ELSE . If zero, execute words between ELSE and THEN ; for example, { IF " NUMBER ON TOP IS NONZERO" ELSE " NUMBER ON TOP IS ZERO" THEN } prints the appropriate message depending on the value on top of the stack.
KEY	0	1	Gets a single character from the keyboard; for example, if the stack before we press the space bar is: 9 9 3 5 Then, after we press the space bar (ASCII value decimal 32), the stack is: 9 9 3 5 32
MAX	2	1	Compares the two top entries on the stack and leaves only the larger; example: before: 9 9 3 5 after: 9 9 5
MIN	2	1	Compares the two top entries on the stack and leaves only the smaller; example: before: 9 9 3 5 after: 9 9 3
MINUS	1	1	Changes the sign of the entry on top of the stack; example: before: 9 9 3 5 after: 9 9 3 −5
OVER	2	3	Copies the second-to-top entry onto the top of the stack; example: before: 9 9 3 5 after: 9 9 3 5 3
PAD	0	1	PAD is a *2-byte variable* that points to the beginning of a 64-byte area for temporary storage of character strings; execution of this word causes the *address* of this 2-byte variable to be placed on top of the stack.
SWAP	2	2	Exchanges the two top entries on the stack; example: before: 9 9 3 5 after: 9 9 5 3
U*	2	1	The *lower 8 bits* of the two top entries on the stack are isolated and multiplied together, leaving their unsigned 16-bit product; example: before: 9 9 3 5 after: 9 9 15 Each factor will effectively be 255 or less, giving a product that will not overflow in 16 bits.
VARIABLE	1	0	Creates a variable that has the value of top-of-stack; example, before executing the phrase { VARIABLE VAR } , the stack looks like: 9 9 −14017 After the phrase has been executed, the stack looks like: 9 9 and the word VAR , when executed, will place the *address* of the variable on the stack. (The 2-byte number stored at that address will contain the value −14017.) Unlike a constant, the value of a variable can be changed using { ! } (store).
{] }	*	*	Resumes compilation of a colon definition. ■

Khachiyan's Algorithm, Part 1:

A New Solution to Linear Programming Problems

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Editor's Note:
This two-part article presents some of the most difficult mathematics we have ever published in BYTE, but we believe that the attention given to the Khachiyan algorithm of late warrants a complete and rigorous treatment here. Part 2 will contain a linear programming example and a TRS-80 BASIC program designed to illustrate the algorithm....CM

Khachiyan's Vector Notation
The vector notation used in Khachiyan's paper is different from that used by most Western mathematicians, so a word of explanation is in order. A system of linear equations (or, as in equation (1.1), linear inequalities) can be expressed in the form:

$$\mathbf{A}\,\mathbf{x} = \mathbf{b}$$

where $\mathbf{x}$ *is a column vector of the variables* x_1 *thru* x_n, $\mathbf{b}$ *is a column vector of the coefficients* b_1 *thru* b_m *(one for each of the m equations in the system), and* $\mathbf{A}$ *is an m-by-n matrix (m rows, n columns), where each row of the matrix* $\mathbf{A}$ *contains the coefficient for the corresponding equation. Khachiyan's notation expresses everything in terms of column vectors. In particular,* $\mathbf{a}_i$ *is a column vector containing the coefficients of the ith equation. But since the coefficient vector must be a row vector in order to be multiplied by the column vector* $\mathbf{x}$*, we follow Khachiyan's notation and denote the corresponding row vector as* $\mathbf{a}_i^t$ *where the superscript t denotes the transposition of column vector* $\mathbf{a}_i$*....GW*

The three-column headline "A Soviet Discovery Rocks World of Mathematics" was spread across the bottom of the front page of the *New York Times* for Wednesday, November 7, 1979. In the following weeks, subsequent articles were heralded as "Shazam! A Shortcut for Computers" and "Mathematician Is Obscure No More." Overnight, Leonid Khachiyan became famous as the author of a revolutionary discovery in the field of linear programming.

What has Khachiyan accomplished? All of the articles in the press are based on second- or third-hand reports and interpretations. [*In fact, the first* New York Times *article incorrectly heralded the discovery as a solution to the still-unsolved "traveling salesman" problem....GW*] Lynn Steen's article in *Science News*, "Linear Programming: Solid New Algorithm," (October 6, 1979) and Gina Bari Kolata's article in *Science*, "Mathematicians Amazed by Russian's Discovery," (November 2, 1979) discuss the basic problem of linear programming and then report on a paper by Peter Gács and Lazslo Lovász that discusses Khachiyan's algorithm. The Gács and Lovász paper opens with the statement "we have ignored his [Khachiyan's] considerations which concern the precision of real computations..." and then proceeds to describe a modification of Khachiyan's algorithm, although the differences between the two procedures are never made explicit.

The notation used in this article, although explained in the text, deserves some attention. In particular, the distinction between boldface and italics is an important one. An italicized variable refers to a scalar quantity (eg: $x_1=3$*). A variable in boldface refers to a column vector or a matrix. For example, in the equation* $\mathbf{Ax}=\mathbf{b}$*,* $\mathbf{A}$ *is a matrix and* $\mathbf{x}$ *and* $\mathbf{b}$ *are column vectors.*

Also, although this article is based on a paper written by Khachiyan, his discovery was not made without the benefit of previous work by other men. Khachiyan's paper is based on earlier work by A Yu Levin, N Z Shor, D B Judin, and A Z Nemirovsky....GW

This article will present a summary of and a commentary on Khachiyan's original paper. A graphic example of how the algorithm works is shown in figure 3. We will show how Khachiyan's method handles linear programming problems and discuss some possible improvements in the computer application of Khachiyan's proposals. We will then turn to the practical question: Is Khachiyan's algorithm capable of immediate computer application? Although our conclusion is a qualified "no," we will discuss a BASIC program (in Part 2 of this article) for the TRS-80 that can be used to gain an appreciation of Khachiyan's achievement.

Khachiyan's Paper

Our discussion of Khachiyan's paper is based on B Seckler's translation of the paper into English. We would like to thank Professor Seckler for making this translation for us. We use Khachiyan's notations in this discussion so that what he did and how he described it will be clear.

Consider the regions of the plane $\mathbf{R}^2$ shown in figure 1. The region in figure 1a is the intersection of the four half-planes $x_1 \geq 1$, $x_1 \leq 2$, $x_2 \geq 1$, and $x_2 \leq 2$. These inequalities may be rewritten in the form:

$$\begin{aligned} -x_1 + 0x_2 &\leq -1 \\ x_1 + 0x_2 &\leq 2 \\ 0x_1 - x_2 &\leq -1 \\ 0x_1 + x_2 &\leq 2 \end{aligned} \qquad (1.1)$$

Since there are points in the plane that satisfy all four inequalities at once, this system of linear inequalities is said to be *consistent*.

In figure 1b, the shaded region on the lower left-hand side is defined by $x_1 \leq 1$ and $x_2 \leq 1$, while the shaded region on the upper right-hand side is given by $x_1 \geq 2$ and $x_2 \geq 2$. If we combine these inequalities into one system:

$$\begin{aligned} x_1 + 0x_2 &\leq 1 \\ 0x_1 + x_2 &\leq 1 \\ -x_1 + 0x_2 &\leq -2 \\ 0x_1 - x_2 &\leq -2 \end{aligned} \qquad (1.2)$$

we notice that there is no point in the plane that satisfies all four inequalities at once. Such a system of linear inequalities is said to be *inconsistent*.

We shall use the letters **a**, **b**, ... to denote column vectors and **a**' to denote the transposition of the column vector into a row vector. (See text box.) We will write $\mathbf{R}^n$ for the usual n-dimensional Euclidean space. [*Readers unfamiliar with vectors and matrices will find descriptions in many engineering mathematics texts.* Advanced Engineering Mathematics *by E Kreyszig, Wiley, 1967, 2nd ed, is particularly good....***CM**]

Using the above notation, we may let $\mathbf{x}' = (x_1, x_2)$, $\mathbf{a}_1' = (-1,0)$, $\mathbf{a}_2' = (1,0)$, $\mathbf{a}_3' = (0,-1)$, and $\mathbf{a}_4' = (0,1)$. Then (1.1) may be rewritten in the form:

$$\mathbf{a}_i' \bullet \mathbf{x} \leq b_i \quad (\text{for } i = 1,2,3,4)$$

where $b_1 = -1$, $b_2 = 2$, $b_3 = -1$, and $b_4 = 2$.

As we see from figure 1, such a system of linear inequalities may or may not be consistent. We will consider only inequalities in which all coefficients are integers. This is no loss of generality, since numbers in a computer can be expressed only to a fixed number of decimal places. By multiplying each inequality through by an appropriate power of ten, we may express each inequality in integers alone.

Thus we are led to the following problem. Given a system of linear inequalities:

$$\mathbf{a}_i' \bullet \mathbf{x} \leq b_i \text{ for } i = 1,\ldots,m \qquad (2)$$

with integral coefficients, is the system consistent or inconsistent?

Advantages of Khachiyan's Algorithm

Khachiyan's algorithm is a procedure for deciding whether the system given in (2) is consistent. In addition, if the system is consistent, it finds the coordinates of a point satisfying all of the inequalities, or it at least determines them within a small margin of error. Furthermore —and this is the "revolutionary" aspect—the method gives at the start a maximum number of steps (each step

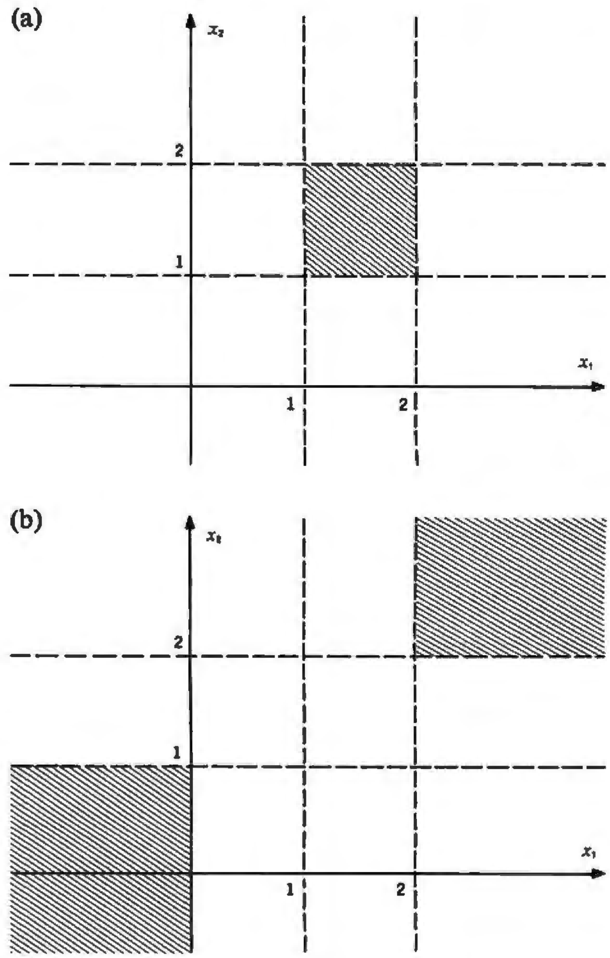

Figure 1: *Consistent and inconsistent systems of linear inequalities. The shaded area in figure 1a represents the solution set of the four inequalities, $x_1 \geq 1$, $x_1 \leq 2$, $x_2 \geq 1$, $x_2 \leq 2$. Since points exist that satisfy all four inequalities, the system is said to be consistent. The system shown in figure 1b is inconsistent. The lower shaded area is given by the equations $x_1 \leq 1$ and $x_2 \leq 1$; the upper shaded area is given by $x_1 \geq 2$ and $x_2 \geq 2$. No point satisfies all four inequalities simultaneously.*

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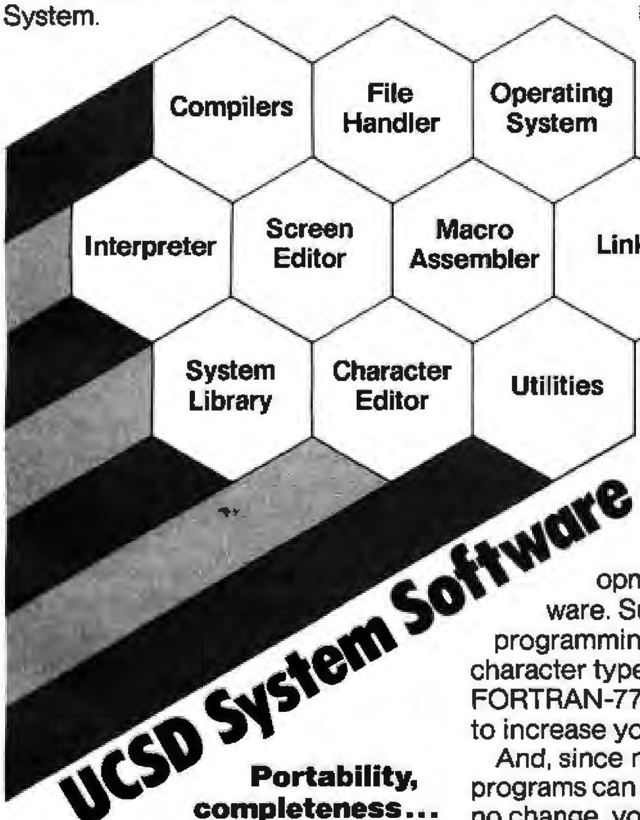

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Massachusetts and California residents add applicable sales tax. CM-17E-(5/80) requiring a fixed number of mathematical operations) that will be required to solve the problem. This maximum number of steps increases as the number of variables in the problem increases. With Khachiyan's method, however, the maximum number of steps grows far more slowly than with any other known method, as will be described shortly.

For a system given by (2), let:

$$L = \left[\!\left[\sum_{i=1}^{m} \sum_{j=1}^{n} \log_2(|a_i^j|+1) + \sum_{i=1}^{m} \log_2(|b_i|+1) + \log_2 nm \right]\!\right] + 1 \qquad (3)$$

where $[\![x]\!]$ denotes the greatest integer less than x. This quantity gives a measure of the size of the system (2) of inequalities and an estimate of the number of binary symbols (0 and 1) needed to pose the system for Turing machine solution.

The execution of the algorithm involves $N = 16Ln^2$ iterations. The values computed at each step are required to be accurate to 2^{-37nL}. Notice that as the system of inequalities is made more and more complicated, the number of steps in the algorithm increases as a polynomial in n. This means that the problem of determining the consistency of a system of linear inequalities belongs to the class of problems that are solvable in *polynomial time* on deterministic Turing machines. But from a practical viewpoint, it must be noted that the precision required also increases tremendously with the size of the problem.

[*The phrase "solvable in polynomial time" means that the time (or amount of computation) necessary to solve the problem is always less than a certain computable amount. The amount is computed by evaluating a function of n, the number of variables in the problem; and when the problem is solvable in polynomial time, the function uses only powers of the function (eg: time* $t=K_n^p$ *for Khachiyan's algorithm, for some very large value of K and some constant value p). This is an advantage when solving a linear programming problem because existing methods solve the problem in exponential time (a function that uses the term* e^n*), and, for a sufficiently large value of n, a solution in exponential time will take much longer than a solution in polynomial time. To date, the extremely high computation time has made computer solution of very large linear programming problems impossible. The significance of Khachiyan's algorithm being computable in polynomial time is that, on the surface, it opens the possibility of computer solution of these problems....GW*]

Details of the Algorithm

The steps of the algorithm involve four quantities: a vector $\mathbf{x}_k$ in $\mathbf{R}^n$ representing the estimate of a solution at the conclusion of the kth iteration; an n-by-n matrix, $\mathbf{Q}_k$, representing the dimensions of an ellipsoid containing the solutions of the system; the current discrepancy $\theta_k(\mathbf{x}_k)$ which measures how far the current estimate $\mathbf{x}_k$ is from being a solution; and the discrepancy of record, Θ_k, which keeps track of the best estimate of a solution found so far by being equal to the smallest θ value encountered within its first k values.

The principle of the algorithm is like the traditional method of catching fish in a net: casting the net over such a large region that some of what is wanted must be inside, then gradually decreasing the volume of the net. When the volume is sufficiently reduced, it becomes obvious whether or not anything has been caught.

At the initial step, $k = 0$, we set:

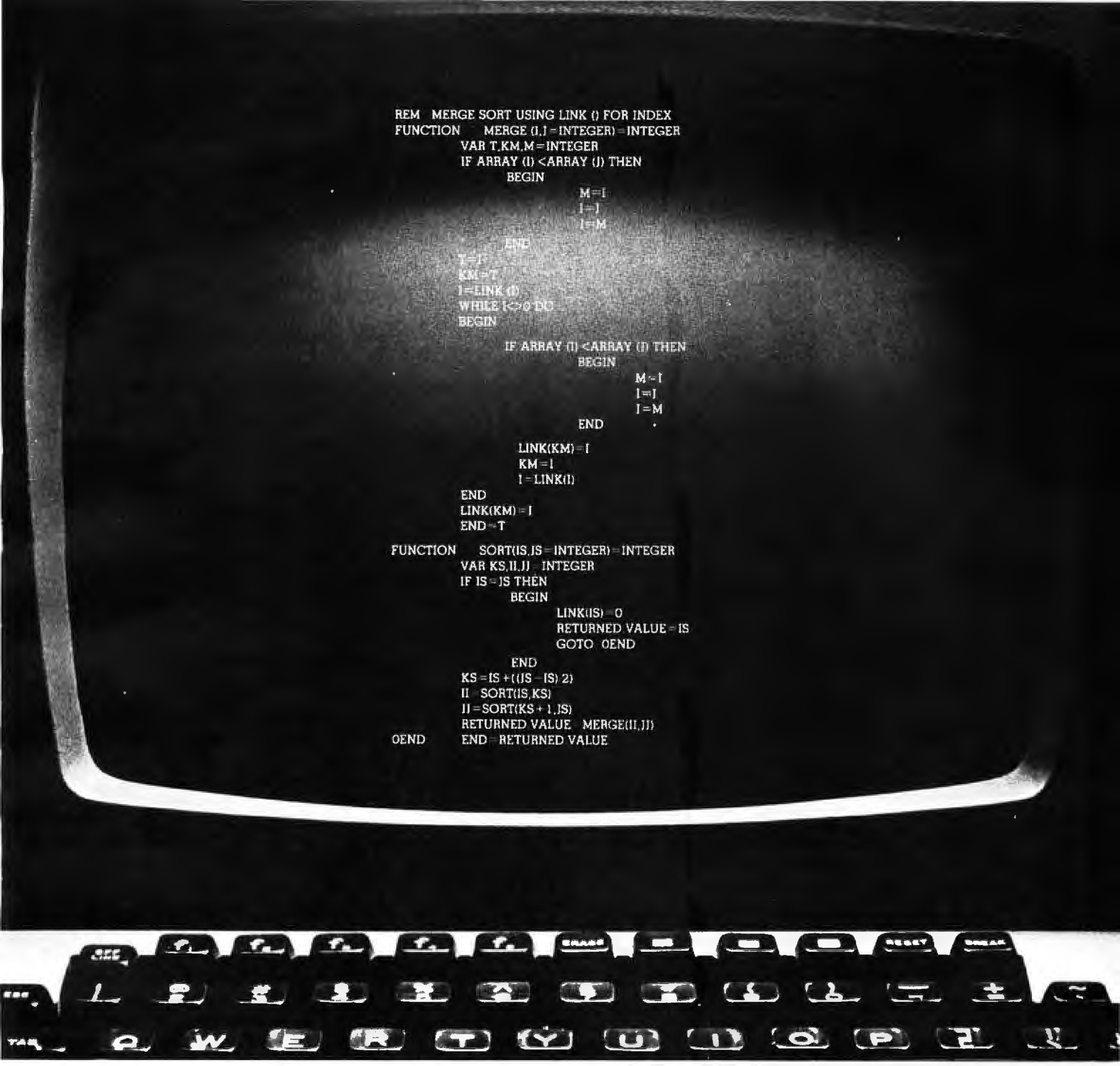
$$\begin{aligned} \mathbf{x}_0 &= 0 \\ \mathbf{Q}_0 &= 2^L \times \mathbf{I}_n \\ \Theta_0 = \theta_0(\mathbf{x}_0) &= \max_i\,(b_i) \end{aligned} \qquad (4)$$

(where $\mathbf{I}_n$ is the n-by-n identity matrix)

The execution of the algorithm at the kth step begins by finding the current discrepancy

$$\theta_k(\mathbf{x}_k) = \max_i\,(\mathbf{a}_i^t \cdot \mathbf{x}_k - b_i)$$

and recording the value of i (labeled *i(k)*) of the equation giving this maximum value. θ_k measures the discrepancy of the current $\mathbf{x}_k$ from being a solution of (2), while *i(k)* specifies the index of the inequality that is the worst offender. The discrepancy of record, Θ_{k+1}, is defined as the minimum of Θ_k and $\theta_k(x_k)$.



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The algorithm then shifts the center of the ellipsoid net in the "direction" of $i(k)$ and shrinks the ellipsoid to close in on the desired solution. (See figure 3 and the following geometric interpretation of the algorithm in the text.) This is accomplished by setting:

$$x_{k+1} = x_k + \frac{1}{n+1} \frac{Q_k \cdot F_k}{\|F_k\|} \tag{5}$$

$$Q_{k+1} = 2^{1/(8n^2)} \times Q_k \cdot \mathrm{Ort}\ (F_k) \cdot \Lambda_n$$

where:

- $F_k = -Q_k^t \cdot a_{i(k)}$
- $\|F_k\|$ is the *norm* (or magnitude) of the column vector F_k
- Ort (F_k) is an orthogonal n-by-n matrix (constructed by the Gram-Schmidt process) with the first column equal to $F_k/\|F_k\|$ (remember that, because of its orthogonality, Ort(F_k) is a distance-preserving linear transformation)
- Λ_n is the n-by-n diagonal matrix with diagonal entries $(n/(n+1))$, $(n/\sqrt{n^2-1})$, ... , $(n/\sqrt{n^2-1})$

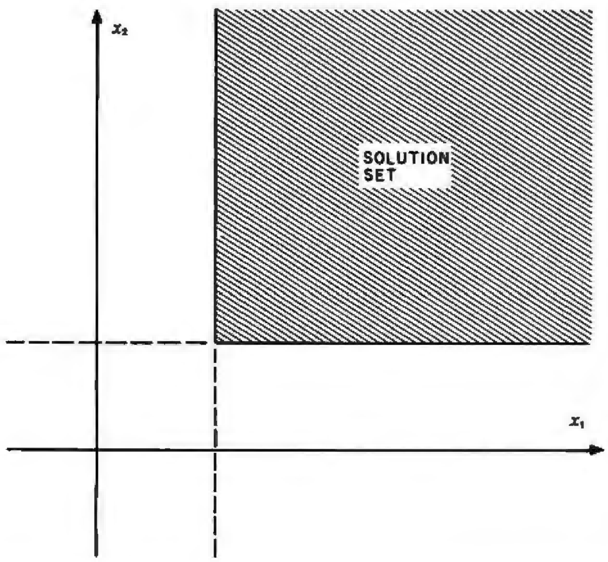

Figure 2: *A set of linear inequalities. The shaded area represents the solution set of the two inequalities, $x_1 \geq 1$ and $x_2 \geq 1$. Figure 3 shows how Khachiyan's algorithm solves this system of linear inequalities.*

It is possible to show by induction that the sizes of the quantities in (5) obey the following constraints:

$$\|x_k\| \leq \frac{1}{2} k\, 2^{16L}$$

$$\|Q_k\| \leq 2^{2L+k/n^2} \tag{6}$$

$$2^{nL-k/n} \leq \det(Q_k) \leq 2^{nL-k/(4n)}$$

where the norm of matrix Q_k ($\|Q_k\|$) is the square root of the sum of the squares of its entries. It is important to note that the point x_k generated by this algorithm may jump around in a rather random and sometimes extravagant manner, and that it is only the steady contraction of the region (which has a volume equal to det (Q_k)) that ensures that a solution will ultimately be found.

If $\theta_k\,(x_k)$ becomes zero or negative at any step, then x_k is a solution of the system (2), and the algorithm is terminated. If the algorithm runs through all $N = 16Ln^2$ steps, the discrepancy Θ_{N+1} is calculated and the process ends.

Geometry of the Algorithm

Geometrically, each solution **x** for the system (2) of inequalities can be considered as a point in n-dimensional space, and the aggregate of all such solution points forms a certain volume, the solution set. In Khachiyan's algorithm, each matrix Q_k specifies an ellipse E_k centered at the point x_k according to $E_k = [y: y = x_k + Q_k z, \|z\| \leq 1]$. [*A less formal description of E_k is as follows: the n-dimensional ellipse E_k is the set of points (or column vectors) y that are formed by adding the column vector $Q_k z$ to the current estimate x_k, where z is an arbitrary n-dimensional column vector with a length (magnitude) of 1 or less....*GW]

The initial choice of x_0 and Q_0 specifies a sphere of radius 2^L centered at the origin. It can be shown that this sphere contains at least a certain minimum volume of solution points, if any exist. The ellipses then change position and shrink, but they always contain at least the prescribed minimum volume of solutions. Khachiyan's observation is that, once the ellipse has shrunk to that

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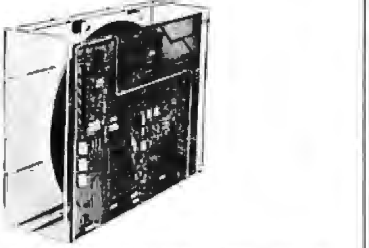

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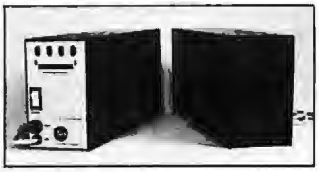

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SIRIUS 80+4 .... **$624.95**

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All 80+ Series Floppy Disk add-ons operate a 5 milliseconds track-to-track access time (eight times faster than the SA 400) but are Expansion Interface Limited to 12 milli-seconds for the TRS-80*.

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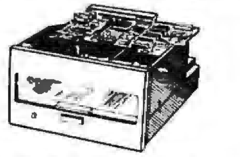

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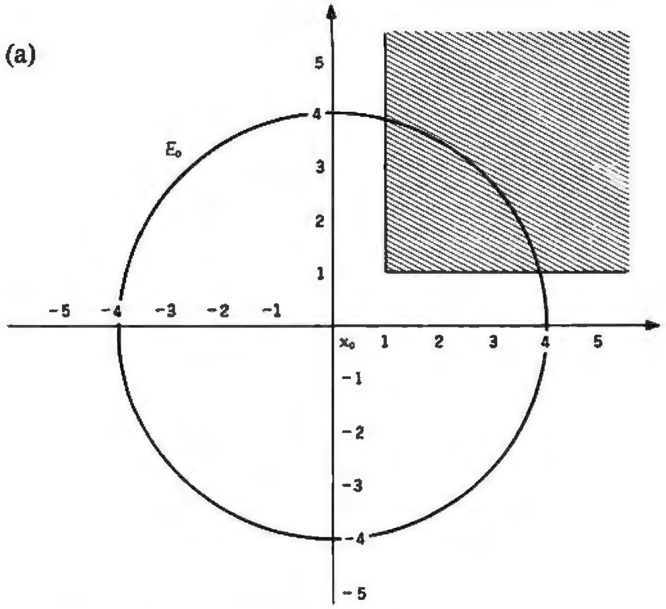

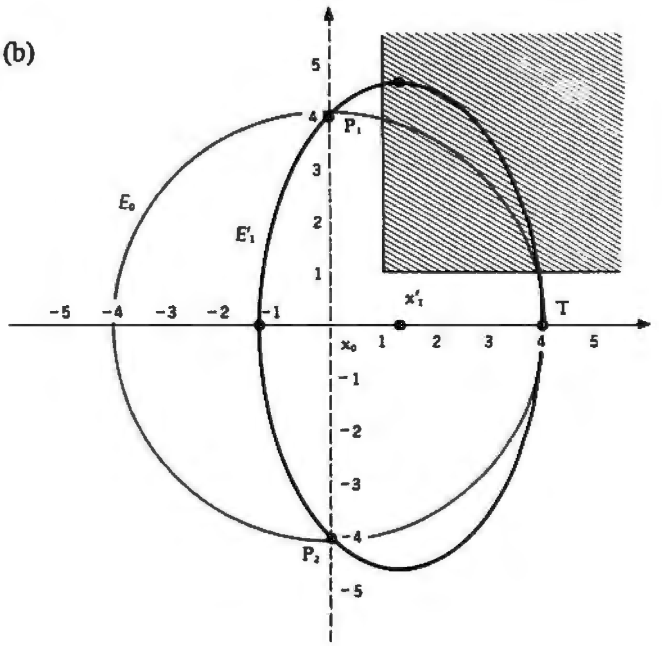

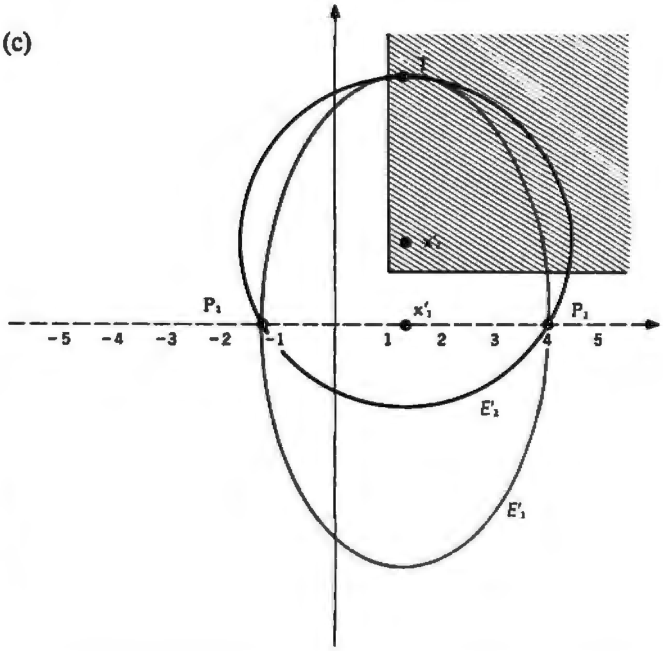

Figure 3: *A graphic example of Khachiyan's algorithm. The Khachiyan algorithm (described here for a two-dimensional problem) begins with a circle centered at the origin with a radius of a given size such that the circle is guaranteed to contain the solution points, if they exist. Successive iterations of Khachiyan's algorithm produce ellipses of smaller area that still contain the solution points. Here, the initial circle E_0 is shown in figure 3a. Ellipse E'_1 is then computed from E_0, as shown in figure 3b, and ellipse E'_2 is computed from E'_1, as shown in figure 3c. In the last two figures, the current ellipse is shown in black, and the previous ellipse is shown in gray. The shaded area in all three figures describes the inequalities' solution set.*

minimum volume (and it does so within $16Ln^2$ steps), it can contain *only* solutions. Thus, either the center x_k is a solution (making the discrepancy ≤ 0), or there were no solutions in the first place, and the system is inconsistent.

To see graphically how the ellipses evolve, we will consider the following simple system of linear inequalities:

$$\begin{aligned} -x_1 + 0x_2 &\leq -1 \\ 0x_1 - x_2 &\leq -1 \end{aligned}$$

graphed in figure 2. These are, in fact, the first and third inequalities of system (1.1).

To make the diagrams clearer, we do not take $L = 7$, as equation (3) would dictate, but $L = 2$, which we will later show (in Part 2) is permissible. This makes $x_0 = 0$ and $Q_0 = \text{diag}(4,4)$ (a 2-by-2 matrix with 4 in the main diagonal elements, 0 elsewhere). The initial ellipse E_0 is shown in figure 3a.

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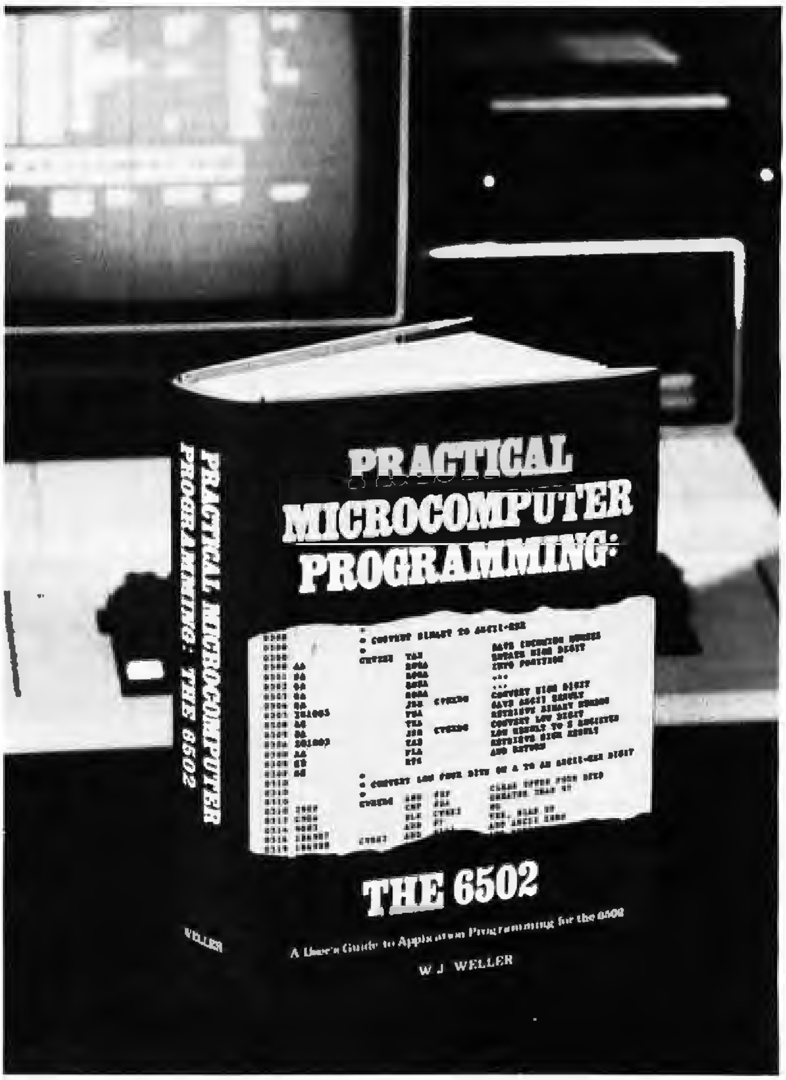

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The object of both the editor/assembler and the debugging monitor are sent to book purchasers **without charge** on either Apple II compatible cassette or paper tape when the licensing agreement at the back of the book is returned. The object code is also available on disk for the Apple II for a nominal charge.

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Khachiyan's algorithm is an approximation of the following geometric construction of the next ellipse E_{k+1} with center $\mathbf{x}_{k+1}$ from the known ellipse E_k with center $\mathbf{x}_k$. Since this construction does not give the exact results of the formulas in (5), we will denote the results of our construction by E'_{k+1} and $\mathbf{x}'_{k+1}$.

The ellipse E'_1 is determined from E_0 and $\mathbf{x}_0$ (see figure 3b) as follows:

- Draw a chord through $\mathbf{x}_0$ parallel to the boundary of the inequality most severely violated (indicated previously as having subscript $i(k)$). This chord cuts the ellipse E_0 at two points, $\mathbf{p}_1$ and $\mathbf{p}_2$. The solution set of the inequality $i(k)$ will lie on one side, the "solution side," of the chord. (The solution side of the hyperplane can be determined by examination.)
- The new ellipse E'_1 passes through $\mathbf{p}_1$ and $\mathbf{p}_2$, has its center on the solution side of the chord, and is tangent to the old ellipse E_0 at the point $\mathbf{T}$.
- Of the infinite family of ellipses satisfying the above conditions, choose the one with the smallest volume. $\mathbf{x}'_1$ is the center of this new ellipse E'_1.

The ellipses E'_1 and E'_2 (determined similarly from E'_1) are shown in figures 3b and 3c, each with its predecessor drawn in gray. Note that the ellipses are shrinking, the three having approximate areas of fifty, forty, and thirty-two square units respectively. The algorithm ended with ellipse E'_2, since its center $\mathbf{x}'_2$ is in the solution set.

It is important to notice that, while the requirements of tangency and minimal volume in our construction are aesthetically pleasing, they are impossible to achieve in practice. Remember that Khachiyan is concerned with a calculation procedure having only a limited degree of accuracy. If any of the numbers encountered in the execution of the algorithm could not be exactly represented in the computer, the cumulative effect of the resulting roundoff errors could be fatal, particularly in the detection of the inconsistency of a system of inequalities. The paper of Gács and Lovász, mentioned previously as ignoring questions of computational precision, presents a modification of the algorithm that computes the tangent ellipses of minimal volume. Thus the Gács-Lovász formulas cannot be expected to be successful in any actual computation.

Khachiyan overcomes this difficulty by choosing his ellipses slightly larger than necessary so that, even with his limited accuracy, he can assure that the region he wants is contained in them. The trick here is that if the ellipses are made too large, they will not shrink down on the solutions fast enough. Khachiyan's formulas in (5) for the ellipses achieve the proper balance between the problem of accuracy and the need for a rapidly shrinking series of ellipses.

If you carry out the calculations for the example of figure 2, you will find that, while E'_1 passes through the points $(0, 4)'$ and $(4, 0)'$, Khachiyan's ellipse E_1 passes through $(0, 4.12)'$ and $(4.06, 0)'$.

Part 2 of this article will discuss a fundamental shortcoming of Khachiyan's algorithm and will include a program in BASIC for the TRS-80. ■

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Construction of a Fourth-Generation Video Terminal, Part 1

Theron Wierenga
POB 2007
Holland MI 49423

The construction of this fourth-generation video terminal is a project that began as a detour from the plans for building a 16-bit microcomputer. I have had a long-standing interest in building an advanced-design video terminal that would have a scrolling feature and a large 2000-character display. It was my desire to have the terminal utilize one of the new programmable video-display-controller integrated circuits, and be a stand-alone unit with its own microprocessor that would not steal cycles from or otherwise load down the host computer. The number of additional parts that are needed to add the microprocessor is quite minimal and, in turn, the microprocessor reduces additional interfacing that would be otherwise needed. The circuitry of this terminal, when wire-wrapped on a single board, could fill one slot in the motherboard of the planned 16-bit microcomputer, or could be used with any other host computer as a stand-alone unit.

Upon receiving a copy of Intel Corporation's *Peripheral Design Handbook* (April 1978 edition), I found a set of plans for just such a terminal. The article is entitled "CRT Terminal Design Using the Intel 8275 and 8279." This circuit and its associated software were the basis for my design. This month, in Part 1, I'll describe the construction up to the point where you can get the 8085 microprocessor operating. Next month, in Part 2, I shall tell about the procedures for assembling the keyboard and video circuitry, putting the control software into operation, and checking out the system. Readers planning to build this terminal should obtain a copy of the *Peripheral Design Handbook*, as well as the *MCS-85 Users Manual*, which describes the operation of the 8085 microprocessor. Included in the fifty-seven-page article are detailed design theory, system specifications, system hardware and software design, an explanation of software subroutines, and the original design schematics and data sheets on the Intel peripheral circuits that are utilized in the design. The Intel handbooks are available from Intel Corporation, Literature Department, 3065 Bowers Ave, Santa Clara CA 95051.

Terminal Features

Here are some of the features of this video terminal:

Display format: eighty characters per display row, twenty-five display rows.

Character format: 5-by-7 character contained within a 7-by-10 matrix, first and tenth lines blanked, first and seventh columns blanked, ninth line cursor position, blinking underline cursor.

Character recognized: Displayable characters: sixty-four American Standard Code for Information Interchange (ASCII) uppercase alphanumeric characters,

Control characters:
- Line feed (control-J),
- Carriage return (control-M),
- Back space (control-H),

Escape sequences:
- Cursor up (ESC, A),
- Cursor down (ESC, B),
- Cursor right (ESC, C),
- Cursor left (ESC, D),
- Clear screen (ESC, E),
- Home (ESC, H),
- Erase to end of screen (ESC, J),
- Erase line (ESC, K).

Characters transmitted: sixty-four

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Data rates: 300, 600, 1200, 2400, 4800 bits per second (bps).
Interface to host computer: 20 mA current loop.
Scrolling capability: Scroll-up feature implemented with 8257 direct-memory-access controller.

The author of the Intel article used an 8080A-based single-board computer, the Intel SDK-80, and an SBC-905 prototype board for the additional circuitry needed. I wanted everything to fit on a single board and to run off a single 5 V power supply, so extensive changes were made in my design. The schematic diagram appears in figure 1. The completed unit retains all of the original features plus one or two more.

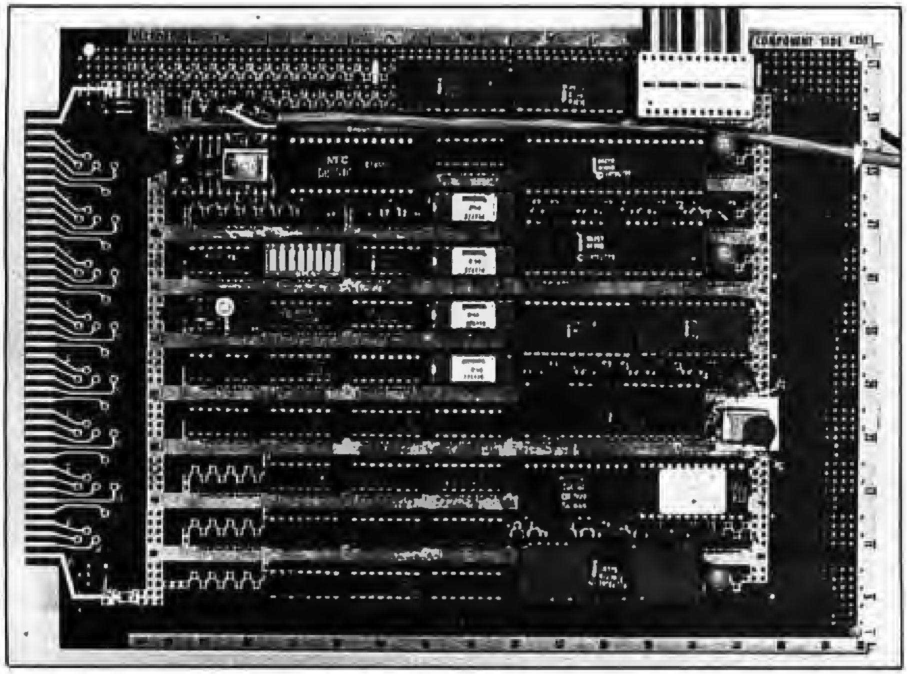


Photo 1: *The complete video terminal circuitry constructed on a wire-wrap board. The component side is shown.*

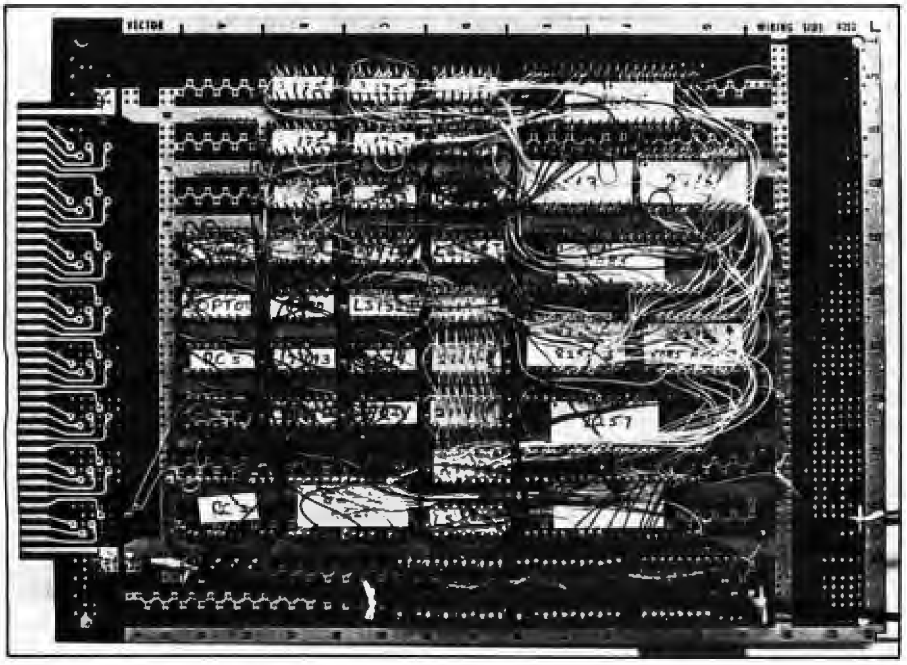


Photo 2: *The bottom or wired side of the video terminal board.*

Hardware Changes

The following are the major hardware changes that were made in my design:

- An 8085 microprocessor was substituted for the 8080A device. Although the parts count is about the same, the 8085 system needs only a single 5 V power supply. The 8085 microprocessor needs an additional 8212 latch for the lower address lines and a 74LS257 multiplexer to produce the control bus. The interfacing to the 8257 direct-memory-access controller is somewhat involved; a detailed schematic of this is provided in the *Peripheral Design Handbook* on pages 1 thru 82.
- The additional 8216 buffer from $\overline{\text{MEMR}}$ and $\overline{\text{MEMW}}$ is unnecessary. These signals can be taken directly from the 74LS257.
- A single 74LS138 decoder was used for enabling the peripheral circuitry (ie: the 8251, 8257, 8275, and 8279 devices).
- A 5 V type, 2513 character-generator read-only memory was substituted for the 2708. This saves programming the sixty-four 5-by-7 matrices into a 2708-type programmable read-only memory.
- The MD (mode) lines on the two 8212s that buffer the 2114 memory integrated circuits are tied to ground instead of +5 V. This is an error in the Intel schematic.
- Interrupt lines for the 8251 and 8275 are not connected into the 8085. The TRAP interrupt is pulled down to ground through a dual-in-line pin (DIP) switch. Opening this switch pulls up the TRAP interrupt, vectoring the 8085 microprocessor to a small system monitor.
- Video and sync signals were added together through the use of a 7401 open-collector NAND package and a single transistor to form a composite-video output.

Text continued on page 216

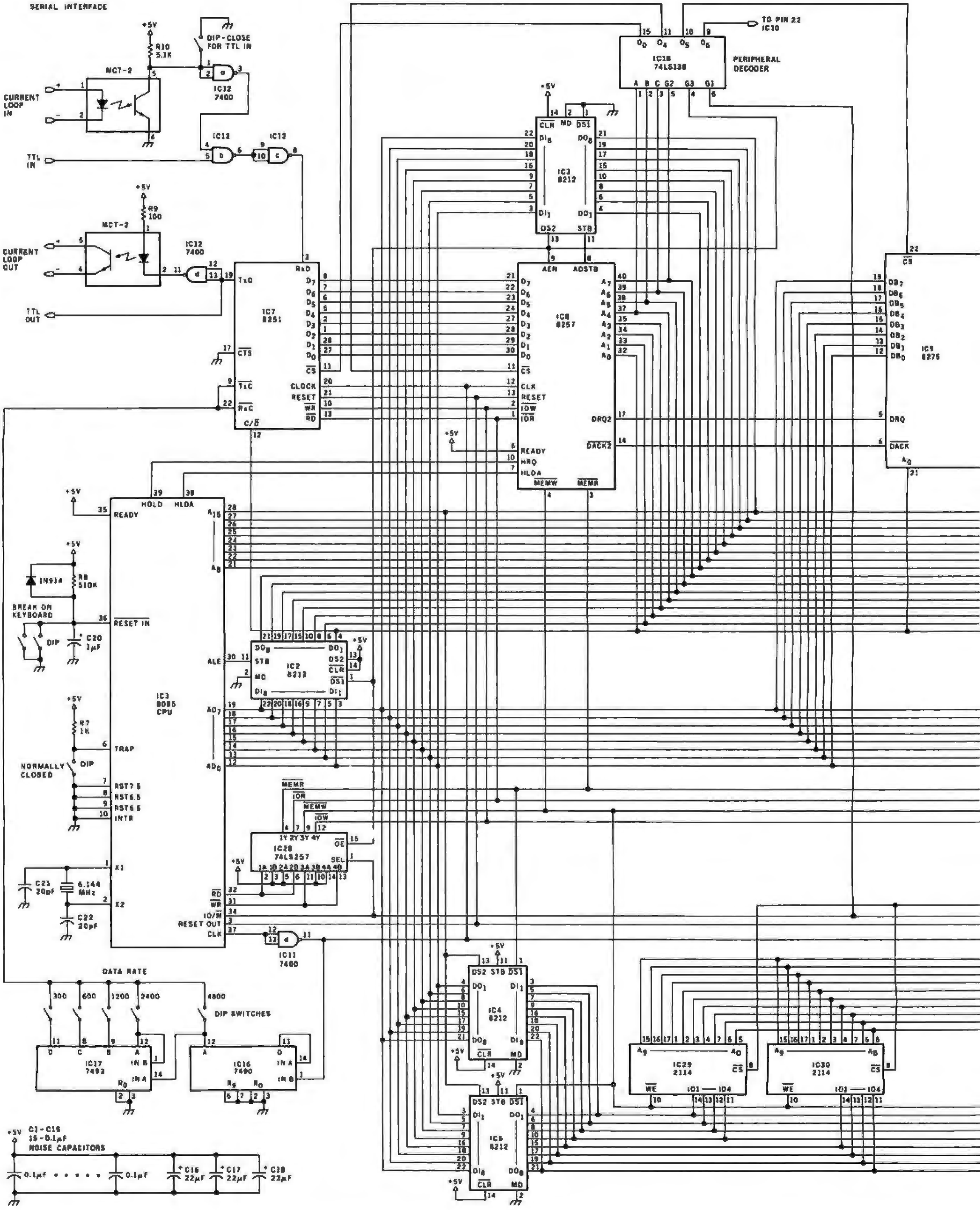
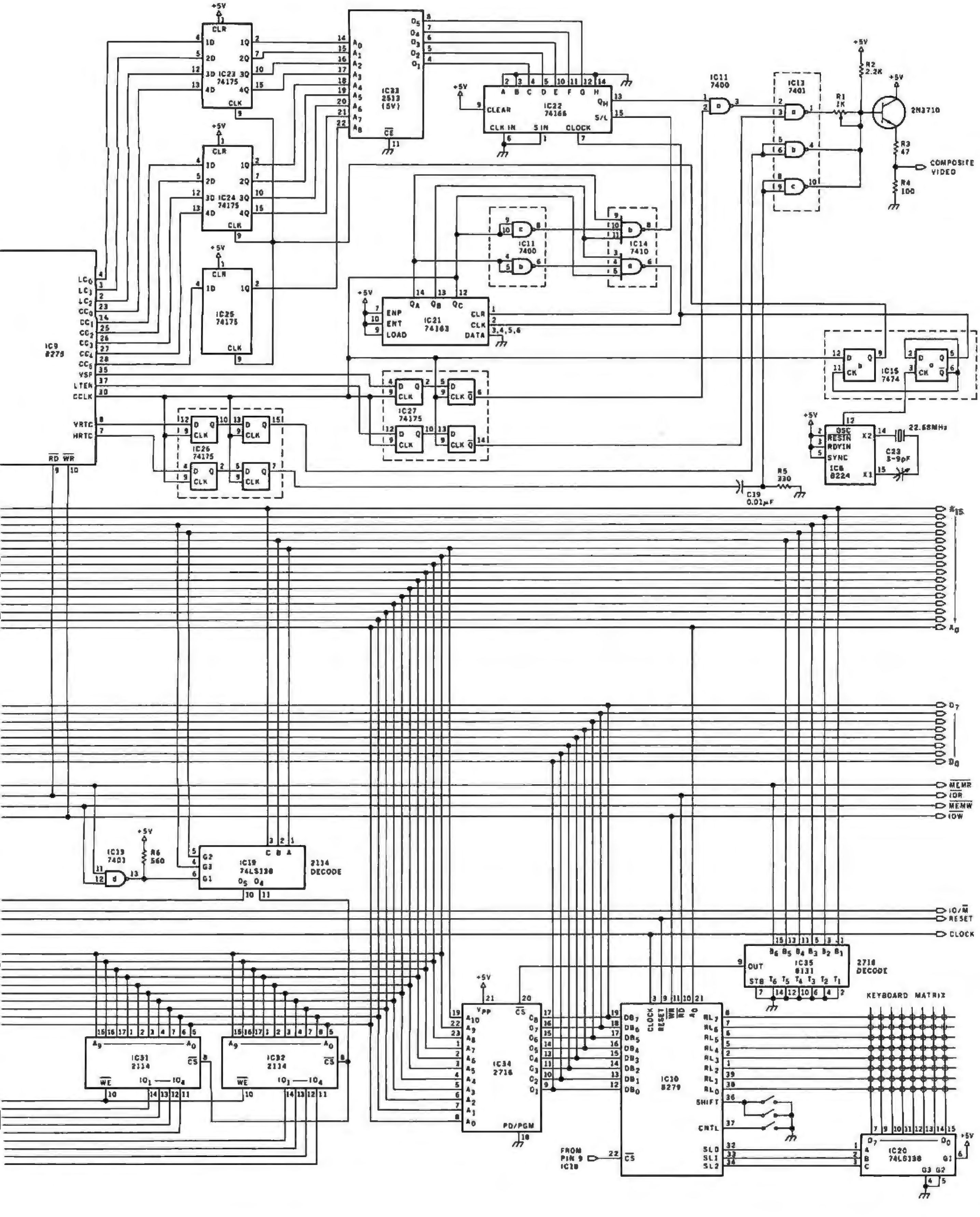


Figure 1: *Schematic diagram of the video terminal circuit. The Intel 8275 video-display controller is in the center of the figure.*


IC9
8275
IC23
74175
IC24
74175
IC25
74175
IC33
2513
(5V)
IC22
74166
IC11
7400
IC13
7401
2N3710
COMPOSITE VIDEO
IC14
7410
IC21
74163
IC27
74175
IC26
74175
IC15
7474
IC6
8224
22.68MHz
IC13
7401
IC19
74LS138
2114 DECODE
IC31
2114
IC32
2114
IC34
2716
IC30
8279
IC35
8131
2716 DECODE
KEYBOARD MATRIX
IC20
74LS138
FROM PIN 9 IC19
MEMR
IOR
MEMW
IOW
IO/M
RESET
CLOCK

Text continued from page 212:

- With a system clock of 6.144 MHz, data rates of 300, 600, 1200, 2400, and 4800 bps were generated with a 7490 and 7493 counter. Data-rate selection is through five positions of an eight-position DIP switch.
- A current-loop interface was used, since only a 5 V supply was available. There is also provision for direct access to the universal asynchronous receiver/transmitter (UART) pins.
- An 8131 comparator was substituted for the 74LS138 used for 2716 decoding.
- Decoding was done somewhat differently for the programmable memory, although the addresses still extend from hexadecimal 8000 to 87FF. These addresses make compatability with the 8257 direct-memory-access controller easy.
- Details are given as to how the keyboard is connected to the system. This is missing in the original article. An inexpensive unencoded keyboard (available from Jameco Electronics) was mounted using a printed-circuit board as well as some wire-wrap connections.
- The video monitor that I used is a 12-inch Motorola unit that takes a composite-video input signal. It was obtained as surplus in used condition. Whatever brand or size is used, it should have a bandwidth of 12 MHz.

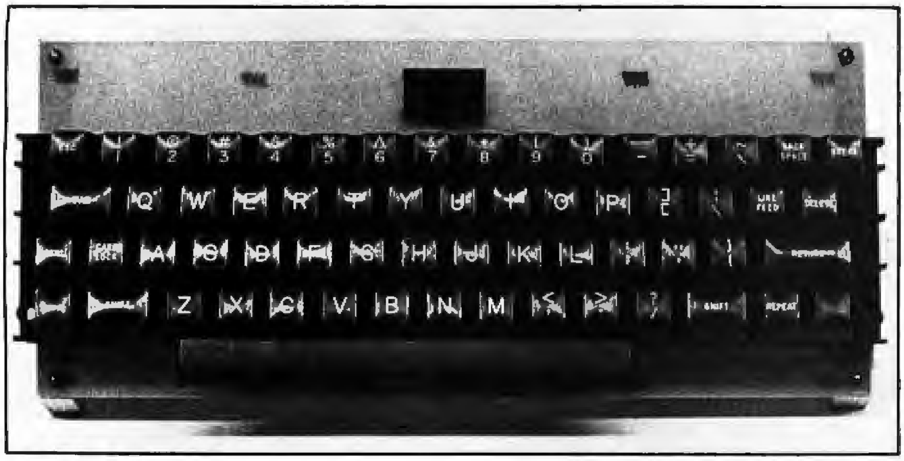


Photo 3: *The sixty-three-key Jameco keyboard mounted on its printed-circuit board and installed on support blocks.*

Software Changes

A number of changes were made in the software as supplied in the Intel articles. Several minor changes have no direct effect on the program execution, but rather just shorten the code. The major changes are as follows:

- The interrupt vectors at the top of the program were removed. A single vector for the TRAP interrupt was left in. When the TRAP switch is opened, the 8085 microprocessor will transfer control to a small system monitor that can be used for debugging.
- A polling system is used in place of the interrupt system to check the states of three of the peripheral systems. First, the system checks to see if a character has been received by the 8212; second, if the 8275 has requested that the 8257 be reinitialized; and third, if the 8279 has a character to be transmitted from the keyboard. A data rate of 4800 bps is still possible using this polling system.
- The table for character lookup for the keyboard has been changed completely. This was done to comply with the way that I had wired the scan matrix for the unencoded keyboard. A few additional ASCII codes were added that can be transmitted from the video terminal. These codes were for keys on the Jameco keyboard.
- The initialization of the 8251 and 8279 was changed. The values used should work for most systems.
- The 8257 was initialized to Mode 0 because of the change to a standard 2513 character generator.
- A system monitor was added at the bottom of the program which *has* five commands. The use of the monitor is covered in Part 2 of this article.

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Circle 155 on inquiry card.

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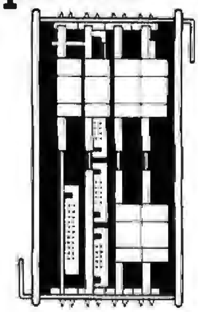

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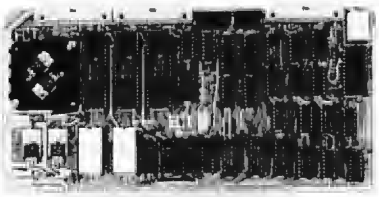

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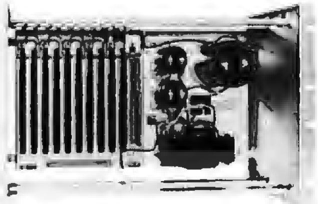

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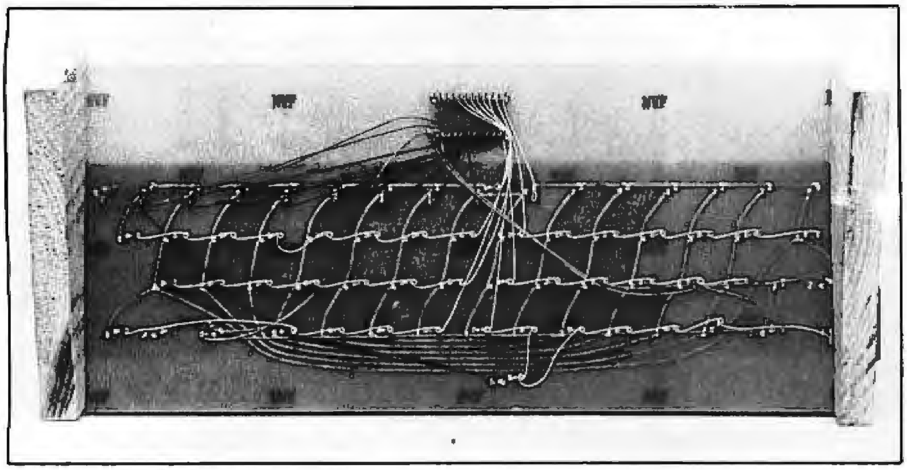

Photo 4: *The etch side of the keyboard circuit board, showing the jumper connections made necessary by use of the single-sided board.*

- The port numbers for the peripheral circuits have been changed. These values are set at the beginning of the video-control software.

Construction

The order in which the sections of this video terminal are built is very important. It is most unusual to put together a project as complex as this without having some sort of problems. Following the order as it is given here will help with some debugging, and hopefully make things go more easily. Do not try to assemble everything and then give it the smoke test.

I chose to connect the electronic parts by wire-wrapping. With the hundreds of connections necessary, it is almost impossible to not make a few wiring errors the first time around. Wire-wrapping allows you to add or change connections easily if it is necessary. Wire-wrap also allows for a very compact design, which helps to cut down the electrical noise in the system. You should have available an oscilloscope, frequency counter, a general-purpose volt-ohm milliammeter, a wire-wrap gun, 30-gauge wire strippers, and a quantity of 30-gauge wire (as well as the usual pliers, screwdrivers, soldering iron, etc).

A large Vector wire-wrap board (#4350) was used for the circuit, but several other general-purpose wire-wrap boards could also be used. Some individuals may choose one of the S-100 type boards, which would work just as well. Use one that has power and ground planes on it. This makes it easy to distribute the power supply lines to integrated circuits, and provides a good method for installing noise capacitors.

Glue the integrated-circuit wire-wrap sockets in place with an epoxy-type glue that comes in two components and must be mixed before use. After mixing the adhesive, wait until it starts to thicken considerably before applying it to the sockets. If the integrated-circuit sockets that you use do not have a few small holes in the bottom of the plastic body, make two or three holes with a 1/16-inch drill. This will give the glue something to which it can adhere. Do not use any of the "super glue" types of instant-bonding adhesive, as these are very thin and can bleed into the integrated-circuit socket, plugging up the pin holes and cementing the contacts together. An illustration of the parts layout is shown in figure 3.

Following my own particular order, I first make all connections to the power-supply pins on the integrated circuits. These connections are given in table 1. Connect 5 V to the power-supply bus and check out the voltage at the proper pins of each integrated-circuit socket before installing the integrated circuits themselves. When you *do* apply power to the circuit, have an ammeter connected to your power supply. High current readings are a quick indication of serious problems. The entire circuit when completed should draw about 1.6 A at 5 V. The usual precautions against static electricity when handling metal-oxide semiconductors (MOS) should be observed for the memory circuits, as

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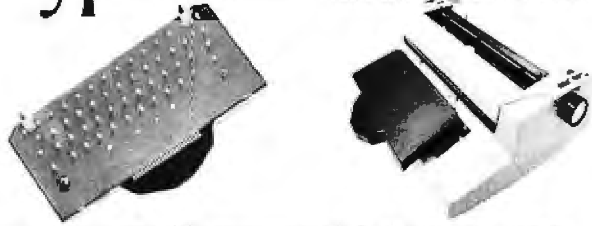

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well as all of the 8000-series Intel circuits.

Next, make a photocopy of the entire schematic diagram. As you begin to wrap connections, use a red pen to trace each connection made on the schematic. This simple method eliminates the need for a wiring table, but establishes a complete bookkeeping system that indicates which connections are installed or incomplete.

It is helpful to use as many different colors of wire as possible. The address bus can be done in one color, the data bus in another, power-supply lines can be red for +5 V and black for ground, and so forth. This is a great help when you have to trace down wires to check connections. Take the time to cut each wire to the exact length needed. Do not make wires any longer than necessary. Route wires neatly in between the wire-wrap sockets, and try to keep the interior portion of the socket area free from bundles of wires. A neat board is much easier to troubleshoot than the "rat's nest" variety.

The few resistors and capacitors that are needed can be mounted on one 16-pin and one 24-pin header plug. The 22.68 MHz crystal and 2N3710 transistor can also be mounted on the 24-pin header plug. The 6.144 MHz crystal with its two 20 pF capacitors is mounted next to the 8085 with Vector T-49 Klipwrap pins.

Getting the 8085 Microprocessor Operating

The first integrated circuits to install are the 8085 (IC1), 8212 (IC2, low address latch for the 8085), 74LS257 (IC28), 8131 (IC35), 2716 (IC34), 8251 (IC7), 74LS138 (IC18, peripheral decoder), 7490 (IC16), 7493 (IC17), the eight-position DIP switch, and IC11 (the 7400 NAND package that contains a gate to buffer the clock output of the 8085). All of the connections should be made to these devices. Program the 2716 read-only memory with the 22-byte checkout program that is given in listing 1. Temporarily ground the HOLD input to the 8085 (pin 39) and three of the inputs that are normally driven by the AEN output (pin 9) of the 8257. These inputs are at pin 4 of IC18 (the 74LS138 peripheral decoder), pin 1 of IC2 (the 8212 latch that holds the low address lines from the 8085), and pin 15 of IC28 (the 74LS257).

After you reset the 8085 microprocessor, the simple test program should send out continuous ASCII "U" characters from the 8251 transmitter data output (pin 19). With the 300 bps switch closed, pin 19 of the 8251 should produce a square wave at 150 Hz, which is 300 bps. The $\overline{IOW}$ line (pin 12 of the 74LS257) should show 30 Hz on a frequency counter. The negative pulses on $\overline{IOW}$ are very narrow and may not show up on an inexpensive oscilloscope. If you have these signals present, your 8085 microprocessor and its associated circuitry are working correctly.

Do not go beyond this point in construction until your 8085 microprocessor is functioning correctly. If you have problems, check the following items. Make sure that the clock output of the 8085 is 3.072 MHz, and that this signal is getting to

Text continued on page 224

Number	Type	+5 V	GND
IC1	8085	40	20
IC2	8212	24	12
IC3	8212	24	12
IC4	8212	24	12
IC5	8212	24	12
IC6	8224	16	8
IC7	8251	26	4
IC8	8257	31	20
IC9	8275	40	20
IC10	8279	40	20
IC11	7400	14	7
IC12	7400	14	7
IC13	7401	14	7
IC14	7410	14	7
IC15	7474	14	7
IC16	7490	5	10
IC17	7493	5	10
IC18	74LS138	16	8
IC19	74LS138	16	8
IC20	74LS138	16	8
IC21	74163	16	8
IC22	74166	16	8
IC23	74175	16	8
IC24	74175	16	8
IC25	74175	16	8
IC26	74175	16	8
IC27	74175	16	8
IC28	74LS257	16	8
IC29	2114	18	9
IC30	2114	18	9
IC31	2114	18	9
IC32	2114	18	9
IC33	2513	24	10
IC34	2716	24	12
IC35	8131	16	8

Table 1: *Power connections for the integrated circuits in the schematic diagram of figure 1.*

Listing 1: *A test program for the 8085 microprocessor section of the video terminal. This should be programmed into the 2716 read-only memory. When the checkout terminal is connected using the temporary interface shown in figure 2 and the 8085 is reset, this program should cause the ASCII character "U" to be printed continuously on the checkout terminal.*

```
                           ; TEST PROGRAM 1 FOR CRT
                           ;
  0001                     CNCTL   EQU   1
  0000                     CNIN    EQU   0
  0000                     CNOUT   EQU   0
                           ;
                           ; INITIALIZE 8251
                           ;
  0000    3E7B                     MVI   A,07BH
  0002    D301                     OUT   CNCTL
  0004    3E27                     MVI   A,027H
  0006    D301                     OUT   CNCTL
                           ;
                           ; SEND CONTINUOUS U'S FROM 8251
                           ;
  0008    DB01             LOOP:   IN    CNCTL          ;INPUT STATUS
  000A    E601                     ANI   1              ;MASK TREADY BIT
  000C    CA0800                   JZ    LOOP           ;LOOP IF NOT READY
  000F    3E55                     MVI   A,055H         ;LOAD A LETTER 'U'
  0011    D300                     OUT   CNOUT          ;SEND OUT FROM 8251
  0013    C30800                   JMP   LOOP           ;LOOP AND SEND NEXT 'U'
                           END
 NO PROGRAM ERRORS
1
 8080 MACRO ASSEMBLER, VER 2.0   ERRORS = 0 PAGE 2

                                SYMBOL TABLE

  * 01

  A        0007       B        0000        C        0001       CNCTL    0001
  CNIN     0000 *     CNOUT    0000        D        0002       E        0003
  H        0004       L        0005        LOOP     0008       M        0006
  PSW      0006       SP       0006


IC CRT2B0
 :100000003E7BD3013E27D301DB01E601CA08003E57
 :0600100055D300C30800F7
 :0000000000
 $
```

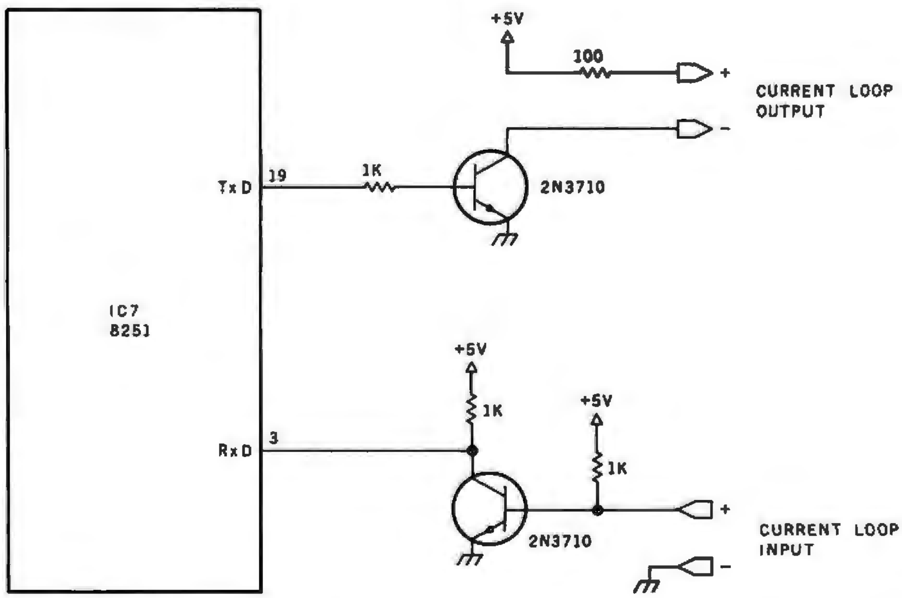

Figure 2: *Schematic diagram of the temporary interface for connecting the checkout terminal to the new terminal for debugging.*

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

SELECT FUNCTION BY NUMBER-

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

WHICH ONE? (ENTER 1-24)
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05 = PRINT (1,2,3): 06 = NUMERIC COMBINATIONS: 07 = SORT
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PRICES: Programs 1-23 EXC (19,20,22,23) £475 — £575 Stock Integrated Option + £100 Bank Integrated Option + £100

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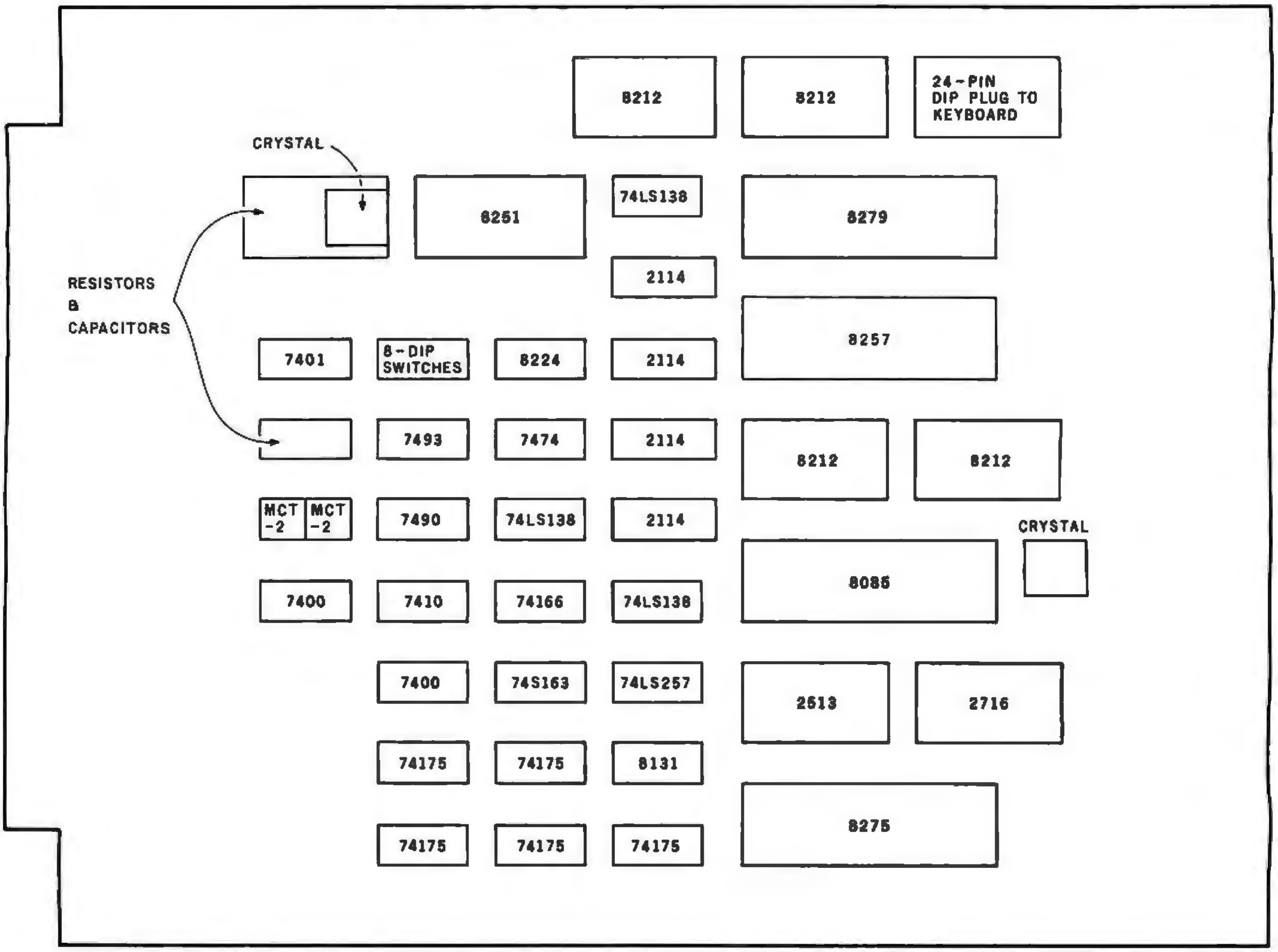

Figure 3: *Diagram of the parts layout on the component side of the main circuit board of the video terminal. A type 4350 Vector wire-wrap board was used.*

Photo 5: *An example of the display produced on the surplus Motorola video monitor.*

Text continued from page 220:
pin 20 of the 8251. Check the $\overline{TxC}$ and $\overline{RxC}$ inputs of the 8251 (pins 9 and 25). The frequency on these inputs should be sixty-four times the desired data rate (ie: for 300 bps it should be 19,200 Hz). If this frequency is not correct, check the connections on the 7490 and 7493, as well as the data rate switch. The ALE line (pin 30 on the 8085) should have a frequency of about 650.8 kHz on it. There should be no activity on the $\overline{MEMW}$ line (pin 9 of the 74LS257). The $\overline{IOR}$ line (pin 7 of the 74LS257) should have a frequency of about 92.2 kHz. The frequencies listed above should all be read with a frequency counter that uses a full 1-second count period, since the pulses on many of these lines do not have a constant duty cycle. Erroneous readings can result from count periods shorter than one second.

Until next month's BYTE arrives, you will have plenty of time to check the construction of this portion of the circuit. Then, in Part 2, we can proceed with the rest of the project. ■

Clubs and Newsletters

Lifelines from Lifeboat

The primary objective of *Lifelines* is to keep readers informed of the current status of all CP/M-compatible software. Issues include statistics on the wide variety of CP/M-compatible software products distributed by Lifeboat Associates. In addition there will be three sections dealing with changes, bugs, and new products. Letters from users are featured. The newsletter recently published a Pascal review and an article on undocumented Z80 op codes. The subscription rate is $18 for twelve issues in the US, Canada and Mexico. Elsewhere the rate is $40. Write *Lifelines*, 1651 Third Ave, New York NY 10028.

International Computer Chess Association Shifts Headquarters

In order to handle the growing membership more effectively, the headquarters for the International Computer Chess Association (ICCA) has been transferred from Northwestern University in Evanston, Illinois, to Bell Telephone Laboratories in Murray Hill, New Jersey. All inquiries and membership applications should be sent to ICCA, c/o of Ken Thompson, Rm 2C423, Bell Telephone Labs, Murray Hill NJ 07974. Editorial material for the newsletter should be sent to B Mittman, *ICCA Newsletter*, Vogelback Computing Center, Northwestern University, Evanston IL 60201. Membership dues are $10. Back issues of the newsletter are $2 for a set of three.

Another Club in Florida

The Level II Club is an organization where TRS-80 owners can exchange software. The group has a large program library and will soon offer an ads section and programming contests. There are no membership fees. For more information, write Level II Club, 3713 Bay-to-Bay Blvd, Tampa FL 33609.

FORTH Interest Group

The FORTH Interest Group meets on the fourth Saturday of each month in the Special Events Room of Liberty House Department Store, Southland Shopping Center, Highway 17 at Winton Ave, Hayward, California. The group also publishes a newsletter, *FORTH Dimensions*. Editorial material is always welcome. A subscription to *FORTH Dimensions* is free when you join the FORTH Interest Group for $12 per year in the US, or $15 overseas. Contact the group by writing, FORTH Interest Group, POB 1105, San Carlos CA 94070.

International Apple Core

The International Apple Core (IAC) is a nonprofit independent organization that will act as the parent organization for local Apple computer groups. Membership is not open to individuals, although they may subscribe to the IAC's quarterly publication. The organization will offer information on hardware, software, application notes, and programming tips to member groups. The IAC will also make its library accessible to member groups. For more information, Apple user groups can contact the International Apple Core, POB 976, Daly City CA 94017.

Free Pascal Newsletter

The *Pascal Newsletter* has articles of general interest to computer enthusiasts, such as Pascal standards and programming techniques. Recent newsletter articles have included a history of Pascal compilers, a Pascal bibliography, a comparison of Rational Data Systems' (RDS) Pascal to competitive products, and a section on matters of programming style. Free subscriptions to RDS's *Pascal Newsletter* and a product brochure are available by writing or calling Rational Data Systems, 245 W 55th St, New York NY 10019, (212) 757-0011.

A Computer Group in Amarillo

The High Plains TRS-80 Users Group of Amarillo, Texas, meets the second and fourth Tuesdays of every month at the downtown branch of the Amarillo Public Library on 413 E 4th St, from 7 to 9 PM. The annual dues are $15. For information, write High Plains TRS-80 Users Group, POB 30545, Amarillo TX 79120.

TBUG-80 in Florida

This group in Tampa Bay, Florida, supports the use of the TRS-80 for games and business applications. Tutorial sessions at the meetings cover everything from the proper operation of the hardware to disk-based programming techniques. The club's newsletter contains program notes, reviews of products for the TRS-80, and letters of

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DB 8/2 48K	3900
DB 8/4	3030
32M PHOENIX	11800
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TELEVIDEO 912	775
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VB1B VIDEO	125	170
CB2 Z80 CPU	168	220
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DM 6400 64K 250ns	640	
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SOFTWARE—DISCS—MISC		
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general interest from members. For information on subscribing to the newsletter, joining the club, or learning about its electronic mail system, write to the Tampa Bay TRS-80 Users Group, *T-BUG 80 Newsletter*, POB 247, Tampa FL 33602.

Apple for the Teacher

Apple for the Teacher is a user group with emphasis on the educational uses of the Apple computer. Its newsletter features reviews of educational software, plus current information on educational computer grants and research. The group operates the national computer-aided instruction library for the Apple and is receiving donations from throughout the world. Contact Apple for the Teacher, 5848 Riddio St, Citrus Heights CA 95610.

Computer Society in Washington

The Whidbey Island Computer Society (WICS) is dedicated to promoting education and fellowship in the realm of home computing. The only requirement for membership is an interest in the field of microcomputing. The group currently has an AIM-65, Apple II, Heathkit H8, TRS-80, Exidy Sorcerer, and a Z80 homebrew system. WICS meets monthly on the second and fourth Saturday. For further information, contact Dee Minter, 1616 Larch Dr, Oak Harbor WA 98277, (206) 675-7964.

Gosub—TRS-80 Users Group

Gosub TRS-80 Users Group was formed to provide TRS-80 users with a place to exchange ideas, information, and other computer-related material. The group meets on the third Sunday of each month in the computer room at the Camar Corporation, 186 Prescott St, Worcester, Massachusetts. The meetings run from 2 to 5 PM. Membership dues are $6 per year and include a subscription to a monthly newsletter. The mailing address is POB 712, Worcester MA 01613, (617) 845-1851. ■

BYTE's Bits

First National Conference on Artificial Intelligence

Stanford University in Palo Alto, California, is hosting the first annual National Conference on Artificial Intelligence. The conference will be held from August 18 thru the 21. It is being sponsored by the newly created American Association for Artificial Intelligence (AAAI) in cooperation with SIGART. The topics will cover robotics, cognitive modeling, vision, problem solving and search, artificial intelligence languages and software, theorem proving, theoretical foundations, mathematical foundations, specialized systems, and more. Many artificial intelligence research groups and manufacturers will be demonstrating AI and other computer hardware and software. A tutorial program on August 18 will examine the current artificial intelligence research in this country. The AAAI is a group whose purpose is to study and disseminate information on AI in the US. AAAI officers are Allen Newell of Carnegie-Mellon University, president; Edward Feigenbaum of Stanford University, president-elect; and Donald Walker of SRI-International, secretary-treasurer. Membership information may be obtained by writing to Dr Bruce Buchanan, AAAI Membership, Computer Science Dept, Stanford University, Stanford CA 94305. ■

Circle 178 on inquiry card.

Event Queue

AUGUST 1980

August 4-6
Data-Entry Management and Supervision Seminar, Chicago IL. This seminar is designed for data-entry managers and supervisors. Topics will range from data-entry control techniques and improving data-entry operator productivity, to personnel communications and motivation. Contact MIC, 140 Barclay Ctr, Cherry Hill NJ 08034, (609) 428-1020.

August 12-14
Computer Graphics '80, Birmingham, England. Computer Graphics '80 will bring together experienced users and specialists to present applications experiences and research findings. In addition to the conference, there will be an equipment exhibition and an animated film festival. To register, contact Paula Stockham, Online, Cleveland Rd, Uxbridge UB8 2DD, England, phone Uxbridge (0895) 39262.

August 14-24
Electronics/China '80, Guangzhou (Canton), China. This is the first exhibition of US electronic companies in the People's Republic of China. The United States-China Trade Consultants are the sponsors of the show. Products demonstrated will include circuit components, system elements, test instrumentation, product equipment, and materials. Details are available through Expoconsul Inc, Clapp and Poliak Inc, Princeton-Windsor Office Park, POB 277, Princeton Junction NJ 08550.

August 23-24
Personal Computer Arts Festival, Philadelphia Civic Center, Philadelphia PA. Tutorials, seminars, musical performances, and graphic extravaganzas will be featured in this show. Contact PCAF '80, c/o Philadelphia Area Computer Society, POB 1954, Philadelphia PA 19105.

August 18-21
First National Conference on Artificial Intelligence, Stanford University, Palo Alto CA. This is the first annual National Conference on Artificial Intelligence. It is being sponsored by the newly created American Association for Artificial Intelligence in cooperation with SIGART. The topics will cover robotics, cognitive modeling, vision, problem solving and search, artificial intelligence languages and software, theorem proving, theoretical foundations, mathematical foundations, specialized systems, and more. Many artificial intelligence research groups and manufacturers will be demonstrating AI and other computer hardware and software. A tutorial program on August 18 will examine the current artificial intelligence research in this country. Information may be obtained by writing to Dr Bruce Buchanan, AAAI Membership, Computer Science Dept, Stanford University, Stanford CA 94305.

August 25-27
Summer Computer Simulation Conference, Olympic Hotel, Seattle WA. Emphasis will be on computer networks, graphics tools for simulation, database management, and management science models, in addition to papers in such traditional areas as simulation. For details, write Simulation Councils Inc, 1980 Summer Computer Simulation Conference, POB 2228, La Jolla CA 92038.

August 25-28

Implementing Cryptography in Data Processing and Communications Systems, University of Southern California, Los Angeles CA. For information on this conference, contact the University of Southern California, Continuing Engineering Education, Powell Hall 216, University Park, Los Angeles CA 90007, (213) 746-6708.

August-December

Short Courses, George Washington University, Washington DC. These courses will cover programming for beginners, configuration management of software programs, computer performance evaluation, Pascal programming, and more. Contact the Director, Continuing Engineering Education Program, George Wasington University, Washington DC 20052, (202) 676-6106, or toll-free (800) 424-9773.

August-December

Information Management Seminars for Professional Development, Harvard University, Cambridge MA. Courses on data communications, distributed systems, office automation, minicomputers, data-base management, computer graphics, computer mapping, and more, are being presented by the Laboratory for Computer Graphics. Write the Center for Management Research, 850 Boylston St, Chestnut Hill MA 02167, (617) 738-5020.

SEPTEMBER 1980

September 9-10

The Thirteenth International Symposium and Exhibition on Minicomputer and Microcomputer Applications, MIMI'80, Montreal, Canada. This symposium will cover communications, signal processing, data acquisition, control, robotics, education, hardware, languages, networks, and other topics. It is being held in conjunction with the first IASTED International Symposium and Exhibition on Office Automation. For more information, contact Professor M H Hamza, Dept of Electrical Engineering, University of Calgary, Calgary, Alberta, I2N 1N4 Canada.

September 11-13

Internepcon Semiconductor International Exposition and Conference, Republic of Singapore. Featuring an exhibition of production machinery, tools, hardware, materials, and test instruments, this show includes conferences keyed to the needs of the engineering, manufacturing, and support personnel of Southeast Asia. It is open to all persons engaged in electronics and semiconductor manufacturing. Contact Industrial and Scientific Conference Management Inc, 222 W Adams St, Chicago IL 60606, (312) 263-4866.

September 16-18

Wescon/80, Anaheim Convention Center, Anaheim CA. This year's show will include a large exhibition and a variety of talks covering communications, computers, microprocessors, consumer electronics, energy, office automation, semiconductor technology, and more. Contact Wescon, 999 N Sepulveda Blvd, El Segundo CA 90245, (213) 772-2965.

September 16 thru October 16

Eastern European Electronics Catalog Exhibit. Exhibits will focus on production tools and machines, test instrumentation, electronic components and hardware, computers for production, chemicals, and other materials. Symposia will cover electronic manufacturing techniques and progressive production computer technology. The host cities will be: Warsaw, Poland; Bucharest, Rumania; Sofia, Bulgaria; Budapest, Hungary; and Prague, Czechoslovakia.

For more information concerning the dates of appearance in each city and any other information, contact Harry Lepinske, East-West Operations, ISCM Inc, 222 W Adams St, Chicago IL 60606.

September 17-19

ACM Small/Personal Computer Conference, Rickey's Hyatt House, Palo Alto CA. This symposium will blend contributed papers with panel and informal discussions. Included will be hardware and software topics involving theory, design, construction, marketing, and applications. Discussions will cover microcomputer applications in business, industry, education, and the home. Details are available from Conference Chairman, Philippe Lehot, PLA, 976 Longridge Rd, Oakland CA 94610.

September 18-21

Mid-Atlantic Business and Home-Computer Show, DC Armory/Starplex, Washington DC. This is an end-user exposition featuring small- and medium-sized business systems, scientific and engineering computers, microcomputers, and electrotechnology. Contact Northeast Expositions Inc, POB 678, Brookline Village MA 02147, (617) 524-0000.

September 22-25

Software INFO, Hyatt Regency, Chicago IL. This is the first national conference and exhibition on packaged software held in the US. For more information, or to reserve exhibition space, call or write Software INFO, Suite 545, 222 W Adams St, Chicago IL 60606, (312) 263-3131.

September 23-25

Compcon '80 Fall, Capital Hilton Hotel, Washington DC. Sponsored by the Institute of Electrical and Electronics Engineers (IEEE), this show explores distributed computing and related topics. Discussions will cover interfaces, standards, and protocols; data communications and networking; computer systems; data bases; security; office systems; and more. Details from Compcon '80 Fall, POB 639, Silver Spring MD 20901.

September 24-27

The Tenth Annual Conference of the Society for Computer Medicine, San Diego Hilton, San Diego CA. This conference has been planned for physicians, attorneys, administrators, computer professionals, comptrollers, engineers, nurses, and anyone interested in the use of computers for patient care. Sessions on medical subjects, technical subjects, and contributed papers on new research in computer medicine will be offered. For information, contact Society for Computer Medicine, 1901 N Ft Myer Dr, Suite 602, Arlington VA 22209, (703) 525-0098.

September 25-28

Mid-Atlantic Personal and Business Computer Show, Philadelphia Civic Center, Philadelphia PA. General admission for adults is $5. This show is being produced by National Computer Shows, POB 678, Brookline Village MA 02147, (617) 524-0000.

September 26-27

Classroom Applications of Computers in Grades K Thru 12, Independence High School, San Jose CA. A visit to "Silicon Valley," tutorials, workshops, and exhibits will highlight this conference. The emphasis will be to inform teachers about the possible uses of computers in all areas of education. Contact Computer-Using Educators, c/o W Don McKell, Independence High School, 1776 Educational Park Dr, San Jose CA 95133.

September 27-28

New Jersey Personal Computer Show and Flea Market—80, Holiday Inn (North) Convention Center, Newark NJ. This show will feature an indoor commercial exhibit and sales area, an outdoor flea market with room for 100 sellers, and forums for all popular hobby computing systems. This show is primarily for hobbyists and small-business owners. The admission price is $4 in advance and $5 at the door. Contact NJPCS, Kengore Corporation, 9 James Ave, Kendall Park NJ 08824, (201) 297-6918 after 7 PM.

September 29-October 4

The Eighth International Conference on Computational Linguistics, Tokyo, Japan. This conference will provide a forum for a variety of computational linguistics topics including theories, methods, and problems of computational linguistics; models of natural language processing; applications of natural language processing; hardware and software supports for language data processing; and more. For information, contact Professor David G Hays, Twin Willows, 5048 Lakeshore Rd, Hamburg NY 14075.

OCTOBER 1980

October 6-8

APL Users Meeting. Toronto, Canada. This conference is aimed at APL users as well as those considering the future use of APL in their systems. Speakers will present papers that discuss the practical use of APL, managing APL resources, teaching APL, and APL programming techniques will be covered. The registration fee of $180 (Canadian currency) includes a copy of the proceedings. For a brochure and registration material, contact Rosanne Wild, I P Sharp Associates Ltd, 145 King St W, Toronto Ontario M5H 1J8, Canada.

October 6-9 and 14-17

The Eighth World Computer Congress, Tokyo, Japan, and Melbourne, Australia. Computer architecture and hardware, software, data base and information systems, computer networks and communication, information processing and education, and computers in everyday life are some of the topics that will be discussed at this conference. There will also be a large exhibition of hardware and software at the conferences.

Contact the US Committee for IFIP Congress '80, c/o The Bowery Savings Bank, 110 E 42nd St, New York NY 10017.

October 8-10

Circulation Computer Systems Symposium, Chicago Marriott Hotel, Chicago IL. More than 425 newspaper publishers, general managers, circulation directors, controllers, and data-processing managers are expected to attend. Workshop sessions will be held for participants who already have or who are considering automated circulation systems. For more information, contact American Newspaper Publishers Association, The Newspaper Center, POB 17407, Dulles Airport, Washington DC 20041, (703) 620-9500.

October 26-29

International Data Processing Conference and Business Exposition, Philadelphia Sheraton Hotel, Philadelphia PA. This conference is being sponsored by the Data Processsing Management Association. Contact Conference Coordinator, DPMA International Headquarters, 505 Busse Hwy, Park Ridge IL 60068, (312) 825-8124. ■

In order to gain optimal coverage of your organization's computer conferences, seminars, workshops, courses, etc, notice should reach our office at least three months in advance of the date of the event. Entries should be sent to: Event Queue, BYTE Publications, 70 Main St, Peterborough NH 03458. Each month we publish the current contents of the queue for the month of the cover date and the two following calendar months. Thus a given event may appear as many as three times in this section if it is sent to us far enough in advance.

Ask BYTE

Conducted by Steve Ciarcia

In "Ask BYTE," Steve Ciarcia answers questions on any area of microcomputing. The most representative questions received each month will be answered and published. Do you have a nagging problem? Send your inquiry to:

Ask BYTE
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If you are a subscriber to The Source, send your questions by electronic mail or chat with Steve (TCE317) directly. Due to the high volume of inquiries, personal replies cannot be given. Be sure to include "Ask BYTE" in the address.

Liquid-Crystal Displays

Dear Steve,

I recently examined a Milton Bradley Microvision miniature video game, which features a 1.5-inch-square liquid-crystal display (LCD) consisting of 16 rows of 16 square blocks. I want to build a circuit to drive this display unit. How difficult would it be to modify the circuit you presented for use with an 8-by-16 array of light-emitting diodes (LEDs)? (See "Self-Refreshing LED Graphics Display," by Steve Ciarcia, October 1979 BYTE, pages 58 thru 69.) The LCD display unit could provide useful capability to a single-board microcomputer.

I have also considered developing a programmable game cartridge for the Microvision console. The console contains two 9 V battery cells, a voltage regulator, a potentiometer "paddle control," a piezoelectric beeper, a 4-by-3 printed-circuit keypad, the LCD unit, and a 40-pin dual-inline-package integrated circuit that appears to be the display driver. The Blockbuster game cartridge that comes with the console contains a 28-pin integrated circuit, a window for the display, and labeled cutouts for four control keys, along with passive components. Communication between the cartridge and the console is via a 24-pin connector.

I don't expect you to design circuits for me; if you did that for everyone who writes, you would not have enough time for your own work. However, you could do me a real favor by identifying two integrated circuits in the Microvision game. The first has 40 pins and is marked "SCUS0488, H 7920." The second has 28 pins and is marked "TMS1100NLL, MP 3450A, DBU7932."

I hope you will keep up the good work.

Daniel Q Dye Jr

A lot of people are interested in using the LCD unit you mention. However, LEDs (light-emitting diodes) and LCDs have very different principles of operation. An LED becomes a source of light when you pass an electric current through it, consuming a fair amount of power. LCDs, on the other hand, act as voltage-controlled reflectors of light. When an AC voltage (not DC) is applied to a liquid-crystal display, the liquid changes from transparent to opaque, consuming relatively little power. Because of this, the design approach in my LED project does not work for LCDs. But don't despair: I

Continued on page 238

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OAE'S new **PP-2708/16** PROM Programmer is the *only* programmer with all these features:

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Omikron's Mapper + NEWDOS/80 8" Drives for the TRS-80

NEWDOS/80 is Apparat's latest upgrade to NEWDOS. Features include variable length records, chaining, and drivers specifically configured for Omikron's MAPPER II. $150.

MAPPER II adapts the TRS-80 to run both 5" and 8" drives. With NEWDOS/80, storage is increased to 300K per 8" drive. $99 plus $10 per cable connector.

MAPPER I adapts the TRS-80 to run the vast library of CP/M software as well as the TRS-80 software. All Lifeboat Software may be ordered for the MAPPER I. All MAPPER I CP/M software is compatible with the CP/M for the Model II. With MAPPER II and 8" drives, the Model I becomes disk compatible with the Model II. Standard features include lower case support, serial and parallel printer drivers, and an addressable cursor. MAPPER I is supplied with complete utilities including a memory test, a disk test, a copy program, and a proprietary program for converting TRS-DOS files to CP/M files. $199.

WORD PROCESSING—MAPPER I supports professional word processors like the Magic Wand and Word Star (see reviews in June 80 Kilobaud). Omikron's implementation includes a blinking cursor, auto repeat, shift lock, debouncing, and an input buffer that eliminates missed characters. Magic Wand super discount price $299.

FIELD PROVEN DESIGNS—After one year of MAPPER production, Omikron has established an impeccable reputation for reliability, integrity, and user support. Omikron's customers include the US Government, major corporations, universities, medical doctors, and professionals in all fields.

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FOREIGN ORDERS must include full payment in US funds plus $25 for air shipping and handling.

See reviews in July 80 and August 80 BYTE By Jerry Pournelle.

*CP/M is a TM of Digital Research. TRS-80 is a TM of Tandy Corporation.

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TRS-80*

APL 80

by Phelps Gates
The powerful scientific language is now available for the TRS-80. Disk version includes lessons, self-teaching manual, and the book, "APL: An Interactive Approach". Tape version loads in 16K Level II. Disk version permits up to 4 workspaces, user-defined functions, return to DOS without losing work-spaces, and many other features.
16K Level II cassette $14.95
32K disk with book $54.95
book separately .... $15.50 + $1

UP PERISCOPE

by Ron Potkin
Two players are pitted against one another as one tries to defend a convoy crossing the 32 x 32 hex area of sea. Submarine commander player tries to sink as many convoy ships as possible. If sub player sinks 3 or more of the 6 convoy ships, he wins. Standard hex-grid playing surface, torpedoes, ramming power, and depth charge capabilities bring back the thrill of open sea battles.
16K Level II cassette $14.95

INVASION

by Chris Freund
Your favorite arcade is now available for the TRS-80. Try to hit the descending *aliens before* they land on the bottom of the screen. Written in machine language for quick response, and no need to [ENTER]. Constantly moving graphics and synchronized sound effects make this a must for the arcade fanatic. Saves on quarters too!
16K Level II cassette $9.95
32K disk $14.95

APPLE*

MICROSOFT ADVENTURE

The original of ADVENTURE written for the DEC-10 systems is now available for the APPLE. Explore Colossal Cave for treasures while avoiding the dangers hidden within its many passages. 130 different rooms, 15 treasures, and characters ranging from helpful to deadly await you within the cave. Be careful where you step, and also who's behind you!
32K disk machine language $29.95

ANDROID NIM

by Leo Christopherson
The game that made Leo Christopherson famous is now available for the APPLE! The improved graphics and color of the APPLE make the game even better. Try to be the last one to shoot the androids on the screen, if you do, you win! Also includes realistic sound effects.
24K cassette machine language . $14.95

MAGIC PAINT BRUSH

Hi-Res graphics package plus! Draw Hi-Res pictures using all APPLE's colors. Connect any points on screen, fill areas, plot, rotate, and scale shapes, or 'paint' with a set of 9 brushes. Also comes with Shape Table Designer and 2 demo programs, Slot Machine and Applesoft Invaders.
32K disk Applesoft-ROM $29.95

THREE-D

You don't have to be an engineer or scientist to have high resolution graphics for your computer! This program permits rotation, scaling, shift, distortion, and combination of three dimensional graphics on the screen. MP Software.
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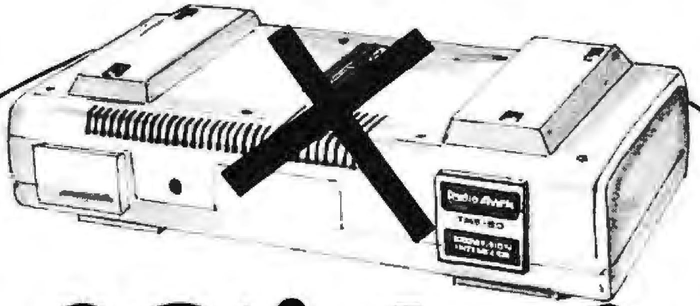

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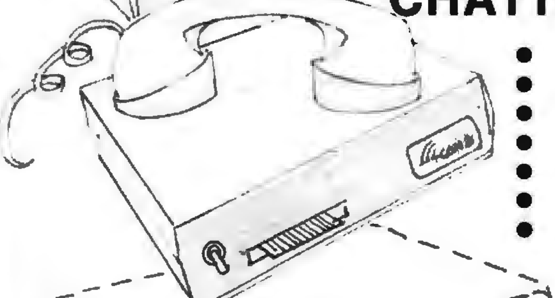

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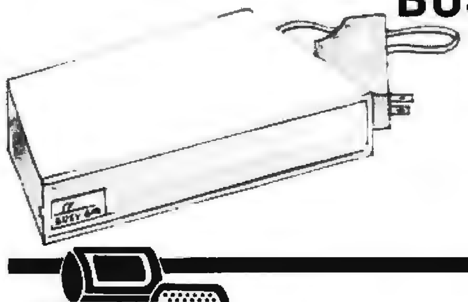

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Continued from page 234: *have written a tutorial article on LCDs to be presented in the October Ciarcia's Circuit Cellar.*

Concerning the components in the Microvision: the 28-pin device is a Texas Instruments TMS1000-series 4-bit microprocessor, that uses CMOS (complementary metal-oxide semiconductor) technology. The program for the Blockbuster game (or other game) is contained within it in a read-only memory. The 40-pin part is a custom multiplexed display-driver circuit for the LCD unit. The display driver is driven through the I/O (input/output) lines of the microprocessor. I hope I've helped.

Steve

The Very Busy Box

Dear Steve,

In all of your articles (which I read avidly) I have not seen any projects directed towards the Heath H8 computer system. I constructed my H8 hoping to learn about computer hardware, but instead found myself only following instructions. I find it very difficult to apply your projects to my system. It would be of great benefit if, in one of your articles, you would include information on interfacing your "house controller" (see "Computerize a Home," January 1980 BYTE, page 28) to the H8.

Bearing in mind that we H8 owners are basically hardware-oriented, I believe that we would be more likely to construct a project than someone who purchased a system completely assembled. Please consider the H8 in future articles; I am sure that the reception will be well worth the effort.

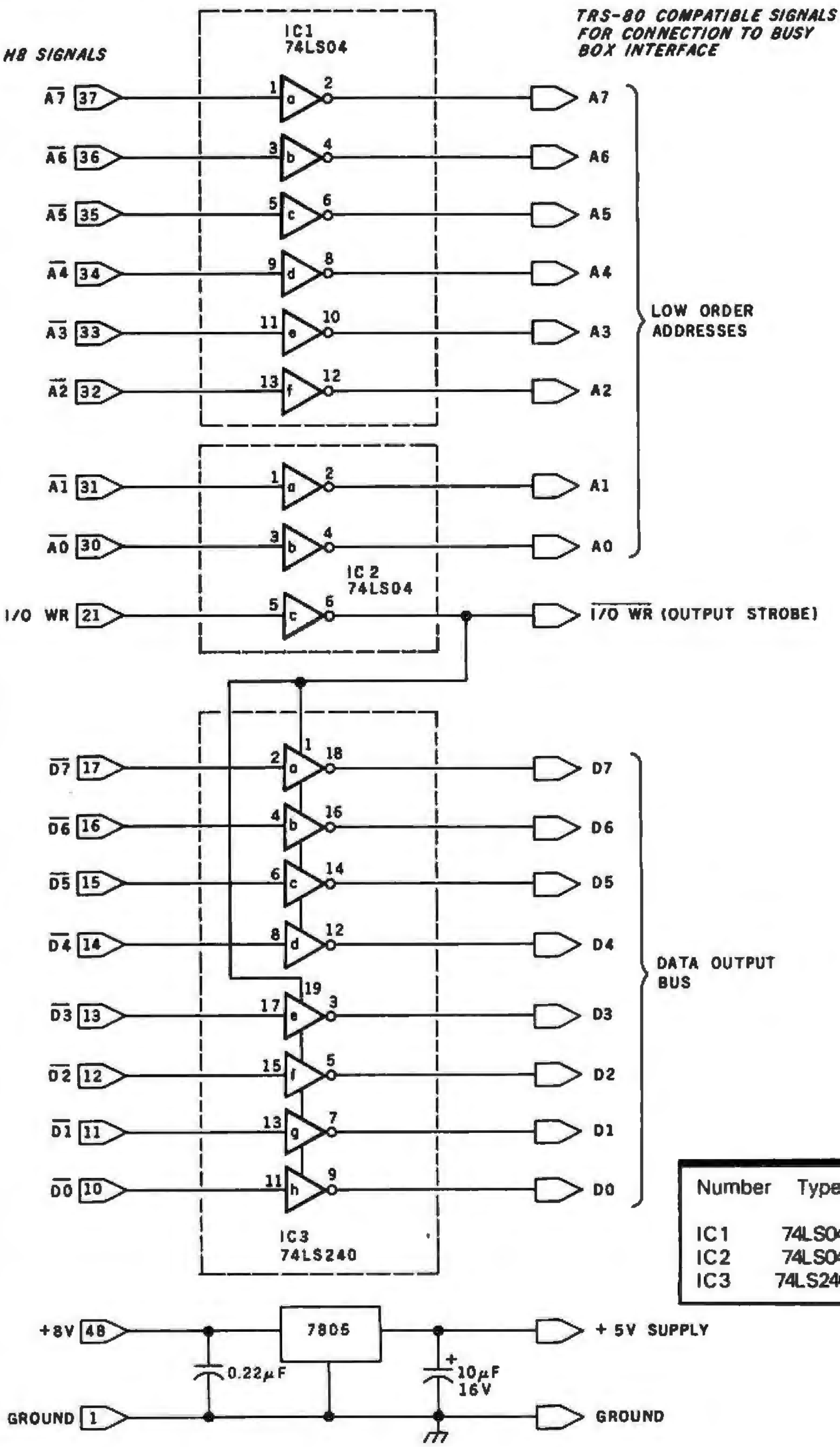
Ted Benglen

Most computers are equal where interfacing is concerned. If you look closely at the bus signals on your H8 you will notice a striking similarity between their names and the names of signals on the Apple and the Radio Shack TRS-80. The BSR interface (trademarked "Busy Box") requires an I/OWR strobe (the "*" indicates a negative-true signal), address lines A0 thru A7, data lines D0 thru D7, and power. All address and data bus lines on the H8 use inverted logic levels, so the circuit of figure 1 is necessary to make the system compatible with the TRS-80 attachment shown in the article.*

I generally try to list signal inputs so that experimenters will not be discouraged by a title that says "TRS-80" or "Apple." For simple input and output ports, the signals are often easily accessible and compatible among systems.

Steve

Figure 1



Number	Type	+5V	GND
IC1	74LS04	14	7
IC2	74LS04	14	7
IC3	74LS240	16	8

A Bit of Music

Dear Steve,

As a composer/performer, I found your article "Sound

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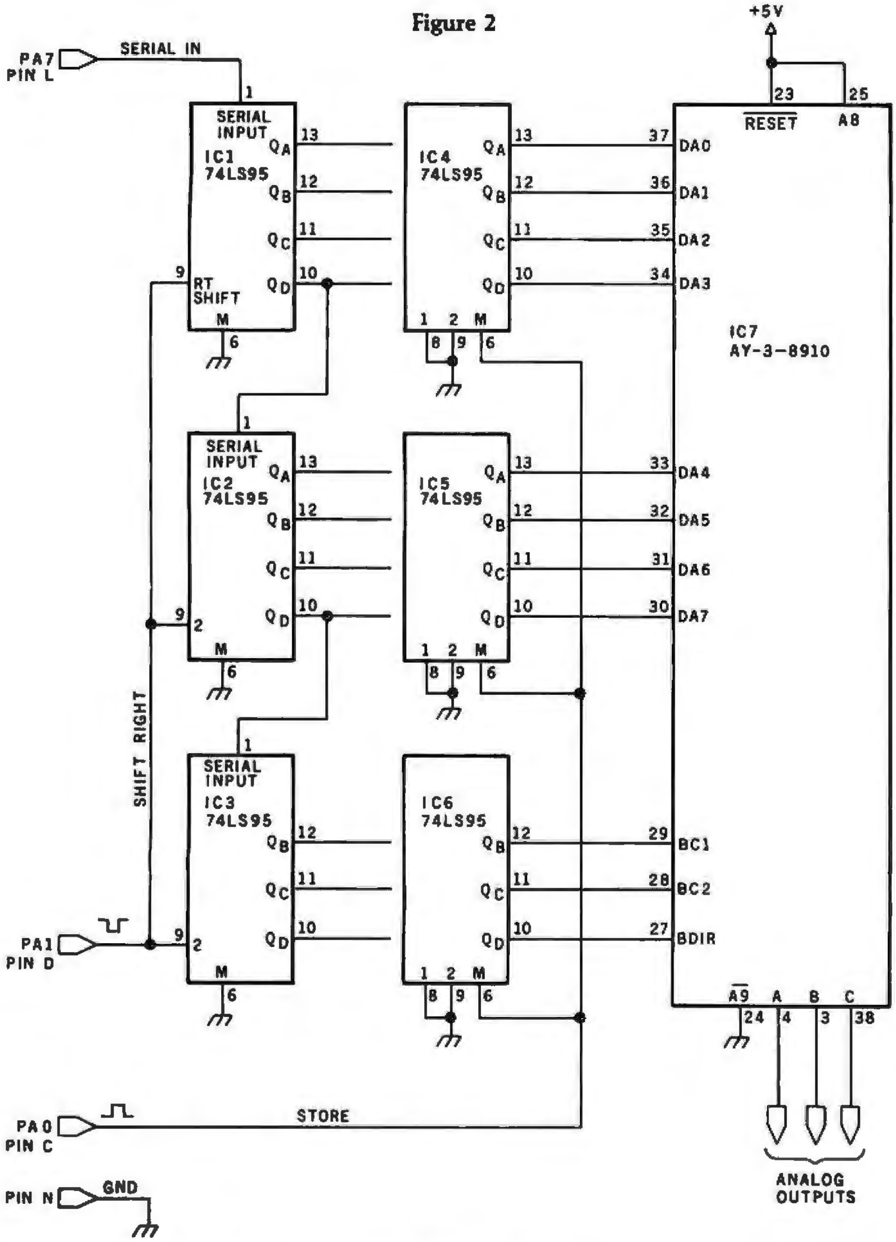
Figure 2



Number	Type	+5V	GND
IC1	74LS95	14	7
IC2	74LS95	14	7
IC3	74LS95	14	7
IC4	74LS95	14	7
IC5	74LS95	14	7
IC6	74LS95	14	7
IC7	AY-3-8910		

Off" (July 1979 BYTE, page 34) quite intriguing. The potential of computer-controlled music generation inspired me to purchase a Commodore PET, but the tones generated by my rudimentary system are not exactly musical.

I would appreciate any improvements and suggestions you might have. The limiting factor in my case, and I am sure this is true for others, is lack of proficiency with the instrument.

Jack Hobson

My talents are geared more toward building the instrument than making music on it. If you are reasonably adept at building circuitry, there is a way to run the General Instrument AY-3-8910 Programmable Complex Sound Generator from the parallel user port (J2) of the PET. The clocking of the integrated circuit is not critical, only the sequence of events, but the circuit does require 11 bits of information.

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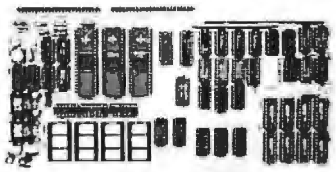

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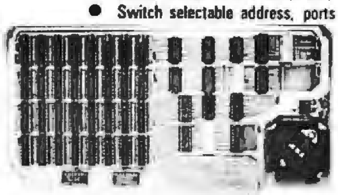

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The circuit of figure 2 here uses only 74LS95 4-bit parallel-access shift registers. IC1, IC2, and IC3 are paralleled to form a 12-bit shift register, and IC4, IC5, and IC6 make up a 12-bit latch. By setting the appropriate logic level on bit 7 of the user port, the information will be loaded into the 12-bit register when a high/low/high transition occurs on bit 1. When 12 bits have been loaded, a low/high/low transition on bit 0 can be used to latch the binary value and stabilize the information while more is loaded.

The fast action of the shift and store operations should be fairly transparent to the AY-3-8910, which should operate as described in the article.

Steve

A Bit More Music

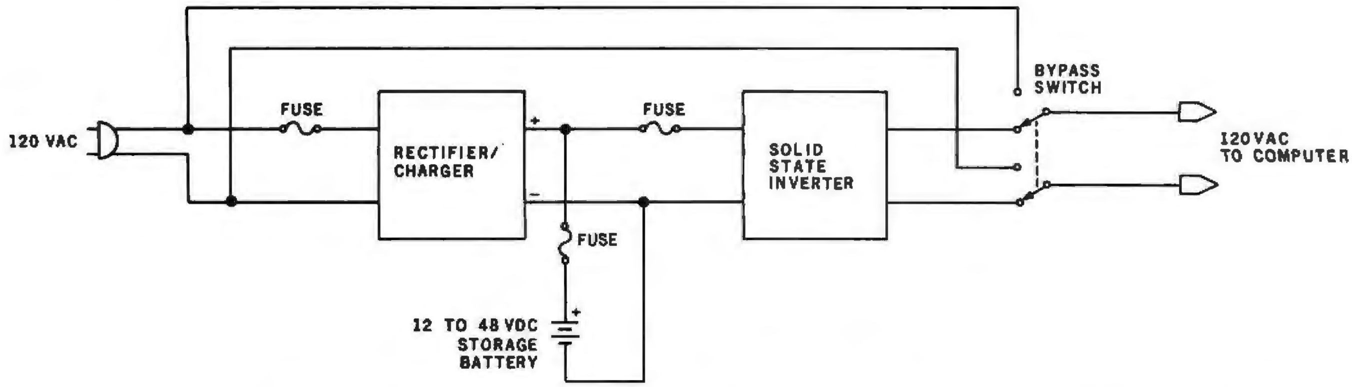
Dear Steve,

I read with interest your article on the AY-3-8910, and I am presently building the interface for my Southwest Technical Products 6800 system. Do you intend to publish any software for the 6800-based processors that will drive the circuit?

Arnold Pung

The AY-3-8910 is made by General Instrument on Long Island (600 W John St, Hicksville NY 11802). They

Figure 3



Power to the Computer

Dear Steve,

I would like to suggest a possible future subject: backup power for microcomputers. I am very interested in home control and security, but the more responsibility and power I give my system, the more strongly I feel that it should have an uninterruptible power source (UPS).

Stanly W Pozeisky

Thank you for your suggestion. I have also been considering uninterruptible power supplies. I have a 26 K-byte Z80 computer running 24 hours a day, and an UPS is a requirement. Unfortunately, when we start talking about running the computer and *disk drives, we start talking about quite a bit of power. This could conceivably require several hundred watts, so a system similar to those used in commercial installations might be in order. (See figure 3.)*

This system uses battery backup, with a large inverter to supply normal AC during an outage. Designing power inverters is an art in itself, and considerable care must be taken so as not to run afoul of the FCC radio-frequency interference (RFI) standards. While I mull this over, you might want to obtain a copy of the February 1980 issue of Digital Design *for a good article on the subject.*

Steve

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Steve

No More Scanner

Dear Steve,

I have been reading BYTE for over a year now and I find your Circuit Cellar articles useful and informative. I would like to read your article "I've Got You in My Scanner: A Computer-Controlled Stepper Motor Light Scanner," November 1978 BYTE, page 76. I am writing you because this article is no longer available through BYTE's back-issue department. Can you direct me to a source for this article?

Walter A Filimon

Thank you for the vote of confidence. There are a number of sources you can use for articles of BYTEs past: BYTE often has back issues which are available for the cover price plus postage. Give BYTE a call on their toll-free number (800) 258-5485; they'll be glad to help. If your interest is specifically in my articles, let me suggest that you pick up a copy of the compendium book Ciarcia's Circuit Cellar, *volume 1, from BYTE Books. It contains most of my articles, including the November 1978 one. It has the extra advantage that any proof errors in the original articles are corrected. BYTE Books may be contacted at 70 Main St, Peterborough NH 03458.*

Steve ■

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From time to time we make the BYTE subscriber list available to other companies who wish to send our subscribers promotional material about their products. We take great care to screen these companies, choosing only those who are reputable, and whose products, services, or information we feel would be of interest to you. Direct mail is an efficient medium for presenting the latest personal computer goods and services to our subscribers.

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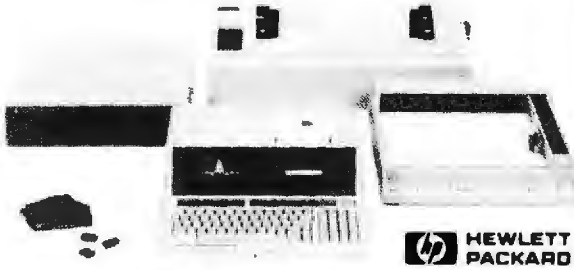

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What's New?

PERIPHERALS

Printer Uses Plastic and Metallized Daisy Wheels Interchangeably

A series of serial impact printers that produce typewriter-quality output for word processing, data processing, and communications applications has been announced by Diablo Systems Inc, 24500 Industrial Blvd, Hayward CA 94545, (415) 786-5207. The Model 630 daisy-wheel printers use plastic and metallized print wheels interchangeably, with print speeds from 32 to 40 cps (characters per second) depending on the type of print wheel, type style, and text. Model 630 printers accept all Diablo and Xerox plastic and metal print wheels. Friction and pin-feed platens and other paper-handling options are offered. The 630 series supports the RS-232C/V.24 interface for communications applications, and a microprocessor interface that permits direct attachment of the printers to a variety of small office and data processing systems. The price is $860 in original equipment manufacturer's (OEM) quantities of 500.

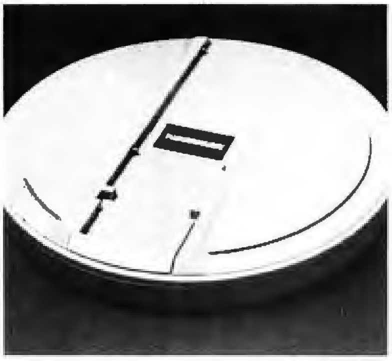
Circle 490 on inquiry card.

An RS-232 Card Reader

The Model 121-4 card reader is capable of reading any common punched or marked card and includes serial RS-232 or card image output (with Hollerith-to-ASCII conversion if necessary), parallel 20 mA current-loop output, self-clocking on both marked and 80-column punched cards, or operation with printed strobe marks on either side of the card. The 121-4 may be set for card feed-through at 6 ips (inches per second), or automatic return of cards to the front after reading. This card reader also has a self-test feature which enables the user to check sensor accuracy. The Model 121-4 operates on either 50 or 60 cps (characters per second) and sells for approximately $520 in original equipment manufacturers quantities. For more information, contact HEI Inc, Jonathan Industrial Center, Chaska MN 55318, (612) 448-3510.

Circle 492 on inquiry card.

Removable Disk Cartridges for CDC and Ampex Drives



The 4420 is a removable disk cartridge for use on Control Data's cartridge module drive (CMD) 9448 series and equivalent disk drives. The product is capable of storing up to 16 megabytes of data. The disk cartridge uses one surface to record data and one surface to function as a dedicated servo reference. Density is 348 tracks per inch, with 823 tracks per surface. The cartridge is available with factory formatting. For information, contact Nashua Corporation, 44 Franklin St, Nashua NH 03061.

Circle 491 on inquiry card.

Two Printers from Facit

Facit Inc, 66 Field Point Rd, Greenwich CT 06830, has developed two printers, the 4520 and the 4542. The 4520 is a bidirectional printer with a speed of 100 cps (characters per second) and a noise level of less than 60 dB. The 4520 is microprocessor-controlled, with a 100% duty cycle. The printer utilizes a 9-by-9 dot matrix, while accommodating paper-roll or fanfold forms. A serial or parallel interface is included. The unit price is under $1000.

The 4542 provides the full graphic capability and control of Facit's 9-by-9 matrix Stored-Force Flex Hammer Head. It features two-color printout, gray scale, and proportioned spacing. All European versions, Katakana, APL, and Libris character sets are available. The 4542 lists for under $4000.

Circle 493 on inquiry card.

Modem Eliminator

International Data Sciences Inc, 7 Wellington Rd, Lincoln RI 02865, (401) 333-6200, has introduced the Model 6100 modem eliminator. The unit allows interconnection of data-terminal equipment without modems. It can be used in asynchronous or synchronous modes, and with terminals configured for half- or full-duplex operation. The IDS modem eliminator also eliminates the need for two back-to-back modems operating within a short distance. Features include internal strap selections for primary and secondary RTS/CTS delays, ring memory functions, and clock source. Data-terminal equipment can be located up to 50 feet from the modem eliminator, allowing a maximum separation of 100 feet. Its DTE interface conforms to EIA RS-232C and CCITT V.24 standards. The Model 6100 is priced at $360.

Circle 494 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.

What's New?

MISCELLANEOUS

Computhink Unveils Small-Business Computer

Computhink Inc, 965 W Maude Ave, Sunnyvale CA 94086, (408) 245-4033, is now offering Minimax, a microcomputer system designed for small businesses and independent software organizations. The Minimax can store over 100 K bytes of internal memory. By using various configurations of floppy-disk drives, the system can have an on-line disk storage capacity ranging from 800 K to 4.8 megabytes. A 6502 microprocessor is used in the system. The system features full-screen data entry, field protect and automatic skip to the next field, and split screen operation. The Minimax, with 800 K bytes of disk storage, has a suggested retail price of $7770. A configuration with a printer is under $10,000. These prices include business-applications software.

Circle 495 on inquiry card.

Introducing the QDP-100 System

This product is a Z80A-based S-100 machine. The single-board unit contains the microprocessor; two serial and two parallel ports; a double-sided, double-density disk controller for 5- and 8-inch floppy-disk drives; an Intel-like 2716 programmable read-only memory (PROM) burner; a real-time clock; and a 2 K-byte monitor. The operating system is CP/M 2.2. A 4 MHz, 64 K-byte dynamic memory board is also supplied. The video display is a "smart" terminal with 80-character by 24-line display, a 25th status line, reverse video, blinking and half-intensity characters, protected and unprotected fields, and other features. The display uses a Z80 microprocessor for display operation. A hard-disk system can be integrated into the system. Accounting, data-base management, word processing, real estate, statistics, and other software packages are offered by Quasar. The price for the QDP-100 is $4795. Details are available from Quasar Data Products Inc, 25151 Mitchell Dr, North Olmsted OH 44070, (216) 779-9387.

Circle 496 on inquiry card.

A Printer from Mauro

Mauro Engineering, Rt 1, Box 133, Mt Shasta CA 96067, (916) 926-4406, has introduced the MP-250 PROAC pen plotter. It uses standard paper sizes and plots at speeds of up to 2.5 inches per second with 0.005-inch resolution. The standard machine uses one parallel output port and comes with full-vector driver software for 8080, 6502, and 6800 microprocessors. Interfaces are available for the TRS-80, Apple, and serial data ports. The MP-250 can be used for graphics, schematics, music composition, architectural drawings, and other applications involving plotting. The MP-250 costs $650.

Circle 497 on inquiry card.

Computer Devices Announces Self-Prompting, Portable Computer

A portable, self-prompting computer for the nontechnical user has been developed by Computer Devices Inc, 25 North Ave, POB 421, Burlington MA 01803, (617) 273-1550. The Miniterm model 1206/PAT operates through the use of preprogrammed application modules. The computer is aimed at industrial, commercial, and financial clients. The 1206/PAT includes 32 K bytes of programmable memory. The application programs are written in either BASIC or Motorola 6800 assembly language. Other standard features of the computer include an 80-column, 50-character per second thermal printer; 5-inch floppy-disk drive; built-in modem; and acoustic coupler. The unit weighs 7.3 kg (17 pounds). The price for the computer is $5195.

Circle 498 on inquiry card.

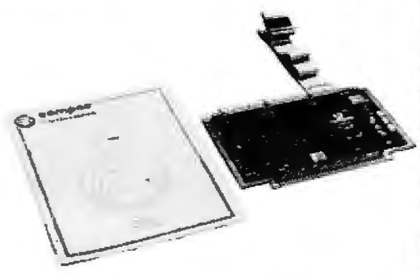
EPROM Programmer with RS-232 Interface

This erasable programmable read-only memory (EPROM) programmer, Model EP-2A-87, with RS-232 and 20 mA loop interfaces, has been introduced by Optimal Technology Inc, Blue Wood 127, Earlysville VA 22936, (804) 973-5482. The programmer includes a 2 K- or 4 K-byte buffer which can be loaded or read by another computer in the on-line mode. Data rates are 110 and 1200 bps (bits per second). In the off-line mode, a keyboard enables the operator to program, verify, and check if the EPROM is erased, and load the buffer from EPROM. EPROMs may be copied in the off-line mode by first loading the buffer from the programming socket. A built-in self-test includes provisions for checking the buffer and whether the EPROM will enter the high-impedance state. Priced at $600 with a 4 K-byte buffer, personality modules are $16 to $35 for programming various EPROMs on the market.

Circle 499 on inquiry card.

6502-Based Single-Board Computer

Compas Microsystems, 224 S E 16th St, Ames IA 50010, (515) 232-8187, has announced CSB 2, a stand-alone module based on the 6502 microprocessor. The board is compatible with the Rockwell System 65 bus standard. EXORcisor-based cards may be used with CSB 2 with minor modifications. CSB 2 includes a 6502 microprocessor, 2 K bytes of static programmable memory, four sockets for Intel 2716 or 2764 erasable



programmable read-only memory (EPROM) integrated circuits, one VIA (6522), one PIA (6520), and one ACIA (6551). CSB 2 provides 30 input/output (I/O) lines, ten buffered output lines, two interval timers, input latching on peripheral ports, an RS-232 port with data speeds from 110 to 19,200 bps (bits per second), and up to 32 K bytes of EPROM space. CSB 2 is priced at $395 and the manual is available for $4.

Circle 500 on inquiry card.

What's New?

MISCELLANEOUS

Nuts & Volts

Nuts & Volts is a new publication serving amateur radio and computer enthusiasts. It is devoted exclusively to classified and display advertising for new and used equipment. Items are categorized for easy reference, and there are sections for business opportunites and wanted items as well. Classified ads are $0.10 per word with a $2 minimum charge. Typesetting and art services are available for display advertisers. *Nuts & Volts* is available monthly for a one-time charge of $5 from *Nuts & Volts* POB 1111, Placentia CA 92670.

Circle 538 on inquiry card.

Reset Extender for TRS-80

The Reset Extender is an aid for TRS-80 owners who have trouble accessing the Reset button in the back of the keyboard. Most TRS-80 owners use a pencil to hit the Reset button. With little effort, the Extender attaches to the hood and simplifies reset tremendously. The Reset Extender is available from Emmanuel B Garcia Jr & Associates, 203 N Wabash, Rm 2102, Chicago IL 60601, (312) 782-9750, for $3.99.

Circle 501 on inquiry card.

Microprocessor-Controlled Floppy-Disk Drive and Controller

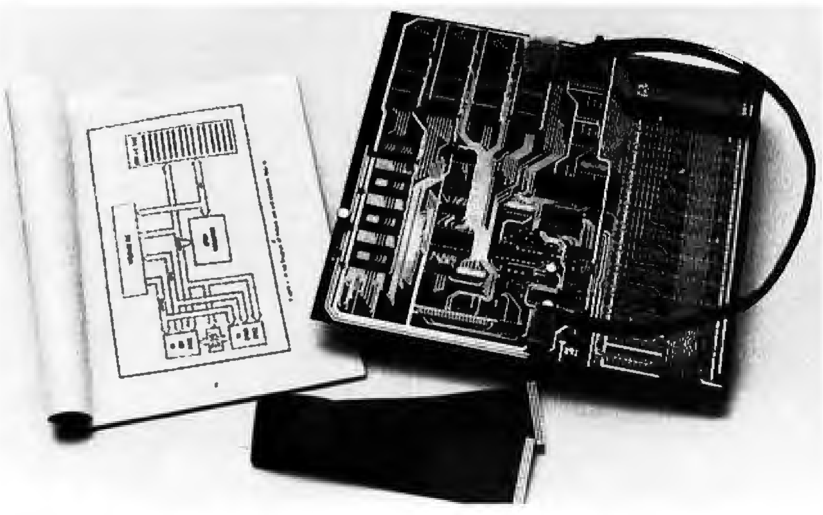
The System 2000/10 is a microprocessor-controlled floppy-disk drive and controller that plugs into the Teletype Model 43, the Texas Instruments Silent 700, and similar typewriter terminals. The System 2000/10 can operate as a stand-alone word processor, or as an on-line, storage, edit, and forward unit. In the on-line mode, the data rate is capable of reaching 9600 bps (bits per second). In the on-line mode, it can be invisible to the host computer. The system can also be used with ADM-3A, Televideo 912, and similar video displays. A software package includes global search and global replace commands. Options include extra programmable memory up to 64 K bytes, a printer port, Telex interface, BASIC and IBM 3740 compatibility. The price for the System 2000/10 is $1695. Contact Terminal Data Corporation, 11878 Coakley Cir, Rockville MD 20852, (301) 881-7655.

Circle 502 on inquiry card.

Commercial Calculators from Texas Instruments

Texas Instruments has announced a family of heavy-duty commercial calculators incorporating the Seiko 350 mechanical printer. Ranging in price from $160 to $205, the TI-5213, -5215, -5217, and -5219, have been designed for operator comfort and reliability. Each model features two-key rollover and 10-level keyboard buffering. The printer delivers 2.8 lines per second using standard 5.8 cm (2.25 inch) paper and prints up to twelve digits plus commas, decimal point, and two-column audit trail. Other features common to all four models include multiplication and division by a constant, automatic computation of percentage calculations, independent add register, grand total register, grand total on/off switch, decimal selector, automatic rounding, and item count. Inquiries should be addressed to Texas Instruments Inc, POB 10508, M/S 5889, Lubbock TX 79408.

Circle 504 on inquiry card.



Memory and Expansion Module for TI's 16-Bit Board

George Goode & Associates Inc, 12840 Hillcrest Rd, Suite 113, Dallas TX 75230, (214) 980-0730, is offering a Memory and Input/Output (I/O) Expansion Module (MEM) for the Texas Instruments University Module 16-bit microcomputer board. The MEM expands the University Module's memory by an additional 8 K bytes and expands I/O address space by an additional 480 bits. An erasable programmable read-only memory (EPROM) programmer with software driver, cables, and integrated-circuit components are included. The MEM includes sockets for up to 8 K bytes of EPROM and 8 K bytes of programmable memory, two 44-pin connectors for I/O expansion, with space for an additional thirteen connectors, and an EPROM programmer for TMS 2708 and 2716s. The MEM is priced at $299, including a manual.

Circle 503 on inquiry card.

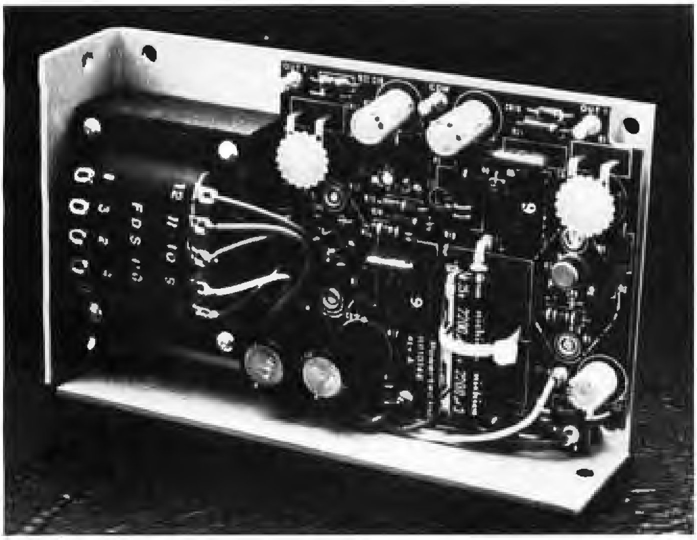
Serial Communications and Control on a Single Card

Vantage Data Products has developed a single-card computer for use in communications and control applications. The Z80-based card is used with serial input/output (I/O), parallel I/O, programmable memory, and erasable programmable read-only memory (EPROM). Serial communications are asynchronous RS-232 and programmable to all standard data rates up to 5600 bps (bits per second). Modem-control functions are also included. Power requirements are +5 V and +12 V. Negative voltage for RS-232 communication is generated on the card. Options include a software-monitor program on EPROM for operation of the computer with a terminal, and single power-supply options. The suggested retail price is $195. Contact Vantage Data Products, 550 W 200 South, Suite 8, Provo UT 84601, (801) 377-6687.

Circle 505 on inquiry card.

What's New?

MISCELLANEOUS



Floppy-Disk Drive Power Supplies

Powertec Inc, 20550 Nordhoff St, Chatsworth CA 91311, (213) 882-0004, has introduced the FD series of floppy-disk, dual-output power supplies. The FD101 delivers main channel outputs of +5 V at 0.75 A and secondary channel outputs of +12 V at 1.8 V. The FD101 offers flexible strap-selectable inputs of 103-127/206-254 VAC, single phase 47 to 440 Hz. Standard features include overvoltage, overload, short circuit and reverse voltage protections, no turn-on or turn-off overshoot, and a one-year warranty. The supplies provide line regulation of ±0.5% for a ±10% input line change, and static loads of 50 to 100%. Load regulation for the units is ±0.5% on all outputs for a 0 to 100% load change, 5 mV peak-to-peak maximum ripple, 0.03°C temperature stability over full operating ranges and 0.3% drift for a 24-hour period. Transient response is less than 50 ms for a 50% load change. Contact the company for prices and availability.

Circle 506 on inquiry card.

Bidirectional Totalizer

The DigiTec Model 8222 bidirectional totalizer is used for counting functions in industrial processes or product-test systems where up-down counting is required. All up-down counting functions, with count direction control, are user-programmable. Operating modes include totalizing two inputs by adding and/or subtracting one from the other based on phase relationship or logic input. Software response ensures that every pulse is added or subtracted even during simultaneous occurrence. The Model 8222 is available with either a 5- or 7-digit LED (light-emitting diode) display. Both models offer polarity and overflow indication. The unit is 4.8 by 18 by 19 cm (1.89 by 6.6 by 6.86 inches), and the cost is $415 for the 5-digit model and $467 for the 7-digit model. Address inquiries to United Systems Corporation, 918 Woodley Rd, Dayton OH 45403, (513) 254-6251.

Circle 507 on inquiry card.

A Talking Voltmeter

This talking voltmeter allows users to keep their eyes on the probes and avoid shocks, short circuits, and blown integrated circuits. It is also an aid for the visually handicapped. The dual microprocessor-based system provides voltage readings that are automatically announced via an internal 3-inch speaker every 7 seconds, or upon operator command. A slave processor selects the speech elements that are required by the measurement, while the main processor controls the system timing and signal processing. The instrument is powered by a rechargeable nicad battery pack. It weighs 1.1 kg (2.5 lbs) and measures 6.2 by 25.5 by 23 cm (2.5 by 10 by 9 inches). An earphone jack is provided for work in noisy environments. Options include an LCD (liquid-crystal display), current and resistance measurement circuits, and a serial interface for recording the digital output on audio cassette recorders. Foreign languages are also available. The price is $395. For details, contact the Franklin Institute Research Laboratory Inc, The Benjamin Franklin Pky, Philadelphia PA 19103, (215) 448-1340.

Circle 508 on inquiry card.

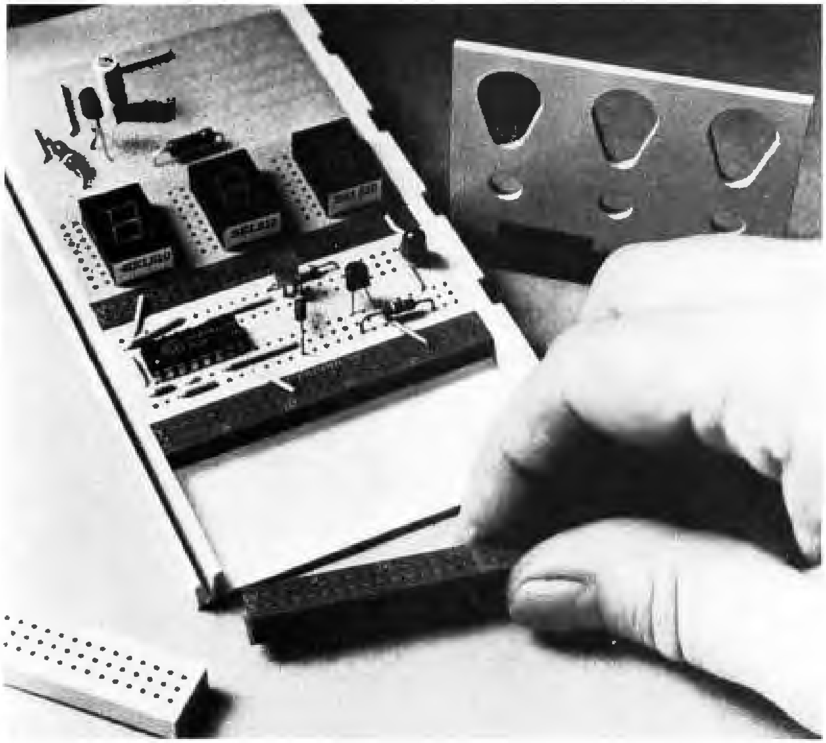
The Connection

The Connection is a modem designed for TRS-80 Models I and II. It eliminates acoustic couplng, so line sensitivity is increased and transmission errors are reduced. The RS-232 port provides the means to simultaneously run a printer or input data from a keyboard. It features a data rate of 300 bits per second (bps), single and duplex mode, direct connection of wires between telephone and cómputer, software, and instructions. For further details on The Connection, contact The micro-Peripheral Corporation, POB 529, Mercer Island WA 98040.

Circle 509 on inquiry card.

What's New?

MISCELLANEOUS



The Hobby-Blox System

Hobby-Blox is a breadboard system that allows the user to customize the board to fit projects. The system includes plug-in tie points, interchangeable modules, color-keyed and cross-indexed modules. There are two starter packs; one for discrete component projects, the other for integrated circuits projects. The system includes 14 modules that can be purchased individually, most with a suggested retail price below $3. The modular packs include a tray, terminal strips, distribution strips, discrete strips, bus strips, display strips, LED (light-emitting diodes) strips, vertical tray, speaker panel, control panel, blank panel, battery holder, binding post strips, and tray extender clips. The two starter packs are priced under $7. For information, contact A P Products Inc, 1359 W Jackson St, Painesville OH 44077.

Circle 510 on inquiry card.

SDI Graphics Interface

The Cromemco SDI is a high-resolution graphics interface designed for use in Cromemco computer systems. The SDI displays color or black-and-white images with up to 756-by-484 point resolution. It features color map selection, dual page windowing function, automatic area fill mode, and NTSC broadcast compatibility. The SDI consists of two circuit boards that plug directly into the S-100 bus of any Cromemco microcomputer system. Each pixel of the display may be mapped from one nybble or from one bit of the display memory. Twelve or 48 bytes of memory may be used for the display memory, allowing four basic modes of operation. In nybble-mapped mode any 16 of 4096 possible colors may be displayed in a single picture. In bit-mapped mode any two of these colors may be displayed in a single picture. For black-and-white nybble-mapped mode there can be 16 shades of grey. A bit-mapped black-and-white picture yields only a black-and-white display. The three outputs of the device can display three different pictures to three different black-and-white monitors simultaneously. The SDI sync signals adhere to the RS-170 standard for the television broadcast industry. The SDI can be synchronized to external television equipment through the use of an external composite RS-170 sync signal, a composite video signal, or external horizontal and vertical sync signals. The SDI graphics interface is available for $595 from Cromemco Inc, 280 Bernardo Ave, Mountain View CA 94043, (415) 964-7400.

Circle 511 on inquiry card.

Winter 1980 Catalog from Inmac

Twenty-four new computer supply and accessory products are featured in Inmac's *Winter 1980* catalog. The new offerings include preformatted floppy disks, thirteen Clear Signal microcomputer cables, sound enclosures designed to keep noise in and dust out, floppy-disk hanging file folders, and mini data-cartridge binder leaves. For a free subscription to the full-color catalog, call or write Inmac, Dept BPR, 2465 Augustine Dr, Santa Clara CA 95051, (408) 727-1970.

Circle 512 on inquiry card.

Computer Products from Electronic Systems

A catalog featuring systems by Apple, Radio Shack, Atari, Compucolor, and other companies is available from Electronic Systems, POB 21638, San Jose CA 95151, (408) 448-0800. Electronic Systems also sells products for S-100 bus systems, tools, software, terminals, and many other items. The catalog includes prices and order forms.

Circle 513 on inquiry card.

Vector Offers Electronic Packaging Catalog

Vector Electronic Company's catalog has complete details on the company's electronic-packaging products, tools, and kits. Emphasis is placed on microcomputer-interface boards for all conventional buses, a variety of card cages and cabinets, breadboarding components, plus numerous sockets and terminals. Price lists are included along with the names and the addresses of Vector's distributors. Contact Vector Electronic Company, 12460 Gladstone Ave, Sylmar CA 91342, (213) 365-9661.

Circle 514 on inquiry card.

The Hayden 1980 Computer Science Catalog

This publication contains the complete selection of Hayden titles on everything about computers from introductory information and programming to software and advanced technology. It is available from Hayden Book Company Inc, 50 Essex St, Rochelle Park NJ 07662, (201) 843-0550.

Circle 515 on inquiry card.

What's New?

MISCELLANEOUS

The Z-88 Processor Card

The Z-88 offers 16-bit processing power to S-100 bus users. The card combines a Z80A and an 8088 microprocessor to allow access to all currently available 8080 software without the need to translate into 8086 machine language. The 8088 is fully software compatible with the 8086, so all 16-bit software, such as Microsoft 8086 BASIC, will run on the Z-88. The Z-88 features an 8-bit data bus that uses existing products without modification; direct memory address of 16 megabytes; selectable IEEE Preliminary Standard or Altair/Imsai S-100 bus; no wait states with 450-ns memory access; vectored or noninterrupting modes that transfer control between processors; a 1 K-byte phantom read-only memory (ROM) which initializes the microprocessor; and an 8-level TTL (transistor-transistor logic) priority-vectored interrupt. The cost to build a Z-88 is around $450. For more information, contact the designers at Programmers Publishing Company, POB 2571, Kalamazoo MI 49003, (616) 344-9323.

Circle 516 on inquiry card.

FORTH for Four Levels

FORTH is available from Ancon, 17370 Hawkins Ln, Morgan Hill CA 95037, (408) 779-0848. There are four levels offered for the following: the hobbyist; the personal high-level language programmer who wants a ready-made editor and some basic utilities; the engineer in the microprocessor-development laboratory creating products; and the commercial original equipment manufacturer (OEM) or sophisticated end-users. The commercial level includes files, data-base management, source data entry, teleprocessing, distributed processing, and accounting packages. The hobby versions are for the TRS-80 with cassette for $29.95; Heath H8-H89 for $49.95; 8080-based systems with an 8-inch floppy disk for $49.95; and 6809-based systems with a 5-inch FLEX floppy-disk drives for $49.94. Personal systems include TRS-80 for $45.95 for cassette and $65.95 for floppy-disk systems; Apple II disk for $99.95; KIM-1 for $90; and 8080 systems with CP/M and 8-inch disks for $125. Industrial systems are available for the EXORcisor, Rockwell System 65, the Intel MDS, 8080 with CP/M, Apple II, and others. Commercial levels are made for Digital Equipment Corporation PDP-11 and VAX, Data General Nova and Eclipse, IBM Series 1, and others.

Circle 517 on inquiry card.

Intel MDS-Compatible 10-Megabyte Storage Unit

Advant Corporation, 696 Trimble Rd, San Jose CA 95131, (408) 946-9300, has introduced a 10-megabyte Winchester hard-disk data storage unit. Interfacing with all Intel MDS models, the MicroSupport Model 105 data storage unit utilizes Shugart 8-inch Winchester hard disks. The MicroSupport 105 features built-in error correction, a microprocessor-based controller, and a power supply. For more information, contact the Advant Corporation.

Circle 518 on inquiry card.

Books from MIT Press

Systems theory, computer sciences, artificial intelligence, programming languages, information, communication, and control are the topics covered by a variety of books published by the MIT Press. The new catalog also contains series and classified listings. For a copy of *Computer. Science, Engineering*, contact the MIT Press, 28 Carleton St, Cambridge MA 02142.

Circle 519 on inquiry card.

Software for the Atari 800

Atari 800 software is now available through Sebree's Computing. Atari's 3-Dimensional Graphics Package, for $29.95, will run on 8 K- or 16 K-byte machines. It features multiple-color control, selectable resolution, line clipping and pushing, telephoto and wide angle views, four program listings, and a manual. Using one of the four programs, the user can input any scene, rotate it and view it from any location in three-dimensional space or even from inside of it. Wumpus Adventure is a mixture of two popular games that has color graphics and sound effects. The user can control arrow direction and action during the battles. The program is designed for the 16 K-byte unit and costs $14.95. Contact Sebree's Computing, 456 Granite Ave, Monrovia CA 91016, (213) 359-8092.

Circle 520 on inquiry card.

What's New?

SOFTWARE

Suprdump for the TRS-80

Definitive Micro Systems, 20 Glenwood Cres, St Alberta, Alberta T8N 1X5, Canada, have announced Suprdump, a disk dump/modify utility for the TRS-80 Model I. Suprdump is designed to expedite the debugging of programs utilizing disk files. It can also create disk-file test data. The utility will dump a specified disk sector onto the video screen in a hexadecimal plus ASCII (American Standard Code for Information Interchange) format. Modification of the information on disk is accomplished by typing over the displayed data. Suprdump is supplied on a floppy disk for $29.95.

Circle 521 on inquiry card.

The Magic Wand

The Magic Wand is a word-processing program that provides underscoring, boldface, superscripting, and subscripting in any combination and even all at once. Boldface can vary in intensity and underlining can be broken or solid. The program provides justification, discretionary hyphens, and other processing capabilities. It can also create form letters from a mailing list, assist in writing standard letters, perform variable line spacing, print with true proportional spacing, print headers and footers on each page, automatic pagination, and more. It is written for the TRS-80 Model II and requires CP/M. The price is $350 from Pickles & Trout, POB 1206, Goleta CA 93017, (805) 967-9563.

Circle 522 on inquiry card.

Attach an Apple to a Malibu

The Malibu/Apple Input/Output (I/O) card serves as an interface between the Apple II and the Malibu Model 165 printer. The Malibu card uses the Apple's microprocessor to provide bidirectional printing, changeable type fonts, high-resolution graphics printout, and other functions. The card is compatible with Integer BASIC, Applesoft, Apple Pascal, as well as Applewriter and EasyWriter. The Malibu card uses a technique whereby it substitutes its software for the Apple's during printing. After the printing is completed, control is passed back to the Apple software. For further information, contact Malibu Design Group Inc, 211109 Nordhoff St, Chatsworth CA 91311.

Circle 523 on inquiry card.

6800 C Compiler

Wintek has introduced a C compiler for the 6800 microprocessor. The compiler includes the features described in the book *The C Programming Language* by Kernighan and Ritchie (Prentice-Hall). C is a structured-programming language for operating systems and numerical, text-processing, data-base programs, and other general applications. Characters, numbers, and addresses can be combined and efficiently moved about with the 6800 arithmetic and logical operations. Consequently, C is very efficient in the amount of 6800 code generated. C provides pointers and the ability to do address arithmetic. Any function can be called recursively and its variables declared in a block-structured fashion. Variables may be internal, external, or global. Functions of a C program can be compiled separately. The C compiler is intended to run under the Wizrd multitasking disk operating system on the Sprint 68 microcomputer. The cost for C is $495. The cost for the Sprint 68 with 48 K bytes of programmable memory, dual 8-inch floppy-disk drives, and Wizrd is $3995. Contact Wintek Corporation, 1801 South St, Lafayette IN 47904, (317) 742-8428.

Circle 524 on inquiry card.

Software for the HP-85: The Pro-Organizer

The Pro-Organizer is for applications ranging from a daily appointment organizer to an index box for maintaining name and address lists, to a data bank for the professional, executive, engineer, or scientist. The program is designed for the 16 K-byte HP-85 computer and is supplied on cartridge. It is completely automatic from power turn-on. Any data-management requirements may be custom formatted. Data may be edited easily. Additional cartridges may be used to build up a library. The suggested retail price is $95. For details, contact Scelbi Publications, 20 Hurlbut St, Elmwood CT 06110, (203) 522-5515.

Circle 525 on inquiry card.

Apple FORTH 1.7

With this FORTH Interest Group-compatible system, Apple users can define operations and enter them as components of the language. Machine-language subroutines can be entered directly from the keyboard, where they are assembled immediately and ready to run or test. Apple FORTH 1.7 includes a screen editor that can be customized. It has facilities to manufacture turnkey disks which boot directly into user applications. FORTH is its own operating system and debugger, including compile-time checks. Progams run faster than Integer BASIC, and object code is very compact. This language is compatible with the FORTH International Standard, so programs can be run on 8080- and PDP-11-based systems. A 48 K-byte Apple II or Apple II Plus with one or two disk drives is required. The price is $140, including a manual, from Cap'n Software, POB 575, San Francisco CA 94101, (415) 848-6913.

Circle 526 on inquiry card.

polyFORTH

polyFORTH is an operating system for microprocessor-development systems and minicomputers. polyFORTH provides the compiler, interpreters, assembler, character editor, virtual memory, and multitasking capability within its 8 K bytes of memory. Applications programs can be coded combining high-level with low-level languages. Program-development time is cut down because the interactive programming environment allows rapid testing and debugging. Memory requirements for complex applications are reduced to as little as half that of assembler programs and to about 10% that of other high-level languages. Run speed is controlled by the programmer. Time-critical routines can run at full machine speed. All versions of polyFORTH are compatible with a minimal number of machine-dependent features. The language features 16-bit arithmetic on all systems, as well as 32-bit capacity. For $2500, users receive polyFORTH on a floppy disk, a set of programmable read-only memory (PROM) integrated circuits containing the precompiled system, two manuals, and access to a hot line service and newsletter. Contact FORTH Inc, 2309 Pacific Coast Hwy, Hermosa Beach CA 90254, (213) 372-8493.

Circle 527 on inquiry card.

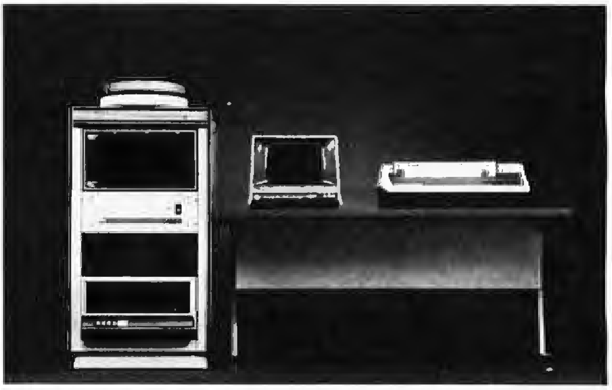
10 Megabyte Hard Disk

$3,495*

5440-12 Top Load Drive
*** Factory rebuilt 10MB cartridge disk drive only**
A new Cameo Data Systems controller is available for $1,495
$4,495 for a brand new Ampex 10MB drive only

We are the CP/M** and MP/M** specialist of Southern California. We can supply you with the latest CP/M ($150) or MP/M ($300) and with Standard BIOS ($150) or Custom BIOS ($300). Immediate delivery worldwide. Domestic and foreign inquiries invited...dealers too.

**CP/M and MP/M are Trademarks of Digital Research



We are a full service computer retailer. We totally integrate hardware and software into high quality, high reliability systems. Systems for use in development, process control and general business. Word processing naturally, multi tasking and multi processing too.

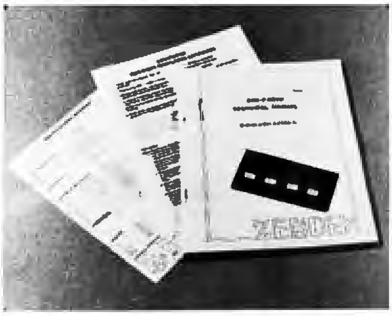
COMPUTER COMPONENTS

5848 Sepulveda Boulevard Van Nuys, California 91411 213•786-7411

Circle 215 on inquiry card.

What's New?

SOFTWARE



SBC-FORTH on EPROM

This implementation of FORTH can run in many of Intel's and National's line of SBC-80 microprocessor cards. It runs stand-alone and requires no additional memory, input/output (I/O) devices, or disks to operate. Standard features include a resident compiler, an 8080/8085 assembler, screen editor, and adaptive disk I/O. The disk I/O allows a combination of four single-density drives or four double-density drives with two additional single-density units for a total capacity of 2500 screens. The system price is $500 including the manual Contact Zendex Corporation, 6398 Dougherty Rd, Dublin CA 94566, (415) 829-1284.

Circle 528 on inquiry card.

FLEX for Custom Hardware

A new version of the FLEX disk operating system is available for users of custom or nonstandard 6800 and 6809 systems. Developed by Technical Systems Consultants Inc, POB 2570, 1208 Kent Ave, West Lafayette IN 47906, (317) 463-2502, it is fully compatible with most versions of FLEX. FLEX supports features such as dynamic file-space allocation, random and sequential file accessing, user startup facility, user environment control, English-language error messages, and over twenty commands for normal disk operations. This version contains a manual describing how to write disk and terminal input/output (I/O) routines to adapt FLEX to most any hardware. The only major system requirement is a soft-sectored floppy-disk drive that uses 256 bytes per sector. When the adaptation is complete, the user's system will be capable of running any standard FLEX software. The $150 price includes the FLEX disk with editor and assembler, and a set of manuals.

Circle 529 on inquiry card.

The Datahandler

The Datahandler is a data-base management system running in MMSFORTH on the TRS-80 Model I with at least 32 K bytes of programmable memory and one floppy-disk drive. Users can specify up to ten data fields appropriate to each particular job. Standard and special report formats can be output to the screen and the printer. The Datahandler includes mail-list and checking-account programs with custom report commands and sample data files. It can sort a typical 100-record file in 5 seconds, and lookups take less than 1 second. An indexed-key structure incorporates string and value selection mechanisms including normal-compares and values inside or outside a range. One feature allows the program area of the Datahandler disk to be software write-protected, while the data-file area is left open. Regularly used system configurations may be precompiled for 5-second loading times. Additions to the Datahandler will be a report-generator module and a large-data-files module. The Datahandler costs $59.90 including the *PIMS Manual*. It also requires the MMSFORTH system disk which provides its language and operating system, which costs $79.95 including an introductory manual. Contact Miller Microcomputer Services, 61 Lake Shore Rd, Natick MA 01760, (617) 653-6136.

Circle 530 on inquiry card.

SL5—A Software-Development Tool

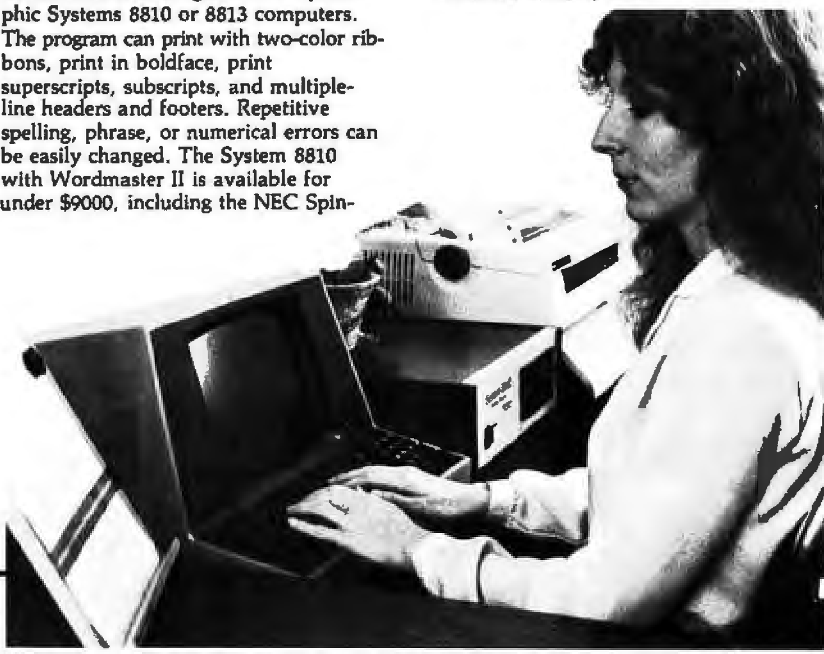
SL5 is a software-development tool for small systems. It is an interactive programming system with an integral compiler, interpreter, assembler, disk operating system, and library of procedures. SL5 is based on the recommendations of the 1977 FORTH Standards Committee. Since SL5 is written in SL5, it adapts to most microcomputer operating systems. A host-executable code kernel, a source-code kernel, and a system-generation program are provided. The system generation program regenerates the kernel from the source or generates compact stand-alone read-only memory (ROM) object modules. An SL5 development system requires less than 32 K bytes of memory. Most applications programs require less than 8 K bytes. SL5 reads and writes standard CP/M files. Versions are available for both the 8080 and Z80. The Z80 system uses the additional registers and instructions of the Z80, and contains an assembler with Z80 mnemonics. The single-system price of $150 includes complete source code and a manual. Original equipment manufacturer (OEM) and resale licenses are available. For more information, contact The Stackworks, POB 1596, 321 E Kirkwood Ave, Bloomington IN 47402, (812) 336-1600.

Circle 531 on inquiry card.

Word Processor and 8810 System from PolyMorphic

Wordmaster II is a menu-driven word processor. The program enables users to create, edit, format, and print documents. It is designed for PolyMorphic Systems 8810 or 8813 computers. The program can print with two-color ribbons, print in boldface, print superscripts, subscripts, and multiple-line headers and footers. Repetitive spelling, phrase, or numerical errors can be easily changed. The System 8810 with Wordmaster II is available for under $9000, including the NEC Spinwriter or comparable printer. Contact PolyMorphic Systems, 460 Ward Dr, Santa Barbara CA 93111.

Circle 532 on inquiry card.



What's New?

SYSTEMS

Matrox Computer Systems MACS-10

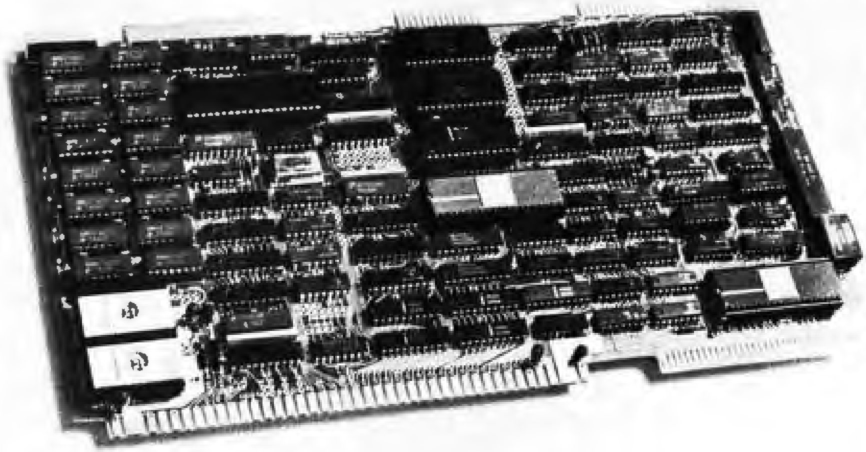
The MACS-10 microcomputer system combines Multibus-based hardware with the CP/M 2.0 disk operating system. The system is configured around the Z80A microprocessor and includes 48 K bytes of programmable memory and sockets for 8 K bytes of ROM (read-only memory) and EPROM (erasable programmable read-only memory). A 2 K-byte monitor, a dual 8-inch double-density floppy-disk drive, a disk controller, and interfaces for a video terminal and line printer are also included. Other peripherals can be connected through additional ports at the rear of the chassis. The microprocessor and floppy-disk controller cards occupy two slots in the card cage, leaving five slots for systems expansion. If more slots are needed, up to three card cages can be stacked together for a maximum of nineteen free card slots. Optional hardware includes a 128 K-byte programmable-memory card, and an alphanumeric and graphic video-display controllers. The price for the MACS-10 system is $5990. Details are available from Matrox Electronic Systems Ltd, 5800 Andover Ave, T M R, Quebec H4T 1H4, Canada, (514) 735-1182.

Circle 533 on inquiry card.

The System 1000 Series from CSSN

CSSN Inc has announced its System 1000 family of microcomputers. This modular, bus-oriented line of systems is organized around the IEEE (Institute of Electrical and Electronic Engineers) S-100 standard bus. The S/1000 includes a 4 MHz Z80A microprocessor, 64 K bytes of programmable memory, an 8-inch Winchester hard disk, a 13.4-megabyte cartridge-tape data backup, a variety of I/O (input/output) devices and other peripherals, and expansion capability to 16-bit processors. It is available in different configurations of operating systems and peripherals, and retails between $15,000 and $20,000. The S/1000 hard-disk cartridge backup combination can store 24 megabytes. Operating systems for the series includes CP/M 2.0, MP/M, OASIS, and CSSN PDOS, a superset of CP/M 1.4. Languages such as BASIC, COBOL, FORTRAN, C, and Pascal, can be run on the systems. For further information, contact CSSN Inc, 120 Boylston St, 4th Fl, Boston MA 02116, (617) 482-2343.

Circle 534 on inquiry card.



AmZ800 Single-Board Computer

The Am96/4116 MonoBoard Computer uses the 16-bit processing power of the 4 MHz AmZ8002 microprocessor. Auxiliary support for the AmZ8002 includes 32 K bytes of programmable memory, 8 K bytes of PROM (programmable read-only memory) sockets, two serial and three parallel I/O (input/output) ports, and five programmable counter/timers. The two RS-232 serial ports transmit data from 50 to 9600 bps (bits per second). The parallel I/O ports break down into twenty-four lines or three 8-bit ports that can be programmed for input, output, or bidirectional operation. The computer can accept multiple interrupt channels from twenty-three independent sources in nonmaskable, vectored, and nonvectored modes of operation. Eight interrupt channels are handled by a programmable interrupt controller which allocates priorities, determines modes of operation and supports direct vectoring. The Am9513 System Timing Controller incorporates five independent 16-bit counters that can count up or down in binary or BCD (binary-coded decimal) at rates up to 7 MHz. The price for the Am96/4116 is $2145. Contact Advanced Micro Computers, 3340 Scott Blvd, Santa Clara CA 95051, (408) 988-7777.

Circle 535 on inquiry card.

System 800 from IPDI

The System 800 can be expanded from 64 K bytes to 2.04 megabytes of programmable memory and from 11.2 to 31.2 megabytes of disk storage on four drives. The system allows a combination of floppy and hard disks, as well as tape cartridge backup in the same system enclosure. IPDI's video-graphics card produces a display of up to 3000 characters of over 256 user-definable characters and symbols on a 15-inch monitor. The video-display system features sixteen levels of gray or full color and is capable of driving over thirty-two displays. For more information, contact IPDI, 2584 Wyandotte, Mountain View CA 94043, (415) 969-6086.

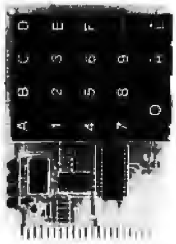
Circle 536 on inquiry card.

A Z8000 Board from Quasar Data Products

This 16-bit Z8000 S-100 board conforms to the proposed IEEE (Institute of Electrical and Electronic Engineers) standards. The system can read and write 8-bit, 16-bit or mixed 8- and 16-bit memories. The module also incorporates on-board, single-step circuitry hardware. The clock rate is 4 MHz. An 8080/Z80 emulator enables users to employ most of the software that has been developed for the 8080/Z80 processors. The system also has provisions to plug an 8-bit microprocessor card in the same bus as the Z8000 module, allowing software to be developed on an 8-bit system and then transferred to and executed by the Z8000. Available software includes a cross assembler, text editor, word processing software, and a business package. The QDP-8100 is available from Quasar Data Products, 25151 Mitchell Dr, North Olmsted OH 44070, (216) 779-9387, for $6395.

Circle 537 on inquiry card.

HEX ENCODED KEYBOARD

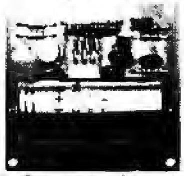


Four onboard LEDs indicate the HEX code generated for each key depression. The board requires a single +5 volt supply. Board only $15.00 Part No. HEX-3, with parts $49.95 Part No. HEX- 3A. 44 pin edge connector $4.00 Part No. 44P.

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 $249.95. Part No. TA 1000C

T.V. INTERFACE



• Converts video to AM modulated RF, Channels 2 or 3. So powerful almost no tuning is required. On board regulated power supply makes this extremely stable. Rated very highly in Doctor Dobbs' Journal. Recommended by Apple • Power required is 12 volts AC C.T., or +5 volts DC • Board only $7.60 part No. 107, with parts $13.50 Part No. 107A

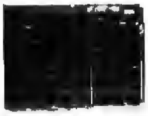
TAPE INTERFACE

• 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

ASCII KEYBOARD

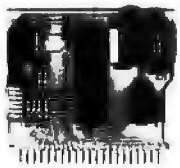
53 Keys popular ASR-33 format • Rugged G-10 P.C. Board • Tri-mode MOS encoding • Two-Key Rollover • MOS/DTL/TTL Compatible • Upper Case lockout • Data and Strobe inversion option • Three User Definable Keys • Low contact bounce • Selectable Parity • Custom Keycaps • George Risk Model 753. Requires +5,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

T.V. TYPEWRITER



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

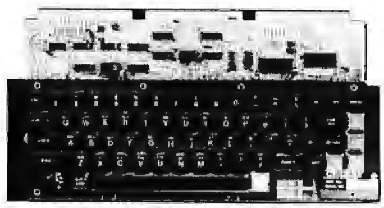
UART & BAUD RATE GENERATOR



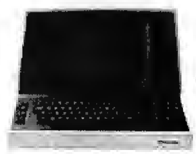
• Converts serial to parallel and parallel to serial • Low cost on board baud rate generator • Baud rates: 110, 150, 300, 600, 1200, and 2400 • Low power drain +5 volts and -12 volts required • TTL compatible • All characters contain a start bit, 5 to 8 data bits, 1 or 2 stop bits, and either odd or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

ASCII KEYBOARD

TTL & DTL compatible • Full 67 key array • Full 128 character ASCII output • Positive logic with outputs resting low • Data Strobe • Five user-definable spare keys • Standard 22 pin dual card edge connector • Requires +5VDC, 325 mA. Assembled & Tested. Cherry Pro Part No. P70-05AB. $119.95.



SOROC IQ 120

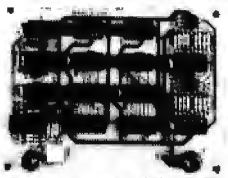


Upper/lower case display • Numeric keypad & cursor keys • Protected fields, ½ intensity display • RS 232 interface & aux. port. IQ120—$799.95 • IQ140 Detachable keyboard—$1199.95

MODEM

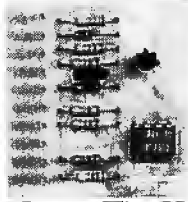
• Type 103 • Full or half duplex • Works up to 300 baud • Originate or Answer • Serial TTL input and output • connect 8 Ω speaker and crystal mic. directly to board • Requires +5 volts • Board only $7.60 Part No. 109, with parts $29.95 Part No. 109A.

A-to-D D-to-A CONVERTER



Analog to Digital, Digital to Analog Converter, A-D conversion time 20us. D-A conversion 5us. Uses include speech and music synthesizing and slow scan TV. Single power supply (5V), 8 Bits wide, latched I/O, strobe lines. Part No. 79287K Complete Kit $49.95 • Part No. 79287A Assembled $69.95

RS-32/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 edge connector, kit $9.95 Part No. 232A 10 Pin edge connector $3.00 part No. 10P.

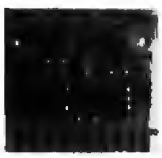
COMPUCOLOR II

With reg. keyboard
MOD3 8K $1449.95
MOD4 16 K $1495.95
MOD5 32K $1699.95
Without disk drive subtract $450.00. Add-on drives, $495.00. With 101 key option add $134.95. With 117 key option add $179.95.

44 BUS MOTHER BOARD

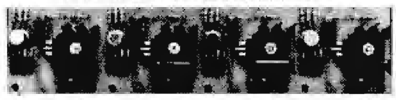
Has provisions for ten 44 pin (.156) connectors, spaced 3/4 of an inch apart. Pin 20 is connected to X, and 22 is connected to Z for power and ground. All the other pins are connected in parallel. This board also has provisions for bypass capacitors. Board cost $15.00 Part No. 102. Connectors $3.00 each Part No. 44WP.

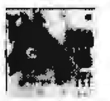
RS-232/20mA INTERFACE



This board has two passive, opto-isolated circuits. One converts RS-232 to 20mA, the other converts 20mA to RS-232. All connections go to a 10 pin edge connector. Requires +12 and -12 volts. Board only $9.95, part no. 7901, with parts $14.95 Part No. 7901A.

SOLID STATE SWITCH





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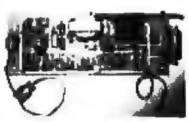

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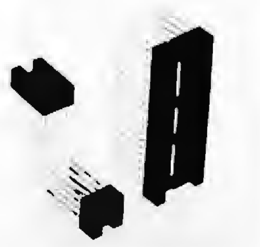

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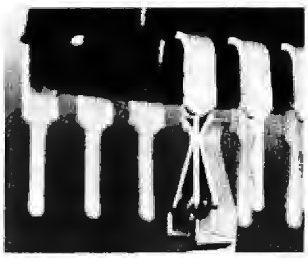

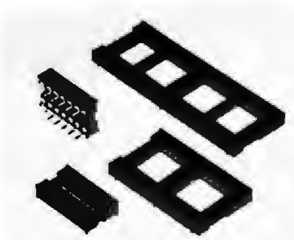

SOLDER TAIL

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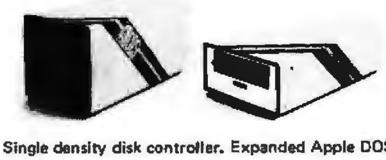

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CD4073	.35	74C174	2.75
CD4075	.35	74C175	2.75
CD4076	1.29	74C192	2.39
CD4077	.35	74C193	2.39
CD4078	.35	74C195	2.39
CD4081	.35	74C922	7.95
CD4082	.35	74C923	8.95
CD4085	1.95	MM80C95	1.50
CD4089	2.95	MM80C97	1.25

74LS00

74LS00N	.35	74LS164N	1.19
74LS01N	.28	74LS165N	.89
74LS02N	.28	74LS166N	2.48
74LS03N	.28	74LS168N	1.89
74LS04N	.39	74LS169N	1.89
74LS05N	.28	74LS170N	1.99
74LS08N	.30	74LS173N	.89
74LS09N	.30	74LS174N	.99
74LS10N	.28	74LS175N	.99
74LS11N	.39	74LS181N	2.20
74LS12N	.30	74LS190N	1.15
74LS13N	.47	74LS191N	1.15
74LS14N	1.25	74LS192N	.98
74LS15N	.39	74LS193N	.98
74LS20N	.28	74LS194N	1.15
74LS21N	.38	74LS195N	.95
74LS22N	.38	74LS196N	.89
74LS26N	.38	74LS197N	.89
74LS27N	.39	74LS221N	1.49
74LS28N	.39	74LS240N	2.99
74LS30N	.26	74LS241N	2.49
74LS32N	.39	74LS242N	2.29
74LS37N	.79	74LS243N	2.29
74LS38N	.39	74LS244N	2.95
74LS40N	.26	74LS245N	6.95
74LS42N	.79	74LS247N	1.10
74LS47N	.79	74LS248N	1.10
74LS48N	.79	74LS249N	1.69
74LS51N	.28	74LS251N	1.79
74LS54N	.35	74LS253N	.98
74LS55N	.35	74LS257N	.98
74LS73N	.45	74LS258N	.98
74LS74N	.59	74LS259N	2.95
74LS75N	.68	74LS260N	.69
74LS76N	.45	74LS261N	2.49
74LS78N	.65	74LS266N	.59
74LS83AN	.99	74LS273N	1.75
74LS85N	1.19	74LS275N	4.40
74LS86N	.45	74LS279N	.59
74LS90N	.75	74LS283N	1.10
74LS92N	.75	74LS290N	1.29
74LS93N	.75	74LS293N	1.95
74LS95N	.88	74LS295N	1.10
74LS96N	.98	74LS298N	1.29
74LS107N	.45	74LS324N	1.75
74LS109N	.45	74LS347N	1.95
74LS112N	.49	74LS348N	1.95
74LS113N	.49	74LS352N	1.65
74LS114N	.55	74LS353N	1.65
74LS122N	.55	74LS363N	1.49
74LS123N	1.19	74LS365N	.99
74LS124N	1.35	74LS366N	.99
74LS125N	.89	74LS367N	.99
74LS126N	.89	74LS368N	.99
74LS132N	.79	74LS373N	2.75
74LS136N	.59	74LS374N	2.75
74LS138N	.89	74LS375N	.69
74LS139N	.89	74LS377N	1.95
74LS145N	1.25	74LS385N	1.95
74LS148N	1.49	74LS386N	.65
74LS151N	.79	74LS390N	1.95
74LS153N	.79	74LS393N	1.95
74LS154N	2.49	74LS395N	1.70
74LS155N	1.19	74LS399N	2.95
74LS156N	.99	74LS424N	2.95
74LS157N	.99	74LS668N	1.75
74LS158N	.79	74LS670N	2.29
74LS160N	.98	81LS95N	1.99
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LM739N	1.18	SN75453N	.49
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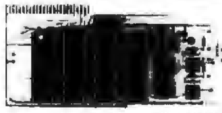

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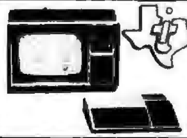

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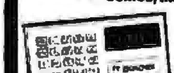

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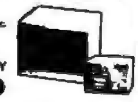

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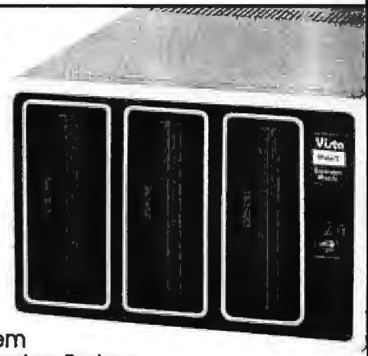

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The switchable, four-section bandpass filter provides the user with excellent out-of-band rejection to assure accurate processing of the received carrier, even at signal levels of less than −47 dBm. Further, the proven soft limiter and phase lock loop discriminator yields data that is essentially jitter free.

The oscillator is built using highly stable, state-variable circuitry that delivers a nearly harmonic free, phase coherent sine wave to the telephone network, assuring compatibility with all other 103 type modems. Because of the pureness of the sine wave, the STAR modem exceeds even the stringent harmonic requirements of all CCITT countries.

CARRIER DETECT
To assure accurate teleprocessing connections, the carrier detect circuitry prevents the modem from attempting to operate when excessive noise would produce errors or cause marginal operation. The circuitry also has a special amplitude sensor that prevents chatter when the received signal fades.

EXCLUSIVE ACOUSTIC CHAMBERS
The exclusive triple seal of Livermore's new flat mounted cups locks the handset into the acoustic chamber yielding superior acoustic isolation and mechanical cushioning. Designed to adapt to most common handsets used throughout the world, the STAR offers the utmost in flexibility and transmission reliability.

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Utilizing the experience gained from building high quality couplers for over twelve years, Livermore has designed a coupler superior to any in its class for cost efficiency in industrial, commercial, business or home situations. You can see why we call it the STAR!

SPECIFICATIONS
Data Rate. 0 to 300 baud.
Compatibility. Bell 103 and 113; CCITT.
Transmit Frequencies.* Originate – 1070 Hz/Space, 1270 Hz/Mark; Answer - 2025 Hz/Space, 2225 Hz/Mark
Receive Frequencies.* Originate - 2025 Hz/Space, 2225 Hz/Mark; Answer 1070 Hz/Space, 1270 Hz/Mark.
Frequency Stability. ±0.3 percent.
Receiver Sensitivity. −50 dBm ON, −53 dBm OFF.
Transmit Level. −15 dBm.
Modulation. Frequency shift keyed (FSK).
Carrier Detect Delay. 1.2 seconds ON; 120 msec OFF.
EIA Terminal Interface. Compatible with RS 232 specifications.
Teletype Interface. 20 milliampere current loop.
Optional Interfaces. IEEE 488; TTL; TTY 43.

***International (CCITT) frequencies available.**
Switches. Originate/Off/Answer; Full Duplex/Test/Half Duplex.
Indicators. Transmit Data, Receive Data, Carrier Ready, Test.
Environmental. Ambient operating temperature 5° C. to 50° C. Relative humidity 10 to 90 percent (non-condensing).
Power. Supplied by 24 VAC/150 MA UL/CSA listed wall-mount transformer. Input 115 VAC, 2.5 watts. (A 220 VAC, 50 Hz adaptor is available upon request.)
Dimensions. 10"x 4"x 2"
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RIBBON SYSTEM: Continuous ribbon 9/16" (14mm) wide, 20 yards (18 3 meters) long. Mobius Loop allows printing on upper and lower portion on alternate passes

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Terms: Visa, MC, BAC, Check, Money Order, U.S. Funds Only. CA residents add 6% sales tax. Minimum order $10.00 Prepaid U.S. orders less than $75.00 include 5% shipping and handling. MINIMUM $2.50. Excess refunded. Just in case ... please include your phone no. Prices subject to change without notice. We will do our best to maintain prices thru Aug 1980.
*SOCKET and CONNECTOR prices based on GOLD, not exceeding $500 per oz.

*Sale Prices are for prepaid orders only credit card orders will be charged appropriate freight

FOR MORE INFORMATION SEE OUR 52 PAGE AD in JANUARY BYTE OR SEND $1.00 FOR CATALOG
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PRIORITY ONE ELECTRONICS

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TRS-80/APPLE
MEMORY EXPANSION KITS
4116's RAMS
from Leading Manufacturers
(16Kx1 200/250ns)

100% GUARANTEED — 1,000's SETS SOLD

8 for $48.00

ADD $3.00 FOR PROGRAMMING JUMPERS FOR TRS-80 KEYBOARD

4116's 100 pcs & UP $5.20 each
1000 pcs & UP $4.45 each

SD SYSTEMS

Factory Rebate Sale

When you purchase any SD SYSTEMS Computer Board, either kit or A&T from PRIORITY 1 ELECTRONICS, you will receive a COUPON FOR A $25.00 CASH REBATE direct from the Manufacturer, SD SYSTEMS. Combine the Rebate with our already low prices, and you can hardly afford to pass up this special offer.

For more information, see last month's issue of Byte, or our catalog.

	Reg. Price	Sale Price
SDS-EXPANDORAM I KIT 0K	$220.00	$210.00
SDS-EXPANDORAM I KIT 16K		$249.00
SDS-EXPANDORAM I KIT 32K		$299.00
SDS-EXPANDORAM I KIT 48K		$349.00
SDS-EXPANDORAM I KIT 64K		$398.00
SDS-EXPANDORAM II KIT 0K	$230.00	$220.00
SDS-EXPANDORAM II KIT 16K		$250.00
SDS-EXPANDORAM II KIT 32K		$325.00
SDS-EXPANDORAM II KIT 48K		$390.00
SDS-EXPANDORAM II KIT 64K		$459.00

	Reg. Price	Sale Price
SDS-VERSAFLOPPY I KIT	$250.00	$220.00
SDS-VERSAFLOPPY II KIT	$350.00	$299.00
SDS-VDB8024 KIT	$370.00	$320.00
SDS-PROM-100 KIT	$200.00	$175.00
SDS-SBC-100 2 Mhz KIT	$295.00	$265.00
SDS-SBC-200 4 Mhz KIT	$320.00	$289.00
SDS-Z80 STARTER KIT	$340.00	$299.00

SD Systems Kits carry a 90 day limited warranty from SD Systems. 4116 ICs supplied by Priority 1 Electronics for use in SD Expandorams carry a 1 year limited warranty from Priority 1 Electronics.

Compare our Sale Prices, and then don't forget your *Rebate!*

QT COMPUTER SYSTEMS INC.

IEEE S-100 COMPATIBLE

EXPANDABLE + DYNAMIC MEMORY (16K to 64K)

- Works With Cromenco Systems
- Uses 3242 Refresh Chip
- 4 Layers Mean A Quiet Board
- Bank Selectable Write Protect
- Phantom Output Disable
- Switch Selectable Output Disable

Bare Board	$ 49.95	32K Kit	$369.95	48K A&T	$494.95
16K Kit	$295.95	32K A&T	$419.95	64K Kit	$519.95
16K A&T	$345.95	48K Kit	$444.95	64K A&T	$569.95

Z + 80 CPU

- 1K Ram On Board + 2 Programmable Timers
- Switch Selectable 2 or 4 MHZ
- Power On Jump to On-Board 1K or 2K EPROM (2708-2716-2732) Can be Addressed on any 1K, 2K or 4K Boundary
- Programmable Baud Rate Selection (110 to 9600)
- On-Board EPROM May be Used in Shadow Mode, Allowing Full 64K RAM to be Used
- On-Board USART for Synchronous or Asynchronous RS-232 Operation (On-Board Baud Rate Generator)

Bare Board $ 45.00 — A&T $229.95
Kit $169.95 — 1K Memory Kit $ 12.00

CLOCK CALENDAR +

- Time of Day in Hours, Minutes and Seconds
- 24 Hour Time Format
- Month and Day Date Function
- Simple Read Instructions Allow Simple Interface to Basic, CPM, Etc.
- Will Run With 4 MHZ Processors
- Can be Located at any Group of 4 I/O Port Addresses

Bare Board $45.00 Kit $99.95 A&T $149.95

LOBO 8" DISK DRIVE CABINET

New from Lobo, a dual Cabinet with power supply, and internal data cable hook-up.

- Cabinet accepts 2 801R, 800R, FD120, or FD200 style disk drives.
- Power Supply for 2 drives
- Assembled, tested and guaranteed by Lobo Drives.
- Shipping Weight 30 lbs.

LBO — DUAL 8 PCS..........$329.00

BUY CABINET AND DRIVES AND SAVE

WITH 1 DRIVE: LBO-801R-1PSC $775.00
WITH 2 DRIVES: LBO-801R-2PSC $1250.00

DISC DRIVE ONLY
SHU-801R.......$499.00

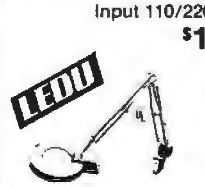
EXTERNAL DATA CABLES
CARDEDGE TO CARDEDGE PRI-50CE-CE $19.95
CARDEDGE TO SOCKET PRI-50CE-SKT $19.95

MEMORY HEADQUARTERS

2716 16K 5 Volt only EPROM..$22.00 ea. 10/$200.00
2708 8K 450ns EPROM.........8/$55.00 $8.50 ea.
2114-3L 1Kx4 300ns Low Power. 8 $45.00 100 + $4.00 ea.
5257-3L 4Kx1 300ns Low Power..8/$55.00 100 + $5.25 ea.
2102AL-2 L/P 250ns in lots of 20. 1.25 ea. 100 + 1.10 ea.

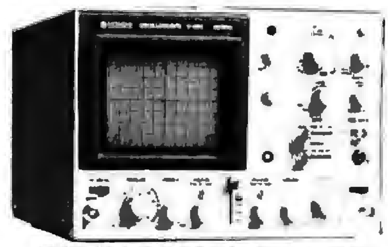
SPECIAL PURCHASES

POWER SUPPLY
5 Volt 3 Amp w/OVP
Input 110/220V Open Frame
$19.95



MAGNIFIER
with T9 fluorescent tube
List $94.95
Sale $49.95
LDU-MG-10A $49.95

Hitachi V302



30MHZ DUAL TRACE OSCILLOSCOPE

LIST 945.00 - **SALE $798.00**

- TV sync-separater circuit
- High-sensitivity 1mV/div (5MHz)
- Sweep-time magnifier (10 times)
- Z-axis input (intensity modulation)
- Signal delay line
- X-Y operation
- Trace Rotation
- Complete with 2 probes
- CH1, CH2, DUAL, ADD, DIFF, Vertical Deflection Modes
- V152 Dual Trace 15MHZ - no delay sweep

LIST 695 00

SALE $595.00

ORDER TOLL FREE
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(213) 894-8171

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PRIORITY ONE ELECTRONICS
16723K Roscoe Blvd. Sepulveda, CA 91343

master charge

Terms: Visa, MC, BAC, Check, Money Order, U.S. Funds Only. CA residents add 6% sales tax. Minimum order $10.00 Prepaid U.S. orders less than $75.00 include 5% shipping and handling. MINIMUM $2.50. Excess refunded. Just in case ... please include your phone no. Prices subject to change without notice. We will do our best to maintain prices thru Aug 1980.
*SOCKET and CONNECTOR prices based on GOLD, not exceeding $500 per oz.
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PRIORITY ONE ELECTRONICS

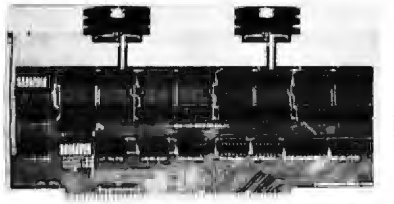
CompuPro™ from GODBOUT ELECTRONICS

MEET THE ECONORAM FAMILY...........
all ECONORAMS from COMPUKIT include:

- Fully static memory used throughout to promote reliable operation and facilitate direct memory access. (DMA)
- 4 MHz with Z80 - 5 MHz with 8085
- Buffered tri-state outputs and buffered inputs.
- All lines buffered; address and data lines buffered to 1 low power Schottky TTL load, all other lines buffered to less than 1 TTL load.
- Onboard regulation.
- DIP switch address selection and deselection (no wire jumpers).
- Low power Schottky support ICs.
- S-100 boards have WRITE strobe selections switch - allows use of memory with or without front panel.
- All ICs are socketed (including support chips)
- Unique multi-block configurations for addressing flexibility.
- Industry standard board sizes.
- High quality, double sided, plate through, solder-masked and legended circuit board.
- LOW current consumption and guaranteed specs.
- 1 year limited warranty (not just 90 days).

SALE **SALE**

Most ECONORAMs come in 3 forms; UNKIT (UKT) - (this means that all sockets, disc capacitors are already soldered in place for easy assembly), fully assembled & tested (A&T), or qualified under the Certified System Component (CSC) high-reliability program (200 hour burn-in, guaranteed 4MHz operation over full temperature range, serial numbered, immediate replacement in event of failure with 1 year of invoice date).



NEW

8K ECONORAM IIA

We realize that this may not look like the 8K, Econoram II board you've known and loved for so many years, however, at Godbout, good things don't come to an end - they just get better! Our NEW 8K Econoram IIA board retains all the best selling features of the old Econoram II PLUS is now 4 MHz STANDARD - still static - with ultra low power consumption S-100 compatible. Single supply required - guaranteed maximum current under 900mA. Typical boards draw 700 to 800mA Phantom feature is included on the new Econoram IIA and is switch selectable Organized as two 4K independently addressable blocks. Includes switched WRITE protect - block and board disable. Also, has provision for memory management. Shipping Weight 2 lbs

	Reg.	Sale
GBT - ECONORAM IIA UKT	$169.00	$159.00
GBT - ECONORAM IIA A&T	$189.00	$169.00

CK022 S-100 INTERFACER

Our new I/O board gives you unparalleled flexibility and operating convenience. We include such features as:

- 2 independently addressable serial ports (dip switch selectable addresses)
- Real LSI hardware UARTs for minimum CPU housekeeping
- RS232C, current loop (20mA), & TTL signals on both ports
- Precision, crystal-controlled Baud rates up to 19.2K Baud (individually dip switch selectable)
- Transmit & receive interrupts on both channels, jumperable to any vectored interrupt line
- Industry standard RS232 level converters with five RS232 handshaking lines per port
- Optically isolated current loop with provisions for both on-board & off-board current sources
- UART parameters, interrupt enables & RS232 handshaking lines are software programmable with power-on hardware default to customer specified hard-wired settings for maximum flexibility
- Port connectors mate directly to ribbon cable & DB25 connectors in standard pinouts
- RS232 lines will conform to either master or slave configurations
- Board gives full feature operation with both 2 & 4 MHz systems
- Low power consumption. +8V @ 450mA. +16V @ 150mA. -16V @ 70mA max
- No software initialization required for board operation, although board parameters may be altered by software 2 lbs

	Reg.	Sale
GBT - INTERFACER I UKT	$199.00	$189.00
GBT - INTERFACER I A&T	$249.00	$219.00

NEW! 32K X 8 ECONORAM X

Static storage for the S-100 buss.

Static storage for the S-100 buss. Guaranteed 4 MHz operation. Configured as two 8K and one 16K block, all independently addressable, protectable & enableable. Suitable for use in phantom systems. Extra select/deselect qualifiers for systems using more than 64K of memory make this board the ideal building block for large memory systems. Maybe you can't believe the low pricing - but you can count on the Econoram performance! Also available populated to 16K. Shipping Weight 2 lbs.

	Reg.	Sale
GBT - ECONORAM X 16K UKT	$329.00	$308.00
GBT - ECONORAM X 16K A&T	$379.00	$319.00
GBT - ECONORAM X 32K UKT	$599.00	$559.00
GBT - ECONORAM X 32K A&T	$689.00	$589.00

INTERFACER II

The new Interfacer II I/O board incorporates one channel of serial I/O with all the features of the INTERFACER dual RS232 serial board, plus 3 full duplex Parallel ports. The serial section includes all the features you've come to expect - a hardware UART, on-board crystal controlled Buad rate generator, hardware/software programmability, RS232 handshaking lines with real RS232 drivers, current loop & TTL drivers, full interrupts and more!!! The parallel selection utilizes LSTTL octal latches for latched input & output data with 24mA drive current, attention, enable & strobe bits for each parallel port (each with selectable polarity), interrupts for each input port, separate 25 pin connectors with power for each channel and a status port for interrupt mask and port status. All in all - an incredibly flexible and easy to use board.

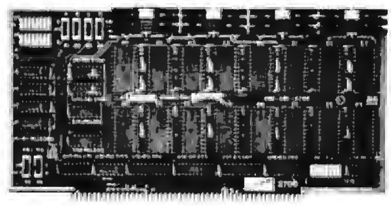
	Reg.	Sale
GBT - INTERFACER II UKT	$199.00	$189.00
GBT - INTERFACER II A&T	$249.00	$219.00

ECONORAM XIIIA-32

32K BANK SELECT! S-100 compatible. 4MHz guaranteed operation (0-70 C.) Features two 16K blocks independently addressable on 16K boundaries. Two independent banks - individual phantom - 256 ports DIP switch selectable ...each block may be deselected with a single switch Perfect for use in Alpha Micro Systems, Marinchip & others. Uses 4K x 1 low power STATIC rams. Current consumption guaranteed 3500mA max. Shipping Weight 2 lbs

	Reg.	Sale
GBT - ECONORAM XIIIA 16K UKT	$349.00	$329.00
GBT - ECONORAM XIIIA 16K A&T	$419.00	$369.00
GBT - ECONORAM XIIIA 24K UKT	$479.00	$449.00
GBT - ECONORAM XIIIA 24K A&T	$539.00	$479.00
GBT - ECONORAM XIIIA 32K UKT	$649.00	$598.00
GBT - ECONORAM XIIIA 32K A&T	$729.00	$649.00

ECONOROM 2708



Has provisions for wait states for 4MHz operations. Configured as four 4K blocks - each independently addressable and disableable. Power-on jump. Does **NOT** include 2708s. Includes all support chips, sockets, regulators, heat sinks, etc. Sold in UNKIT form **only**. Shipping Weight 2 lbs.

GBT - ECONOROM 2708 UKT **$85.00**

NEW **NEW**

	Reg.	Sale
GBT-SPECTRUM (Color graphics) KIT	339.00	319.00
GBT-SPECTRUM (Color graphics) A&T	399.00	349.00
GBT-CPU-Z80 KIT	225.00	210.00
GBT-CPU-Z80 A&T	295.00	269.00
GBT-CPU-8085 KIT	235.00	220.00
GBT-CPU-8085 A&T	325.00	259.00
GBT-CPU-8085/8088 KIT	385.00	365.00
GBT-CPU-8085/8088 A&T	495.00	449.00
GBT-BOX-DESK (S-100 Mainframe)	289.00	269.00
GBT-BOX-RACK (S-100 Mainframe)	329.00	309.00

ECONORAM XIV

16K x 8 for S-100. Addressable on any 4K boundary. Direct addressing on up to 24 address lines. Fully meets IEEE S-100 buss. specs. Low power, hi speed static memory Operates up to 5MHz with newest 8085/8086/8088 CPUs. Can be used with 8080, Z80, 8085, 8086, 8088, Z8000, etc.

	Reg.	Sale
GBT - ECONORAM XIV UKT	$299.00	$279.00
GBT - ECONORAM XIV A&T	$349.00	$298.00

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Circle 229 on inquiry card.

PRIORITY ONE ELECTRONICS

Circle 230 on inquiry card.

Circle 231 on inquiry card.

Circle 232 on inquiry card.

Circle 233 on inquiry card.

Circle 234 on inquiry card.

Circle 235 on inquiry card.

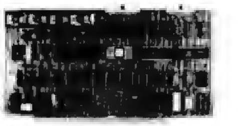
Circle 236 on inquiry card.

Circle 237 on inquiry card.

DELTA IS READY . . .

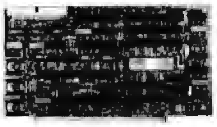
Call For DEALER In Your Area

Z—80 CPU



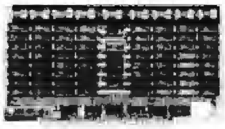
Two serial ports, three parallel ports. 2/4 MHz, on board Prom Monitor Phantoms. (Less cable and Monitor). A & T $325.00

DOUBLE/SINGLE DISK CONTROLLER



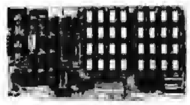
Two stage phase lock loop circuitry for greatest reliability, data transfer at maximum rate. Transparent density selection. 8" or 5" operation 2 or 4 MHZ (Some restrictions on DMA).
DMA — $425.00
STD. — $385.00

16K, 32K STATIC RAM



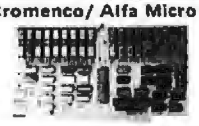
Worlds most reliable memory, responds to extended address lines A16, A17, cool running, fast.
16K-$395.00 32K-$650.00

32K, 48K, 64K DYNAMIC RAM



Basic dynamic board tested to run at 4MHZ with our Z-80 board. 4116 chips at 200 nanosecond speed insures most reliable data storage. Double density and DMA compatible.
32K-$580.00 48K-$640.00
64K-$750.00

32K, 48K, 64K ERROR DETECTING
Cromenco/ Alfa Micro



State of the art development. Parity generation and error detection. Compatible with 16 bit CPU designs. 16K bank, select under software control. 4MHZ Z-80, 8086, Cromenco, Alpha Micro compatible.
32K-$650.00 48K$725.00
64K-$850.00

FLOPPYS

8" Shugart	$550.00
8" Siemans	$525.00
5" Siemans	$350.00
(Double Sided)	
8" CDC	$675.00
8" Remex	$645.00

TELEVIDEO 912

80 x 24—Lower case descenders. Teletype or typewriter keyboard 110/220 VAC. 50 to 19.2K Baud Hex entry pad. Similar to SOROC but better looking with NO FAN NOISE

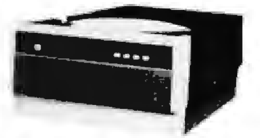
TELEVIDEO 920

Similar to TV 912 but has programmable functions keys across top. Excellent for WORDSTAR Text Editing.

WINCHESTER/SHUGART SA 1000

5 megs now expandable to 10, works alongside floppy disk drive for expanded storage. Use with controller below.
$1950.00

WINCHESTER/CENTURY DATA SYSTEM
(Hunter Shown)



20 megs expandable to 40—Marksman series, plugs into our CPU parallel port or MP/M board drive, cabinet, power supply, 2.0 Bios.
$4850.00

FLOPPY DISKS

DYSAN Quality

dysan

8" SSSD	$4.25
8" SSDD	$5.50
8" DSDD	$7.60
5" SSDD	$4.10

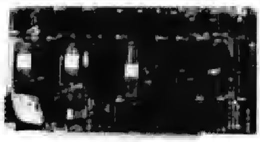
(Boxes of 10 only)

MPM® I/O TIMER

COMING SOON

Designed for MP/M® software of Digital Research. 6 users serial port, three 8 bit parallel ports for hard disk. Timer and vectored interrupt.
®TM Digital Research

80 x 24 VIDEO



Keyboard input, Z—80 Processor, on board RAM makes this a non-memory mapped substitute for a terminal when mated with a keyboard.
$430.00

WINCHESTER/FLOPPY INTERFACE

COMING SOON

Allows mixing of Shugart Winchester and floppy drives on same cable when used with DP-DSK. Supplied with software Bios for MP/M® and 2.0
®TM Digital Research

SOFTWARE/ CABLES/PROMS

CP/M® 2.2	$150.00
MP/M®	$350.00
2708 Monitor	$ 25.00
2716 Monitor	$ 40.00
Disk 50 Pin	$ 22.00
RS-232	$ 15.00
CPU to Back	$ 32.00
Disk DC	$ 4.50
Disk AC	$ 2.50
Winchester	$ 28.00

COMPLETELY *NEW* FROM DELTA PRODUCTS

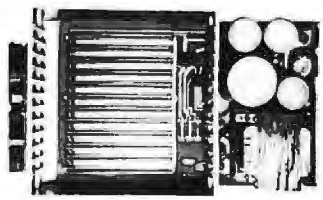
S-100 MAINFRAME

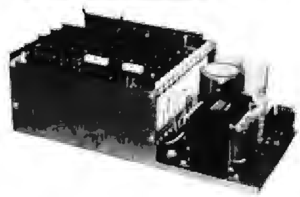
- Twin Verticle Drive Mounting, Fits Shugart, Siemans, Etc.
- Key-Lock Switch
- Detachable Power/Mother Module
- Detachable Drive Platform
- 12-Slot Motherboard, Fully Terminated
- INCLUDES S-100 MODULE SHOWN AT RIGHT.

LESS DRIVES **$849.00**
INTRODUCTORY SPECIAL

S-100 MODULE

- 30A of +8V
  6A of ±16V
- Disc Power Supply
  6A of +24V
  5A of +5V
  1A of −5V
- 220V or 110V AC
  50 or 60 Cycle Operation
- Connectors Supplied For Up To 4 Drives
- OPTIONAL Fans Mount Neatly On 1 Side For Forced Air Cooling





$249.00
INTRODUCTORY SPECIAL

West:
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Huntington Beach, CA 92649
TELEPHONE: (714) 898-1492

DELTA PRODUCTS

East:
DELTA PRODUCTS
11 Edison Drive
New Lennox, IL 60451
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TELEX: 681-367 DELTMAR HTBH

WE WILL NOT BE UNDERSOLD

16K MEMORY UPGRADE KITS — $54

for TRS-80*, Apple II, Sorcerer (specify)

PRINTERS

NEC Spinwriter

Letter Quality High Speed Printer
Includes TRS-80* interface software, quick change print fonts, 55 cps, bidirectional, high resolution plotting, graphing, proportional spacing — $2689
With Tractor Feed — $2889

DIABLO 1650 — R.O. $2890 — KSR $3285

779 CENTRONICS TRACTOR FEED PRINTER — $969
Same as Radio Shack line printer I

737 CENTRONICS FRICTION & PIN FEED PRINTER — $839
9 × 7 matrix

730 CENTRONICS FRICTION & PIN FEED PRINTER — $639
7 × 7 matrix Same as Radio Shack line printer II

P1 CENTRONICS PRINTER — $269
Same as Radio Shack quick printer

PAPER TIGER (IP440) — $939
Includes 2K buffer and graphics option

TI-810 Faster than Radio Shack line printer III
Parallel and serial w/TRS-80* interface software — $1575
with upper and lower case and paper tray — $1665

OKIDATA Microline 80 Friction and pin feed — $559
Tractor Feed, friction, and pin feed — $679

EATON LRC 7000 + 64 columns, plain paper — $349

ANADEX DP-9500 — $1369

CAT MODEM Originate and answer same as Radio Shack Telephone Interface II — $148

LEEDEX MONITOR Video 100 — $129

DISK DRIVES — $314

More capacity than Radio Shack 35 Track (80 K Bytes) drives. Fully assembled and tested. Ready to plug-in and run the moment you receive it. Can be intermixed with each other and Radio Shack drive on same cable. TRS-80* compatible silver enclosure.

90 DAY WARRANTY. ONE YEAR ON POWER SUPPLY.

FOR TRS-80*		
CCI-100	5¼", 40 Track (102K Bytes) for Model I	**$314**
CCI-200	5¼", 77 Track (197K Bytes) for Model I	$549
CCI-800	8" Drive for Model II (½ Meg Bytes)	$795
For Zenith Z89		
CCI-189	5¼", 40 Track (102K Bytes) add-on drive	$394
Z-87	Dual 5¼" add-on drive system	$995

DISKETTES — Box of 10 (5¼") - with plastic library case — $24.95
8" double density for Model II (box of 10) — $36.49

COMPLETE SYSTEMS

TRS-80* LEVEL II-16K with keypad — $719
TRS-80* Expansion Interface — $269
ZENITH Z89, 48K all-in-one computer — $2595
ZENITH Z19 — $740
TELEVIDEO 912B $745 — 920B $769
ATARI 400 $489 — **ATARI 800** $799 — **TI 99/4** $894
MATTEL INTELLIVISION — $249
NORTH STAR Horizon 1 32K, Double Density — $2129

DISK OPERATING SYSTEMS

PATCHPAK #4 by Percom Data — $ 8.95
CP/M for Model I, Zenith $145 • for Model II, Altos $169.00
NEWDOS Plus — with over 200 modifications and corrections to TRS-DOS — 35track $ 89.00 — 40 or 70 Track $ 99.00

SOFTWARE FOR THE TRS-80* (Software w/Manual / Manual Alone)

CCI-INVESTMENT PORTFOLIO MANAGER: This is what investors have been waiting for! This powerful program was developed by security analysts working with software designers. It comes on one cassette — 16K LEVEL II BASIC on one side, 32K DISK BASIC on the other. Store and report data; Review your portfolio, Produce detailed status, value, gain, and security analyses; Compare alternatives — $49.95/$10

INTELLIGENT TERMINAL SYSTEM ST-80-III BY LANCE MIKLUS: Enables a TRS-80* to act as a dial-up terminal on any standard time sharing network. Provides a TRS-80* with control key, ESC Key, Repeat Key, Rub Out Key, Break Key, full upper and lower case support, selectable printer output and program selectable transmission rates — $139/$10

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CSA-MAILIST SYSTEM: Creates, maintains and efficiently utilizes a name, address and telephone number file. 400 individual name/address entries can be maintained on a single density mini-floppy, and are manipulated directly by record number (direct access file method). Sorts can be performed, name + address combinations can be coded. Listing-directones and labels can be printed. A conversion facility is provided to convert most sequential name, address file formats into direct. Requires 32K TRS-80 and one drive. — $49.95/$10

S & M SYSTEMS
INSEQ-80™: Indexed Sequential Access Method (ISAM) for the TRS-80 Model I. A must for anyone writing business programs. Eliminate wasted disk space from direct record processing. Split second access to any record. Access data records instantly via alpha/numeric "key" eg. Part NR, zip code or sequentially in ascending key sequence. Add/modify records in any order. Access up to three files per program — Files may be spread over multiple disks. Machine language processing from your basic program. Utility program to convert direct files to INSEQ-80 format — $49.95/$10

FULLY INTERACTIVE ACCOUNTING PACKAGE: ISAM (INSEQ-80) based. Includes General Ledger, Accounts Payable, Accounts Receivable and Payroll. System runs "stand alone" or "co-ordinated G/L" at users option. Based on Osborne accounting method. Requires 32K, TRS-80, 2 or 3 drives. N/A CA
General Ledger — $99/$10
Accounts Receivable — $99/$10
Accounts Payable — $99/$10
Payroll — $99/$10
Osborne books: Req'd as additional documentation — $20 ea

INVENTORY Requires 32K, TRS-80, 1 drive — $125/$10

INSORT-80: Callable form BASIC via USR. Sorts "Random" Disk Files. "Disk" to "Disk" sort times — 350 records in 35 secs, 1000 records in 8 minutes, 3500 records in 12 minutes. Machine language processing. Up to 35 sort keys ascending/descending. Utility to build BASIC program. Runs under NEWDOS. — $49.95/$10

ACCESSORIES
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Re-orders of rings only: $ 7.95

CP/M BASED SOFTWARE for Zenith, Altos, Radio Shack, Apple (Software w/Manual / Manual Alone)

MICROSOFT
BASIC-80: Disk Extended BASIC ANSI compatible with long variable names, WHILE/WEND, chaining, variable length file records. — $325/$25

BASIC COMPILER: Language compatible with BASIC-80 and 3-10 times faster execution. Produces standard Microsoft relocatable binary output. Includes MACRO-80. Also linkable to FORTRAN-80 or COBOL-80 code modules. — $350/$25

FORTRAN-80: ANSI 66 (except for COMPLEX) plus many extensions. Includes relocatable object compiler, linking loader, library with manager. Also includes MACRO-80 (see below) — $425/$25

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BDS 'C' COMPILER: Supports most features of language, including structures, arrays, pointers, recursive function evaluation, and overlays. Package contains: compiler, linker, library manager; sample source files include games, a terminal emulator with disk I/O plus the source for many standard library functions; BDS C User's Guide; Book - The C Programming Language by Dennis Ritchie and Brian Kernigham. Requires at least 24K of RAM — $125/$20

CONFIGURABLE BUSINESS SYSTEM BY DMA: CBS is a data management system that allows true transaction processing. Custom accounting systems for payables, receivables, inventory control, order entry, and general ledger can be set up without using any programming languages. CBS can be used to define an application such as an inventory control system by specifying master files to describe the inventory, customer and vendor files. Transaction files can then be used to describe activities such as purchases and sales. An extremely easy-to-use data entry program is used to enter information about customers, vendors, inventory, sales and purchases. After data entry is complete, an update program can process the transactions against the various master files, updating account balances and inventory quantities. The system features a screen menu generator and a comprehensive report generator which can be used to produce invoices, purchase orders, re-order reports, mailing labels or other special reports specific to the application. Good documentation and a demonstration inventory system supplied. Requires at least 48K memory. Does not require any support language. — $295

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- Compatible with Heath™ H8 hardware and software
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- Jump-On-Reset to any 1K boundary
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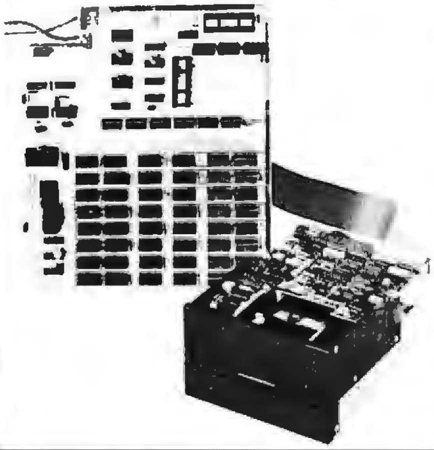

610 Expander Board

For use with Superboard II and Challenger 1P. 8K static RAM expandable to 24K or 32K system total. Accepts up to two mini-floppy disk drives.
Requires +5V @ 4.5 amps **$298**

Mini-Floppy Disk Drive

Includes Ohio Scientific's PICO DOS software and connector cable. Compatible with 610 Expander Board.
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4KP 4K RAM chip set	$ 79
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SAMS manual C1P/Superboard II	$ 8
SAMS manual C4P	$ 16
OS-65D V3.2 Disk Operating System with 9-digit extended BASIC, random access from sequential files	$ 49
C4P computer 8K RAM expandable to 32K RAM	$ 750
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32K S-100 EPROM CARD

NEW!

$74.95 KIT

USES 2716's

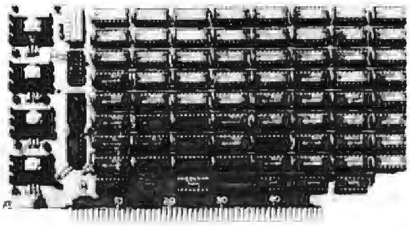
Blank PC Board - $34

ASSEMBLED & TESTED ADD $30

SPECIAL: 2716 EPROM's (450 NS) Are $19.95 EA. With Above Kit.

KIT FEATURES
1. Uses +5V only 2716 (2Kx8) EPROM's
2. Allows up to 32K of software on line!
3. IEEE S-100 Compatible
4. Addressable as two independent 16K blocks
5. Cromemco extended or Northstar bank select
6. On board wait state circuitry if needed
7. Any or all EPROM locations can be disabled
8. Double sided PC board, solder-masked, silk-screened
9. Gold plated contact fingers
10. Unselected EPROM's automatically powered down for low power
11. Fully buffered and bypassed
12. Easy and quick to assemble

8K LOW POWER RAM KIT-S 100 BUSS



21L02 (450 NS RAMS!)

$119.50 KIT

ASSEMBLED & FULLY BURNED IN ADD $35

Thousands of computer systems rely on this rugged, work horse RAM board. Designed for error-free, NO HASSLE, systems use.

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Blank PC Board w/Documentation - $29.95
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4K STATIC RAM'S. MAJOR BRAND, NEW PARTS.
These are the most sought after 2114's, LOW POWER and 300NS FAST.
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16K STATIC RAM KIT-S 100 BUSS

PRICE CUT!

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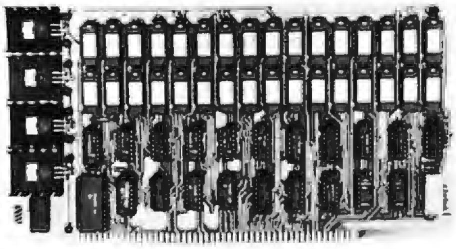

KIT FEATURES
1. Addressable as four separate 4K Blocks
2. ON BOARD BANK SELECT circuitry. (Cromemco Standard!) Allows up to 512K on line!
3. Uses 2114 (450NS) 4K Static Rams
4. ON BOARD SELECTABLE WAIT STATES
5. Double sided PC Board, with solder mask and silk screened layout. Gold plated contact fingers
6. All address and data lines fully buffered
7. Kit includes ALL parts and sockets
8. PHANTOM is jumpered to PIN 67
9. LOW POWER: under 1.5 amps TYPICAL from the +8 Volt Buss
10. Blank PC Board can be populated as any multiple of 4K

BLANK PC BOARD W/DATA-$33
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OUR #1 SELLING RAM BOARD!

16K STATIC RAM SS-50 BUSS

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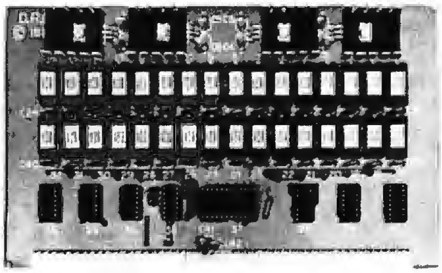

FULLY STATIC!

FOR 2MHZ ADD $10

FOR SWTPC 6800 BUSS!

ASSEMBLED AND TESTED - $35

KIT FEATURES
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2. Uses 2114 Static Ram
3. Fully Bypassed
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5. All Parts and Sockets included
6. Low Power: Under 1.5 Amps Typical

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NEW! STEREO! S-100 SOUND COMPUTER BOARD NEW!

At last, an S-100 Board that unleashes the full power of two unbelievable General Instruments AY3-8910 NMOS computer sound IC's. Allows you under total computer control to generate an infinite number of special sound effects for games or any other program. Sounds can be called in BASIC, ASSEMBLY LANGUAGE, etc.

COMPLETE KIT! **$84.95** (WITH DATA MANUAL)

BLANK PC BOARD W/DATA $31

KIT FEATURES:
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- ALL SOCKETS, PARTS AND HARDWARE ARE INCLUDED
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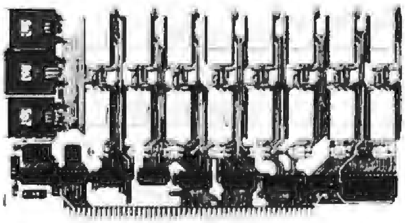
Both Basic and Assembly Language Programming examples are included

SOFTWARE:

SCL™ is now available! Our Sound Command Language makes writing Sound Effects programs a SNAP! SCL™ also includes routines for Register Examine-Modify, Memory-Examine-Modify and Play-Memory. SCL™ is available on CP/M* compatible diskette or 2708 or 2716. Diskette - $24.95 2708 - $19.95 2716 - $29.95 Diskette includes the source. EPROM'S are ORG at E000H

16K EPROM CARD-S 100 BUSS



$59.95 KIT

BLANK PC BOARD - $28

USES 2708's!

Thousands of personal and business systems around the world use this board with complete satisfaction. Puts 16K of software on line at ALL TIMES! Kit features a top quality soldermasked and silk-screened PC board and first run parts and sockets. Any number of EPROM locations may be disabled to avoid any memory conflicts. Fully buffered and has WAIT STATE capabilities.

ASSEMBLED AND FULLY TESTED — ADD $30

OUR 450 NS 2708'S ARE $8.95 EA. WITH PURCHASE OF KIT

RCA CMOS COMPUTER CHIP SET

INCLUDES:

1-CDP1802CD CPU	1-CDP1861CD VIDEO IC
2-CDP1822CE 256 x 4 RAM	1-CDP1862CE COLOR GEN.
1-CDP1858CE 4 BIT LATCH	1-CDP1863CE SOUND GEN.

COMPLETE SET $45 LIMITED QTY

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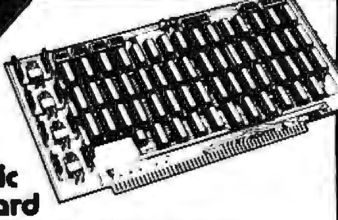
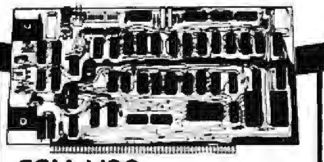


CCS 16K Static Ram Board

True static RAM board designed specifically for the S-100 bus Requires only +5VDC Features true static operation, and all bus signals labeled on-board! Uses 2114 low power static RAS. S-100 compatible, fully buffered. Silk screened PC board, solder masked on both sides.

Cat No.	Description	Wt	Price
1601A	16K RAM 450ns Kit	1 lb	$253.50
1601B	16K RAM 200ns Kit	1 lb	$333.50
1601C	16K RAM 300ns Kit	1 lb	$293.50
1602A	16K RAM 450ns A & T	1 lb	$285.75
1602B	16K RAM 200ns A & T	1 lb	$371.50
1602C	16K RAM 300ns A & T	1 lb	$328.50
1603	16K RAM Bareboard only	6 oz.	$ 29.95

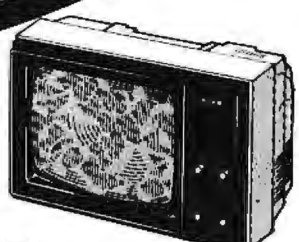


SSM VB2 VIDEO BOARD

I/O controlled video interface board With a TV monitor, the VB2 becomes a video terminal! No other I/O card is required for keyboard input and video display The cursor, linefeed, carriage return, backspace and clear screen are hardware controlled The display is 64 X 16 all upper case and is selectable for white-on-black or black-on-white

Produces a clear bright display and features adjustable picture size and character width Circuitry is provided to drive a speaker for beep tone

Cat No.	Description	Price
1438	VB2 kit	$169.00
1439	VB2 A&T	$234.00



Leedex VIDEO 100 12" MONITOR

- *Compatible with TRS-80 (no interface required)*
- *Compatible with many home computers!*

Now from LEEDEX One of the most popular low cost yet high resolution (650 line) monitors currently available These units compare favorably with monitors costing twice as much Because of the fact that standard composite video input is utilized no RF modulator is needed An extremely sharp and stable picture is achieved The video bandwidth is 12 mhz + / − 3db with a 75 ohm input impedance

Cat No. 1204	Video 100 Monitor	Wt. 18 lb.	$149.00
Cat No. 1937	TRS-80/Leedex cable kit	Wt. 6 oz.	$3.00

CCS 32K Static RAM Board $710

Uses 2114, 250ns fully Static Rams, bank selectable in 8K blocks. Enable/Disable on Power up or Reset. Compatible with North Star, Alpha Micro, Cromeco, etc. Also front panel compatible, addressable in 8K blocks. Selectable Wait state. Wt 1 lb. Assembled & tested.
Cat No. 2644

THE PIE 2.0 $79.95 (Programma Improved Editor)

Don't be mislead by the low price of this outstanding wordprocessing package PIE 2 0 is a powerful text editor and print format processor that has all the bells and whistles expected of wordprocessing software costing three times as much Some features include

1) *Character/line insert and delete*
2) *Complete Cursor mobility*
3) *String search forward and backward*
4) *Single, conditional or global search and replace*
5) *Move and/or copy blocks of text*
6) *Page scrolling*
7) *Tabs, margins, paragraphing, etc.*

Research conducted by IBM Corp revealed that the time required to create, edit and complete a one page document was decreased by as much as 60% when comparing the performance of a Wordprocessing system to an ordinary typewriter Finding ways to remain competitive these days is a challenge for the business executive Todays office can substantially improve their daily productivity level with PIE 2 0 Wordprocessing software and an Apple II computer with 32k RAM memory

As a businessman you want every dollar you spend to count, so wordprocessing makes sense, and PIE 2 0 Wordprocessing software gives you more for your hard earned dollar PIE 2.0 Wordprocessing software comes complete with program diskette and detailed documentation in a handsome, simulated leather binder
Cat No. 2562

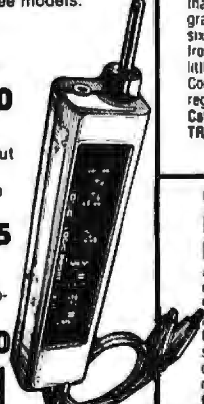
Continental Specialties LOGIC PROBES

Compact and versatile. Perfect for test and troubleshooting all types of digital applications! Simple to operate . . . just connect the clip leads to the circuits power supply, flip the logic switch, and test! LEDs indicate test results and circuit conditions. Combines the functions of level detector, pulse detector, pulse stretcher, and memory. Available in three models.

LP-1 Hand-held instant reading of logic levels for TTL, DTL, HTL, or CMOS.
Cat No. 2067 **$44.00**

LP-1 The economy model without the memory capability. Safer than a voltmeter, more accurate than a scope!
Cat No. 2068 **$26.85**

LP-3 Faster version of the LP-1. High speed logic probe captures pulses as short as 10 nsec.
Cat No. 2069 **$69.00**



TRS-80 CP/M

At last, CP/M is available for the TRS-80! Long a standard for software development and interchange for all the "other" 8080/Z80 computers on the market, CP/M will now provide the same environment for the TRS-80 CP/M is a file-oriented disk operating system that provides a common set of utilities for program development and operation There are six built in commands plus utilities called in from disk CP/M will run on a TRS-80 with as little as 16k of memory and one disk drive Comes complete with six manuals CP/M is a registered trade mark of Digital Research
Cat No. 1679
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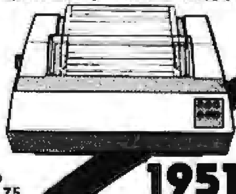

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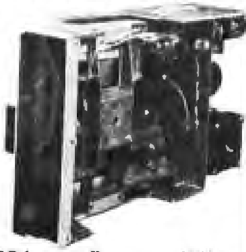

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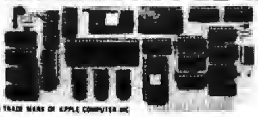

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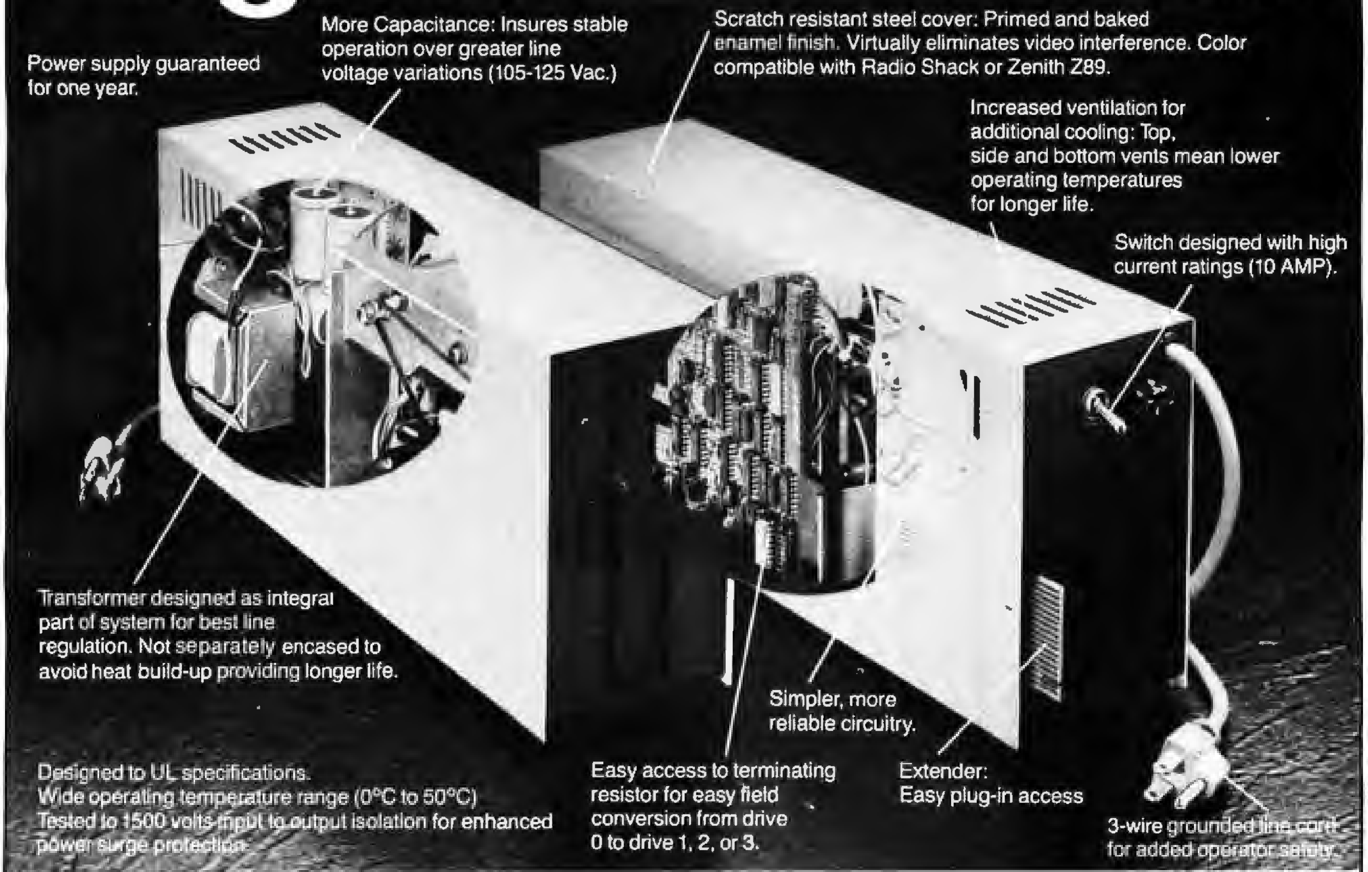

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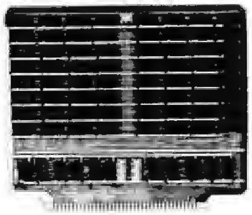

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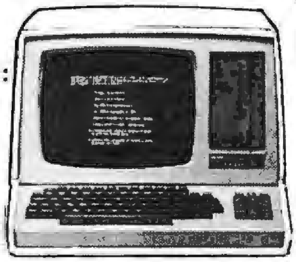

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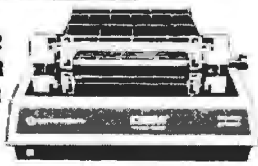

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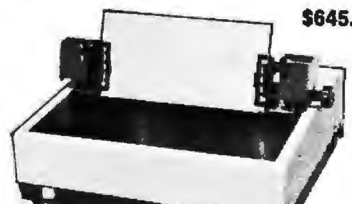

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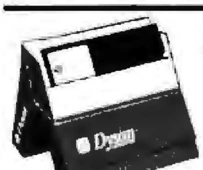

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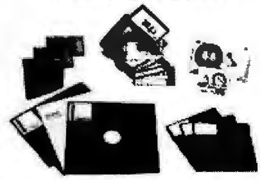

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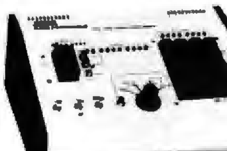

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- Stand alone EPROM Programmer consisting of: A 16 key Hexadecimal Keyboard assembly, Programmer Board assembly with 4 power supplies and a LED/Test Socket Panel Board assembly. The Test Socket is zero force insertion type. Power requirements: 115VAC, 60Hz, 6W.
- Compact desk top enclosure. Color coordinated designer's case with light tan panels and molded end pieces in mocha brown. Size: 3¾"H x 11"W x 6¾"D. Weight: 5 lbs.

The JE608 EPROM Programmer is a completely self contained unit which is independent of computer control and requires no additional systems for its operations. The EPROM can be programmed from the Hexadecimal Keyboard or from a pre-programmed EPROM. The JE608 Programmer can emulate a programmed EPROM by the use of its internal RAM circuits. This will allow the user to test or pretest a program, for a system, prior to programming a chip. Any changes in the program can be entered directly into the memory circuits with the Hexadecimal Keyboard so that rewriting the entire program will not be necessary. The JE608 Programmer contains a Programmer Board with 25 IC's and including power supplies of -5V +5V +12V and +26V. The Hexadecimal Keyboard and LED/Test Socket Panel Board are separate assemblies within the system.

JE608 KIT $399.95

JE608 Assembled and Tested $499.95

DISCRETE LEDS

XC556R	.200"	red	5/$1	MV50	.085"	red	6/$1	XC111R	.190"	red	5/$1
XC556G	.200"	green	4/$1	XC209R	.125"	red	5/$1	XC111G	.190"	green	4/$1
XC556Y	.200"	yellow	4/$1	XC209G	.125"	green	4/$1	XC111Y	.190"	yellow	4/$1
XC556C	.200"	clear	4/$1	XC209Y	.125"	yellow	4/$1	XC111C	.190"	clear	4/$1
XC22R	.200"	red	5/$1	XC526R	.185"	red	5/$1				
XC22G	.200"	green	4/$1	XC526G	.185"	green	4/$1	INFRA-RED LED			
XC22Y	.200"	yellow	4/$1	XC526Y	.185"	yellow	4/$1	¼"x¼"x1/16" flat			5/$1
MV10B	.170"	red	4/$1	XC526C	.185"	clear	4/$1				

DISPLAY LEDS

TYPE	POLARITY	HT	PRICE	TYPE	POLARITY	HT	PRICE
MAN 1	Common Anode-red	.270	2.95	MAN 6730	Common Anode-red ± 1	.560	.99
MAN 2	5 x 7 Dot Matrix-red	.300	4.95	MAN 6740	Common Cathode-red-D.D.	.560	.99
MAN 3	Common Cathode-red	.125	.25	MAN 6750	Common Cathode-red ± 1	.560	.99
MAN 4	Common Cathode-red	.187	1.95	MAN 6760	Common Anode-red	.560	.99
MAN 7G	Common Anode-green	.300	1.25	MAN 6780	Common Cathode-red	.560	.99
MAN 7Y	Common Anode-yellow	.300	.99	DL701	Common Anode-red ± 1	.300	.99
MAN 72	Common Anode-red	.300	.75	DL704	Common Cathode-red	.300	.99
MAN 74	Common Cathode-red	.300	1.25	DL707	Common Anode-red	.300	.99
MAN 82	Common Anode-yellow	.300	.49	DL728	Common Cathode-red	.500	1.49
MAN 84	Common Cathode-yellow	.300	.99	DL741	Common Anode-red	.600	1.25
MAN 3620	Common Anode-orange	.300	.49	DL746	Common Anode-red ± 1	.630	1.49
MAN 3630	Common Anode-orange ± 1	.300	.99	DL747	Common Anode-red	.600	1.49
MAN 3640	Common Cathode-orange	.300	.99	DL749	Common Cathode-red ± 1	.630	1.49
MAN 4610	Common Anode-orange	.300	.99	DL750	Common Cathode-red	.600	1.49
MAN 4640	Common Cathode-orange	.400	.99	DL338	Common Cathode-red	.110	.35
MAN 4710	Common Anode-red	.400	.99	FND70	Common Cathode	.250	.69
MAN 4730	Common Anode-red ± 1	.400	.99	FND358	Common Cathode ± 1	.357	.99
MAN 4740	Common Cathode-red	.400	.99	FND359	Common Cathode	.357	.75
MAN 4810	Common Anode-yellow	.400	.99	FND503	Common Cathode(FND500)	.500	.99
MAN 4840	Common Cathode-yellow	.400	.99	FND507	Common Anode (FND510)	.500	.99
MAN 6610	Common Anode-orange-D.D.	.560	.99	5082-7730	Common Anode-red	.300	.99
MAN 6630	Common Anode-orange ± 1	.560	.99	HDSP-3400	Common Anode-red	.800	1.50
MAN 6640	Common Cathode-orange-D.D.	.560	.99	HDSP-3403	Common Cathode red	.800	1.50
MAN 6650	Common Cathode-orange ± 1	.560	.99	5082-7300	4 x 7 sgl. Digit-RHDP	.600	19.95
MAN 6660	Common Anode-orange	.560	.99	5082-7302	4 x 7 Sgl. Digit-LHDP	.600	19.95
MAN 6680	Common Cathode-orange	.560	.99	5082-7304	Overrange character (±1)	.600	15.00
MAN 6710	Common Anode-red-D.D.	.560	.99	5082-7340	4 x 7 Sgl. Digit-Hexadecimal	.600	22.50

RCA LINEAR

CA3013T	2.15	CA3082N	2.00
CA2023T	3.25	CA3083N	1.60
CA3035T	2.48	CA3086N	.85
CA3039T	1.35	CA3089N	3.75
CA3046N	1.30	CA3130T	1.39
CA3059N	3.25	CA3140T	1.25
CA3060N	3.25	CA3160T	1.25
CA3080T	1.25	CA3401N	.59
CA3081N	2.00	CA3600N	3.50

CALCULATOR CHIPS/DRIVERS

MM5725	$2.95
MM5738	2.95
DM8864	2.00
DM8865	1.00
DM8887	.75
DM8889	.75
9374 7-seg. LED driver	1.50
MM5309	4.95

CLOCK CHIPS

MM5309	4.95
MM5311	4.95
MM5312	4.95
MM5314	4.95
MM5316	6.95
MM5318	9.95
MM5369	2.95
MM5387/1998a	4.95
CT 7001	6.95

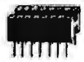
MOTOROLA

MC1408L7	4.95
MC1408L8	5.75
MC1439L	2.95
MC3022P	2.95
MC3061P	3.50
MC4016(74416)	7.50
MC4024P	3.95
MC4040P	6.95
MC4044P	4.50

LOW PROFILE (TIN) SOCKETS

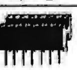
	1-24	25-49	50-100
8 pin LP	.17	.16	.15
14 pin LP	.20	.19	.18
16 pin LP	.22	.21	.20
18 pin LP	.29	.28	.27
20 pin LP	.34	.32	.30
22 pin LP	.37	.36	.35
24 pin LP	.38	.37	.36
28 pin LP	.45	.44	.43
36 pin LP	.60	.59	.58
40 pin LP	.63	.62	.61

SOLDERTAIL STANDARD (TIN)



	1-24	25-49	50-100
14 pin ST	.27	.25	.24
16 pin ST	.30	.27	.25
18 pin ST	.35	.32	.30
24 pin ST	.49	.45	.42
28 pin ST	.99	.90	.81
36 pin ST	1.39	1.26	1.15
40 pin ST	1.99	1.45	1.30

SOLDERTAIL (GOLD) STANDARD



	1-24	25-49	50-100
8 pin SG	.39	.35	.31
14 pin SG	.49	.45	.41
16 pin SG	.54	.49	.44
18 pin SG	.59	.53	.48
24 pin SG	.79	.75	.69
28 pin SG	1.10	1.00	.90
36 pin SG	1.65	1.40	1.26
40 pin SG	1.75	1.59	1.45

WIRE WRAP SOCKETS (GOLD) LEVEL #3

	1-24	25-49	50-100
8 pin WW	.59	.54	.49
10 pin WW	.69	.63	.58
14 pin WW	.79	.73	.67
16 pin WW	.85	.77	.70
18 pin WW	.99	.90	.81
20 pin WW	1.19	1.08	.99
22 pin WW	1.49	1.35	1.23
24 pin WW	1.39	1.26	1.14
28 pin WW	1.69	1.53	1.38
36 pin WW	2.19	1.99	1.79
40 pin WW	2.29	2.09	1.89

1/4 WATT RESISTOR ASSORTMENTS – 5%

ASST. 1	5 ea	10 OHM / 27 OHM	12 OHM / 33 OHM	15 OHM / 39 OHM	18 OHM / 47 OHM	22 OHM / 56 OHM	50 PCS	$1.75
ASST. 2	5 ea	68 OHM / 180 OHM	82 OHM / 220 OHM	100 OHM / 270 OHM	120 OHM / 330 OHM	150 OHM / 390 OHM	50 PCS	1.75
ASST. 3	5 ea	470 OHM / 1.2K	560 OHM / 1.5K	680 OHM / 1.8K	820 OHM / 2.2K	1K / 2.7K	50 PCS	1.75
ASST. 4	5 ea	3.3K / 8.2K	3.9K / 10K	4.7K / 12K	5.6K / 15K	6.8K / 18K	50 PCS	1.75
ASST. 5	5 ea	22K / 56K	27K / 68K	33K / 82K	39K / 100K	47K / 120K	50 PCS	1.75
ASST. 6	5 ea	150K / 390K	180K / 470K	220K / 560K	270K / 680K	330K / 820K	50 PCS	1.75
ASST. 7	5 ea	1M / 2.7M	1.2M / 3.3M	1.5M / 3.9M	1.8M / 4.7M	2.2M / 5.6M	50 PCS	1.75

ASST. 8R Includes Resistor Assortments 1-7 (350 PCS.) **$9.95 ea.**

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AY-5-9200	Repertory Dialler	14.95
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74C922	Keyboard Encoder (16 keys)	7.95
74C923	Keyboard Encoder (20 keys)	6.25

ICM CHIPS

ICM7045	CMOS Precision Timer	24.95
ICM7205	CMOS LED Stopwatch/Timer	19.95
ICM7207	Oscillator Controller	7.50
ICM7208	Seven Decade Counter	19.95
ICM7209	Clock Generator	8.95

NMOS READ ONLY MEMORIES

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MCM6575	128 X 9 X 7 Alpha Control Char Gen	13.50

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TL074CN	Quad Low Noise bi-fet Op Amp	2.49
TL494CN	Switching Regulator	4.49
TL496CP	Single Switching Regulator	1.75
11C90	Divide 10/11 Prescaler	19.95
95H90	Hi-Speed Divide 10/11 Prescaler	11.95
4N33	Photo-Darlington Opto-Isolator	3.95
MK50240	Top Octave Freq. Generator	17.50
DS0026CH	5Mhz 2-phase MOS clock driver	3.75
TIL308	.27" red num. display w/integ. logic chip	10.95
MM5320	TV Camera Sync. Generator	14.95
MM5330	4½ Digit DPM Logic Block (Special)	3.95
LD110/111	3½ Digit A/D Converter Set	25.00/set
MC14433P	3½ Digit A/D Converter	13.95

LITRONIX ISO-LIT 1
Photo Transistor Opto-Isolator
(Same as MCT 2 or 4N25)
49¢ each

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SOUND GENERATOR
Generates Complex Sounds
Low Power - Programmable
$3.95 each

TV GAME CHIP AND CRYSTAL
AY-3-8500-1 and 2.01 MHZ Crystal (Chip & Crystal includes score display, 6 games and select angles, etc. **7.95/set**

EXAR

XR205	$8.40			XR2242CP	1.50
XR210	4.40			XR2264	4.25
XR215	4.40			XR2556	3.20
XR320	1.55			XR2567	2.99
XR-L555	1.50	JE2206KB	19.95	XR3403	1.25
XR555	.39	XR1800	3.20	XR4136	1.25
XR556	.99	XR2206	4.40	XR4151	3.95
XR567CP	.99	XR2207	3.85	XR4194	1.45
XR567CT	1.25	XR2208	5.20	XR4202	3.60
XR1310P	1.95	XR2209	1.75	XR4212	2.05
XR1468CN	3.85	XR2211	5.25	XR4558	.75
XR1488	1.95	XR2212	4.35	XR4739	1.15
XR1489	1.95	XR2240	3.45	XR4741	1.47

DIODES

TYPE	VOLTS	W	PRICE	TYPE	VOLTS	W	PRICE
				1N4002	100 PIV	1 AMP	12/1.00
				1N4003	200 PIV	1 AMP	12/1.00
1N746	3.3	400m	4/1.00	1N4004	400 PIV	1 AMP	12/1.00
1N751	5.1	400m	4/1.00	1N4005	600 PIV	1 AMP	10/1.00
1N752	5.6	400m	4/1.00	1N4006	800 PIV	1 AMP	10/1.00
1N753	6.2	400m	4/1.00	1N4007	1000 PIV	1 AMP	10/1.00
1N754	6.8	400m	4/1.00	1N3600	50	200m	6/1.00
1N757	9.0	400m	4/1.00	1N4148	75	10m	15/1.00
1N759	12.0	400m	4/1.00	1N4154	35	10m	12/1.00
1N959	8.2	400m	4/1.00	1N4733	5.1	1w	.28
1N965	15	400m	4/1.00	1N4734	5.6	1w	.28
1N5232	5.6	500m	.28	1N4735	6.2	1w	.28
1N5234	6.2	500m	.28	1N4736	6.8	1w	.28
1N5235	6.8	500m	.28	1N4738	8.2	1w	.28
1N5236	7.5	500m	.28	1N4742	12	1w	.28
1N5242	12	500m	.28	1N4744	15	1w	.28
1N5245	15	500m	.28	1N1183	50 PIV	35 AMP	1.60
1N456	25	40m	6/1.00	1N1184	100 PIV	35 AMP	1.70
1N458	150	7m	6/1.00	1N1185	150 PIV	35 AMP	1.70
1N485A	180	10m	5/1.00	1N1186	200 PIV	35 AMP	1.80
1N4001	50 PIV	1 AMP	12/1.00	1N1188	400 PIV	35 AMP	3.00

SCR AND FW BRIDGE RECTIFIERS

C36D	15A @ 400V	SCR(2N1849)	$1.95
C36M	35A @ 600V	SCR	1.95
2N2328	1.6A @ 300V	SCR	.50
MDA 980-1	12A @ 50V	FW BRIDGE REC.	1.95
MDA 980-3	12A @ 200V	FW BRIDGE REC.	1.95

TRANSISTORS

C106B1	.50			2N3904	4/1.00
MPSA05	.30	2N3055	.89	2N3905	4/1.00
MPSA06	5/1.00	MJE3055	1.00	2N3906	4/1.00
TIS97	6/1.00	2N3392	5/1.00	2N4013	3/1.00
TIS98	6/1.00	2N3398	5/1.00	2N4123	6/1.00
40409	1.75	PN3567	3/1.00	PN4249	4/1.00
40410	1.75	PN3568	4/1.00	PN4250	4/1.00
40673	1.75	PN3569	4/1.00	2N4400	4/1.00
2N918	4/1.00	MPS3638A	5/1.00	2N4401	4/1.00
2N2218A	2/1.00	MPS3702	5/1.00	2N4402	4/1.00
2N2221A	4/1.00	2N3704	5/1.00	2N4403	4/1.00
2N2222A	5/1.00	MPS3704	5/1.00	2N4409	5/1.00
PN2222 Plastic	7/1.00	2N3705	5/1.00	2N5086	4/1.00
2N2369A	4/1.00	MPS3705	5/1.00	2N5087	4/1.00
MPS2369	5/1.00	2N3706	5/1.00	2N5088	4/1.00
2N2484	4/1.00	MPS3706	5/1.00	2N5089	4/1.00
2N2906	4/1.00	2N3707	5/1.00	2N5129	5/1.00
2N2907	5/1.00	2N3711	5/1.00	PN5134	5/1.00
		2N3724A	.65	PN5138	5/1.00
2N2925	5/1.00	2N3725A	1.00	2N5139	5/1.00
MJE2955	1.25	2N3772	2.25	2N5210	5/1.00
2N3053	2/1.00	2N3823	1.00	2N5449	3/1.00
		2N3903	5/1.00	2N5951	3/1.00

CAPACITOR CORNER

50 VOLT CERAMIC DISC CAPACITORS

	1-9	10-99	100+		1-9	10-99	100+
10 pf	.05	.04	.03	.001µF	.05	.04	.035
22 pf	.05	.04	.03	.0047µF	.05	.04	.035
47 pf	.05	.04	.03	.01µF	.05	.04	.035
100 pf	.05	.04	.03	.022µF	.06	.05	.04
220 pf	.05	.04	.03	.047µF	.06	.05	.04
470 pf	.05	.04	.035	.1µF	.12	.09	.075

100 VOLT MYLAR FILM CAPACITORS

	1-9	10-99	100+		1-9	10-99	100+
.001mf	.12	.10	.07	.022mf	.13	.11	.08
.0022	.12	.10	.07	.047mf	.21	.17	.13
.0047mf	.12	.10	.07	.1mf	.27	.23	.17
.01mf	.12	.10	.07	.22mf	.33	.27	.22

+20% DIPPED TANTALUMS (SOLID) CAPACITORS

	1-9	10-99	100+		1-9	10-99	100+
.1/35V	.39	.31	.25	1.5/35V	.41	.33	.26
.15/35V	.39	.31	.25	2.2/35V	.51	.41	.33
.22/35V	.39	.31	.25	3.3/25V	.53	.43	.34
.33/35V	.39	.31	.25	4.7/25V	.63	.51	.41
.47/35V	.39	.31	.25	6.8/25V	.79	.63	.50
.68/35V	.39	.31	.25	15/25V	1.39	1.12	.88
1.0/35V	.39	.31	.25	22/6V	.79	.63	.50

MINIATURE ALUMINUM ELECTROLYTIC CAPACITORS

Axial Lead				Radial Lead			
.47/50V	.15	.13	.10	.47/25V	.15	.13	.10
1.0/50V	.16	.14	.11	.47/50V	.16	.14	.11
3.3/50V	.14	.12	.09	1.0/16V	.15	.13	.10
4.7/25V	.15	.13	.10	1.0/25V	.16	.14	.11
10/25V	.15	.13	.10	1.0/50V	.16	.14	.11
10/50V	.16	.14	.12	4.7/16V	.15	.13	.10
22/25V	.17	.15	.12	4.7/25V	.15	.13	.10
22/50V	.24	.20	.18	4.7/50V	.16	.14	.11
47/25V	.19	.17	.15	10/16V	.14	.12	.09
47/50V	.25	.21	.19	10/25V	.15	.13	.10
100/25V	.24	.20	.18	10/50V	.16	.14	.12
100/50V	.35	.30	.28	47/50V	.24	.21	.19
220/25V	.32	.28	.25	100/16V	.19	.15	.14
220/50V	.45	.41	.38	100/25V	.24	.20	.18
470/25V	.33	.29	.27	100/50V	.35	.30	.28
1000/16V	.55	.50	.45	220/16V	.23	.17	.16
2200/16V	.70	.62	.55	470/25V	.31	.28	.26

Circle 218 on inquiry card.

If North Star or Cromemco offer it . . .

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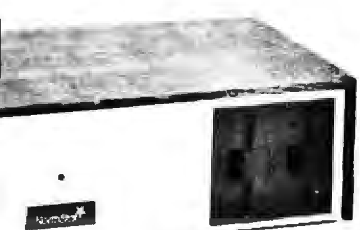
Immediate Delivery at Discount Prices



NORTH STAR Horizon® 2

32K Double Density
Assembled and Tested
List $3095

ONLY $2619

North Star KIT products have been discontinued. MiniMicroMart HAS INVENTORY of most items!

KITS		ASSEMBLED	
HORIZON 1 16K, DD	$1474	HORIZON 1, DD	$2279
32K, DD, List $1999	1684	32K, QD, List $2995	2539
32K, QD, List $2199	1869	HORIZON 2, 32K, DD	$2619
HORIZON 2, 16K, DD	$1824	32K, QD, List $3595	3049
32K, DD, List $2399	2034	48K, DD, List $3590	3039
32K, QD, List $2779	2359	48K, QD, List $4090	3469
		64K, DD, List $3830	3239
		64K, QD, List $4330	3669

NORTH STAR APPLICATIONS SOFTWARE

(Exclusive for use with North Star Disk Systems — specify Double or Quad Density)

NORTHWORD, List $399	$339
MAILMANAGER, List $299	249
INFOMANAGER, List $499	419
GENERALLEDGER, List $999	799
ACCOUNTSRECEIVABLE, List $599	499
ACCOUNTSPAYABLE, List $599	499

NORTH STAR HARD DISK HD-18

18 megabytes, plugs into parallel port of North Star Horizon. Utilizes tried-and-proven 14" Century Data Marksman. List $4999. **OUR PRICE $4199**

NORTH STAR MDS-A — Double (or Quad) Density Disk System, Kit, List $799 . **OUR PRICE $669**
Assembled and Tested, List $899 **SPECIAL $719**

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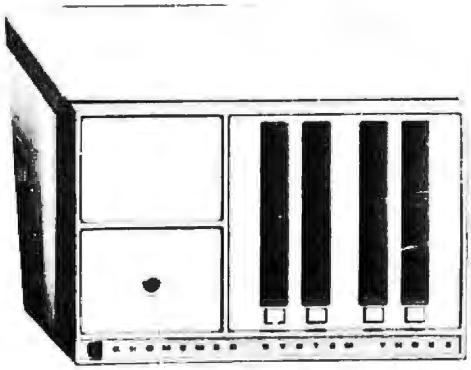
16K Dynamic RAM (RAM-16-A/A), Assembled, List $499	$420
Kit, List $449	SPECIAL $299
32K (RAM-32/A), Assembled, List $739	$620
Kit, List $669	ONLY $499



CROMEMCO System 3

with 64K of RAM
List $6990

OUR PRICE $5890

CROMEMCO SYSTEM 2 — Now features dual-sided drives — double the capacity. Similar to System 3, except features dual, double-sided mini floppy disk drives. List $3990 . . . . . **ONLY $3390**

Z-2 COMPUTER SYSTEM (can be rack mounted), List $995 . . . . . **$845**

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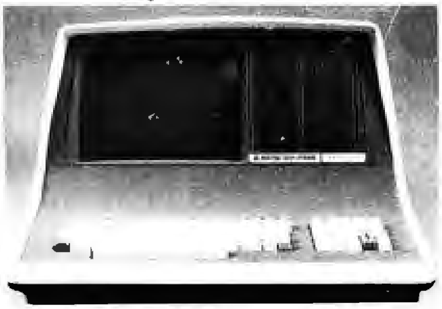

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Double Density, Kit
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w/Assembled Bd. and MPI-51.......... $769
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Upper and lower case, 15 baud rates: 75 to 19,000 baud, dual intensity, 24 x 80 character display, 12 x 10 resolution. Numeric pad. Programmable reversible video, auxiliary port, self-test mode, protect mode, block mode, tabbing, addressable cursor. Microprocessor controlled, programmable underline, line and character insert/delete. "C" version features typewriter-style keyboard. List $950

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Software compatible with a Soroc IQ-120, Hazeltine 1500, ADM-3A or DEC VT-52. Features block mode transmission and printer port; 12" anti-glare screen; 18-key numeric keypad; full cursor control. List $895

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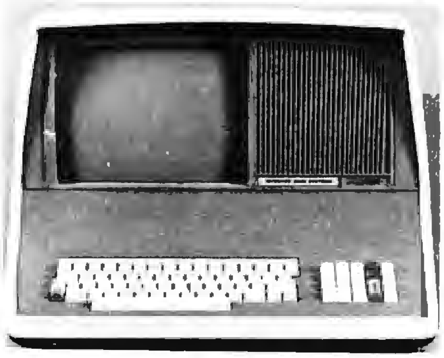

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12" display, 24 x 80 format, 18-key numeric keypad, 128 upper/lower case ASCII characters. Reverse video, blinking, complete cursor addressing and control. Special user-defined control function keys, protected and unprotected fields. Line insert/delete and character insert/delete editing, eleven special line drawing symbols.

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SPECIAL

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1500

ONLY

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1410 w/numeric keypad, List $900	$749
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with anti-glare CRT

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NEW 730, parallel, friction, tractor	**$679**
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702 120 cps, bi-direct., tractor, VFU	1995
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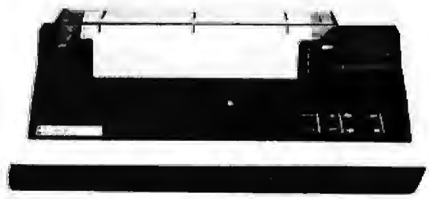
TI-810



TI-810 Basic Unit, $1895 . **ONLY $1695**

TI-810 w/full ASCII (Lower case), vertical forms control, and compressed print . **$1895**

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These notices are free of charge and will be printed one time only on a space available basis. Notices can be accepted from individuals or bona fide computer users clubs only. We can engage in no correspondence on these and your confirmation of placement is appearance in an issue of BYTE.

Please note that it may take three or four months for an ad to appear in the magazine.

FOR SALE: New Glution Rustrack inkless strip-chart recorder with paper roll. Also, Graphic Sciences Dex 570 and Dex I graphic communications systems. They send photos and legal documents over phones, self-contained. R Qualls, College Inn Apts, Box 238, Durant OK 74701, (405) 924-6306 after 5.

FOR SALE: Expandor Black Box printer, 80-column for parallel port; $350. SwTPC MP-N calculator; $35, Newtech Model 68 music board and software; $48, SwTPC CT-64 terminal with CT-VM; $350. All postpaid. Dennis Doonan, 2307 Carlisle Ave, Racine WI 53404.

FOR SALE: Two teletypewriters. Friden 7102 with upper and lowercase, full ASCII, 110 baud RS-232/20 mA, paper-tape reader/punch, and wide carriage. $420 each or $800 for both plus freight. Gary, (317) 784-9519.

FOR SALE: TRS-80 quick printer and/or line printer and cables. Both almost new. Stanley Strauss, (201) 763-7249.

FOR SALE: Three 8 K DRC S-100 programmable memories; one 8 K Seals S-100 programmable memory. $125 each. Perry A Lipford, 5005 Oxford Ave, Mays Landing NJ 08330, (609) 653-1542.

FOR SALE: Heath H11A computer system with 64 K bytes memory. Uses DEC LSI-11/2 processor board. Includes serial input/output (I/O) board, all manuals, and documentation. System value over $2900. Will sell for $2500 or best offer. Art Lundquist, 13118 Glasgow Way, Ft Washington MD 20022, (301) 868-0005.

FOR SALE: HP-67 programmable calculator. With standard accessories, stat, math, standard, and business decisions PAC. Package of blank cards. Must sell. Recently purchased Apple II system. Will ship to first cashier's check or money order for $525. I pay shipping. 100% operational. D Robbins, 1161 York Ave 1L, New York NY 10021.

FOR SALE: Complete collection of BYTE. Both bound editions and single copies in good condition. Outstanding investment in personal computing. Make best offer. M N Andersen, 10684 Esmeraldas Dr, San Diego CA 92124.

FOR SALE: BYTE from February 1978 thru February 1980. Available individually or in groups at $2 apiece. Also, first four issues of *onComputing* magazine for $8 and February 1979 thru January 1980 *Creative Computing* for $20. Will answer all inquiries. John Scholze, Rt 5, Box 449, Black River Falls WI 54615.

FOR SALE: H8 computer with 24 K Godbout programmable memory plus serial input/output (I/O) and cassette interface. All assembled and tested and includes recent version of Benton Harbor BASIC. All for $700 plus shipping. Daniel Bush, (404) 394-3341.

WANTED: A used terminal printer with acoustic coupler, Bell System 103 compatible, and 300 bps. Also, need a video display terminal. J A Gatlin, 1115 S Main, Ottawa KS 66067.

WANTED: BYTE magazines, February 1976 and June 1976. T Higbee, 4572 Trafalgar Dr, La Palma CA 90623.

FOR SALE: RCA 1802 Cosmac processor with 16 K static memory, Netronics giant board, ASCII keyboard, Netronics video-display board, Netronics Level III BASIC, 5-card bus, power supply, Tiny BASIC, 15-inch GBC monitor, game cassettes, complete data, and instructions. Everything in good working order. Original cost over $1000, asking $600. William Gordon, 11 Canterbury Ln, Short Hills NJ 07078, (201) 467-9792.

FOR SALE: Altair 8800A, 16 K, Meca Alpha I tape, 2 SIO, Act I terminal, 8 K, and Extended BASIC. $1400 takes all, or will separate. D Gietzen, 313 Meadow Ln, Hastings MI 49058, (616) 945-5334.

FOR SALE: 48 K Apple II with manuals, paddles, and software on cassette. Software includes the S-C Assembler II, an implementation of the FORTH language, and the Apple Invaders game. $1100 or best offer. Will ship via UPS. Tim Tillson, 2712 Adobe Dr, Fort Collins CO 80525, (303) 223-7364.

FOR SALE: BYTE magazines: November 1976 and November 1977 thru June 1979. All twenty-one issues for $53. I pay postage. Send certified check or money order. David McCracken, 6850 Freedom Blvd, Aptos CA 95003, (408) 688-0358.

FOR SALE: Dynamic programmable memory circuits. National MM5280-055 (2107) 4 K by 1. These parts are available due to project cancellation. They are new and guaranteed to meet specifications. Have 300; will sell all or part at $1.75 each. Doryn Johnson, 12A Triads, Logan UT 84321, (801) 752-9378.

FOR SALE: Wang advanced programming calculator. Model 720B with Model 702 plotting output writer. Also, manuals and service schematics. $950. Frank Shea, 78 Pilgrim Ave, Worcester MA 01604, (617) 798-8485.

FOR SALE: 8800B Altair S-100 mainframe; $650, SSM video VB-1B graphics board; $95, two Godbout 8 K Econoram memory boards; $95 each, Altair 88ACR cassette-interface board; $85. Documentation included with each item. Robert Faulkner, 607 Bryan Ct, Altamonte Springs FL 32701, (305) 830-4387 after 7 PM.

FOR SALE: Litton Model 1252 business computer in excellent condition. Includes central processor Model 1601, keyboard, printer (30 cps), punch, reader, and auxiliary storage. Recently serviced. Computer comes complete with operator's manual and software for many business applications. $3000. Jesse Collum, (919) 847-4053 or (919) 556-4031.

FOR SALE: Processor Technology 64KRA-1 (64 K by 8) memory board for S-100 computers with 2 MHz clock such as SOL-20, IMSAI 8080 and 8085, and Altair. Has three different bank select options; includes manual with updates, $575. John Edwards, 408 13th St #545, Oakland CA 94612, (415) 462-3394.

FOR SALE: Ohio Scientific Challenger II-8P cassette-based system with 20 K bytes static memory, 540 video board, 542 polled keyboard, two full parallel ports, OSI Assembler/Editor, some game tapes, and two binders of documentation and notes. This is a plain but reliable computer with a heavy power supply. Cost about $1250 new; will sell for $650 or best offer. Gregg Williams, (603) 924-9281 Monday thru Thursday.

FOR SALE: Ohio Scientific printed-circuit boards, documentation, backplane, and cabinet for 6800 or 6502 Challenger system. Original cost $300, will sell for $200. Included are: #400 processor and input/output (I/O) board, #420 4 K programmable memory boards, #430 cassette A/D and D/A board, #440 Video Graphics board, #450 8 K read-only memory and I/O board, and #480 backplane board. Paul Manos, 28743 Lincoln Rd, Bay Village OH 44140, (216) 331-3010 evenings.

FOR SALE: Memorex hard-copy terminal with digital cassette. 60 characters per second. Includes all manuals. Needs some work. $500. Michael C Lewis, 1602 Shepherd Dr, Duarte CA 91010.

WANTED: Clock generator circuit for TMS9900 microprocessor (ie: TIM9904 or 74LS362). Please contact me if you can sell me one or know of a source for one. I am also interested in corresponding with other 9900 users. Andy Hall, 4124-55th St, Des Moines IA 50310, (515) 276-2459.

FOR SALE: Sphere 6800 computer, 12 K memory, video board, cassette/modem interface board. Best offer over $300; original cost $1000. David Moore, 1518 Jefferson, Quincy IL 62301, (217) 228-1792.

FOR SALE: DECwriter II with APL option, current loop and RS-232, writing table, noise shield. Complete with maintenance manual and all schematics. Maintained by DEC and in perfect working order. Reliable hard copy at 30 cps in full ASCII or APL character sets. Character set software-selectable. Asking $1800. Lloyd Botway, 325 Dartmouth Rd, Kansas City MO 64113, (816) 361-4988.

WANTED: Printer (and/or Micromodem II, Disk II without controller) for Apple II. Will trade (or sell) Acoustat X direct-drive electrostatic speaker system and Kenwood KT8300 FM/AM tuner. Also, Applesoft read-only-memory card without Autostart read-only memory for sale; make offer. Charles White, 1712F Newport Cir, Santa Ana CA 92705, (714) 979-9666 days, (714) 751-1296 evenings and weekends.

FOR SALE: BYTE from first issue up to current. All original publications in excellent condition. No marks, scribbles, or underlines. Give issues you want and offer. C Tseng, 67-05 Austin St, Forest Hills NY 11375.

FOR SALE: Three 16 K dynamic S-100 memory boards ($75 each); minicomputer system PDP-8/L 4 K memory; four cartridge drives; ASR33; 100 cps printer; and RS-232 interface. Cost of entire system, $750. Kalon Kelley, 149 Rametto Rd, Santa Barbara CA 93108, (805) 969-1539.

WANTED: PDP-8/E minicomputer or MM8-EJ extended memory option for same. Name your price. Martin J Durbin, 2649 N Sacramento, Chicago IL 60647, (312) 235-1620 evenings.

FOR SALE: Memorex 651 floppy-disk drive (new), thirty blank disks, Ken Welles floppy-controller board; all for $350. 2708s $5 each, 5204s $4 each, 1702s $3 each, 4116s $5 each. Paper-tape reader; $10. Gordon Wilson, 819 San Lucas Ave, Mtn View CA 94043.

FOR SALE: D C Hayes Micromodem for Apple II. Like new, works perfectly. Only $320. H Rothman, 218 Huntington Rd, Bridgeport CT 06608, (203) 579-0472.

WANTED: Processor Technology VDM-1 board, working or not, and ALS-8 information. Richard Miller, POB 6337, Jacksonville FL 32205.

WANTED: Heathkit ET-3400 microprocessor trainer only in kit or assembled; also, Radio Shack TRS-80 Level II with 16 K, integral keyboard, power supply, video monitor, and cassette recorder. All in good condition. Roland Dumont, 731 Jacques Berthiaume, Ste-Foy Quebec, G1V 3T2 Canada.

FOR SALE: Chalco high-speed paper-tape reader; 5, 6, 7, or 8 level tape (ASCII or Baudot), 625 cps, self-contained power supply, simple interface. Industrial quality, excellent condition, complete with documentation. New; $755. Asking $100. Fred Goldberg, 29 Clearview Rd, E Brunswick NJ 08816, (609) 734-2160 days.

WANTED: Schematics (service documentation) for Vogue Instrument Co line printer. Please call Steve Gardner, Birmingham AL 35209, (205) 942-8567.

FOR SALE: New P4 video display; $30. Purchased from Electrolabs; never used. Will ship UPS COD. Frank Sneade, Rt 1 Box 60A, Rawlings VA 23876, (804) 949-7835.

FOR SALE: SIM-1 microcomputer with Microsoft BASIC (read-only memory), 4 K monitor, 1 K programmable memory, and power supply. All manuals and documentation supplied. Will ship UPS for $250. Robert Dixon, Rt 1 Box 239-A, Lynnville TN 38472, (615) 363-7489.

BOMB

BYTE's Ongoing Monitor Box

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7	198	Khachiyan's Algorithm, Part 1: A New Solution to Linear Programming Problems	Berresford, et al
8	210	Construction of a Fourth-Generation Video Terminal, Part 1	Wierenga

May BOMB Results
Floppy Disks

BYTE readers output their interest in Steve Ciarcia's "I/O Expansion for the Radio Shack TRS-80" (page 22) by expanding Steve's rank with another first place. John Hoeppner also interfaced well with readers, receiving a second place for his floppy-disk-controller article (page 72). First place for May was 1.84 standard deviations above the mean, while second was 1.09, closely followed by Gregory J Walker ("Error Checking and Correcting for your Computer," page 250) in third place and Emory Cook ("The Cassette Lives On," page 12) in fourth place.

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A ☐ The swingline table top burster will separate single-ply continuous forms into individual sheets up to 15". Length 2⅜" to 12". Paper weight 10 to 110 lb. bond. Speed is constant at 125 ft. per minute.

Wt. 95 lbs. **Sale Price $879.00**

B ☐ Our custom forms have a guarantee that speaks for itself. Our time on forms range from two to five weeks for custom work and before we start a job we now give a guaranteed shipping date and price, depending on art work, from two to five weeks and for every day we're late we give you a 10% discount. To get a quote just mail the detached portion of this ad with sample of form or layout and we will call you the day we get the information with a price and guaranteed day of shipment.

C ☐ The swingline table top decollator is a portable unit which separates both carbon and carbonless continuous computer forms into stacks. The separated carbon is easily and neatly removed from carbon pick-up spool. Form size is up to 15" wide. Wt. is 10 to 110 lb. bond paper, and the speed is variable from 75 to 200 feet per minute and takes only 120 volts AC 60 hertz to operate.

Wt. 40 lbs. **Sale Price $369.00**

D ☐ The Datatech Intimus 007 shredder works for Scotland Yard, for government authorities, for important corporations, banks and embassies. The cutting capacity is 12 to 14 sheets at one pass. Cross cut is 1/35 x 3/8. It has a 2 H.P motor and runs off of 220/380 V 3 phase.

Wt. 320 Lbs. **Sale Price $6599.00**

E ☐ The Intimus 306 is designed for trouble free operation and has a switch for forward and reverse rotation. It has 2 motors with terminal overload. Housing consists of coated steel, mounted on rubber cushions for noiseless shredding. The 306 can sit on a table or a stand. Cutting width is ⅛" or ¼" and has two 150 watt 110 V 60 cycle, 1 phase motors.

Wt. 66 Lbs. **Sale Price $1189.00**

F ☐ The Intimus Simplex is designed for security without problems in the office. One push of the button renders confidential information into five illegible paper strips ⅛" thin. The simplex has a wide opening in the middle for throw away of cans, etc. Even a paper clip is simply cut into pieces. The cutting capacity is 8 to 10 sheets at one time. It has a 1/5 H.P. motor and runs off of 110 volts.

Wt. 27 Lbs. **Sale Price $569.00**

G ☐ Our catalog consists of more information on equipment in this ad. Other models are available plus a complete line of calculators and typewriters by Adler, Lathem time recorders, several varieties of safes, and our disintegrator that destroys paper, aluminum, film and carbon to a complete loss of identity.

Price $2.00

H ☐ Free Brochures and more information·
1. ☐ Business Forms
2. ☐ Calculators
3. ☐ Forms Handling Equipment
4. ☐ Time Recorders
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Terms: Check or money order U.S. funds only. Prepaid orders add 3% S/H, COD's add 5% S/H (U.S.only). California residents add 6% sales tax.
Prices subject to change without notice. Sale ends Sept. 15, 1980

Circle 309 on inquiry card.

The home computer you thought was years away is here.

C8P DF $2,895

Ohio Scientific's top of the line personal computer, the C8P DF. This system incorporates the most advanced technology now available in standard configurations and add-on options. The C8P DF has full capabilities as a personal computer, a small business computer, a home monitoring security system and an advanced process controller.

Personal Computer Features
The C8P DF features ultra-fast program execution. The standard model is twice as fast as other personal computers such as the Apple II and PET. The computer system is available with a GT option which nearly doubles the speed again, making it comparable to high end mini-computer systems. High speed execution makes elaborate video animation possible as well as other I/O functions which until now, have not been possible. The C8P DF features Ohio Scientific's 32 x 64 character display with graphics and gaming elements for an effective resolution of 256 x 512 points and up to 16 colors. Other features for personal use include a programmable tone generator from 200 to 20KHz and an 8 bit companding digital to analog converter for music and voice output, 2-8 axis joystick interfaces, and 2-10 key pad interfaces. Hundreds of personal applications, games and educational software packages are currently available for use with the C8P DF.

Business Applications
The C8P DF utilizes full size 8" floppy disks and is compatible with Ohio Scientific's advanced small business operating system, OS-65U and two types of information management systems, OS-MDMS and OS-DMS.

The computer system comes standard with a high-speed printer interface and a modem interface. It features a full 53-key ASCII keyboard as well as 2048 character display with upper and lower case for business and word processing applications.

Home Control
The C8P DF has the most advanced home monitoring and control capabilities ever offered in a computer system. It incorporates a real time clock and a unique FOREGROUND/BACKGROUND operating system which allows the computer to function with normal BASIC programs at the same time it is monitoring external devices. The C8P DF comes standard with an AC remote control interface which allows it to control a wide range of AC appliances and lights remotely without wiring and an interface for home security systems which monitors fire, intrusion, car theft, water levels and freezer temperature, all without messy wiring. In addition, the C8P DF can accept Ohio Scientific's Votrax voice I/O board and/or Ohio Scientific's new universal telephone interface (UTI). The telephone interface connects the computer to any touch-tone or rotary dial telephone line. The computer system is able to answer calls, initiate calls and communicate via touch-tone signals, voice output or 300 baud modem signals. It can accept and decode touch-tone signals, 300 baud modem signals and record incoming voice messages. These features collectively give the C8P DF capabilities to monitor and control home functions with almost human-like capabilities.

Process Controller
The C8P DF incorporates a real time clock, FOREGROUND/BACKGROUND operation and 16 parallel I/O lines. Additionally a universal accessory BUS connector is accessible at the back of the computer to plug in additional 48 lines of parallel I/O and/or a complete analog signal I/O board with A/D and D/A and multiplexers.

Clearly, the C8P DF beats all existing small computers in conventional specifications plus it has capabilities far beyond any other computer system on the market today.

C8P DF is an 8-slot mainframe class computer with 32K static RAM, dual 8" floppies, and several open slots for expansion.

C8P $950

Or get started with a C8P with cassette interface, 8K BASIC-in-ROM which includes most of the features of the C8P DF except the real time clock, 16 parallel I/O lines, home security interface and accessory BUS. It comes with 8K static RAM and Ohio Scientific's ultra-fast 8K BASIC-in-ROM. It can be expanded to a C8P DF later. Base price $950. Virtually all the programs available on disk are also available for the C8P cassette system on audio cassette.

Computers come with keyboards and floppies where specified. Other equipment shown is optional.

For literature and the name of your local dealer, CALL 1-800-321-6850 TOLL FREE.

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